Glen A. Winn
14 Carlton St.
Toronto, Ontario
M5B 1K5

Telephone: 416.542.2517
Facsimile: 416.542.3024
regulatoryaffairs@torontohydro.com

toronto hydro
electric system

April 1, 2011

via RESS e-filing – signed original to follow by courier

Ms. Kirsten Walli
Board Secretary
Ontario Energy Board
PO Box 2319
2300 Yonge Street, 27th floor
Toronto, ON M4P 1E4

Dear Ms. Walli:

Re: Toronto Hydro-Electric System Limited ("THESL")
Application for Approval of 2011-2014 CDM Programs –
Interrogatory Responses and Notice of Program Withdrawal
OEB File No. EB-2011-0011

Pursuant to Procedural Order #1, THESL hereby submits its responses to interrogatories received from Ontario Energy Board Staff, the Association of Major Power Consumers in Ontario, Canadian Energy Efficiency Alliance, Consumers Council of Canada, Green Energy Coalition, Low Income Energy Network, Pollution Probe Foundation, School Energy Coalition, and the Vulnerable Energy Consumers Coalition. THESL did not receive any interrogatories from Energy Probe Research Foundation, Horizon Utilities Corporation, Hydro One Networks Inc., Ontario Power Authority, PowerStream Inc., and Veridian Connections Inc.

All submissions, including live spreadsheets, will be available at the start of the next business day on THESL's Regulatory webpage at:
http://www.torontohydro.com/sites/electricsystem/Pages/RegulatoryAffairs.aspx

In addition, THESL wishes to advise the Board and all parties that it withdraws the In-Store Engagement and Education program and associated budget as a standalone program from its application in this proceeding. That program was in fact consolidated with the

Community Outreach and Education Initiative program prior to finalization of the program portfolio, but inadvertently it remained as a separate program in the application materials filed with the Board on January 10, 2011. In other words, the In-Store Engagement and Education program has been subsumed within the Community Outreach and Education Initiative and the budget for this consolidated program is reflected in the Program Budget on page 13, Tab d, Application 4 of THESL's prefiled evidence.
The consolidation of these two programs does not affect the requested budgets for any of the remaining programs. THESL regrets any confusion this administrative error may have caused.

Please contact me if you have questions.

Yours truly,

[original signed by Jack Lenartowicz for]

Glen A. Winn
Manager
Regulatory Applications & Compliance

/encl.

:GAW/JL/acc

cc: J. Mark Rodger, THESL Counsel, by email only
Intervenors of Record for EB-2011-0011, by email only

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

INTERROGATORY 1:

Reference(s): none provided

Within the CDM Code, when discussing the requirements for the CDM Strategy, it states at section 2.1.1(c) that a distributor must confirm that CDM Programs will be offered for all customer types in a distributor's service area, as far as is appropriate and reasonable having regard to the composition of the distributor's customer base.

a) Please provide a table, broken down by customer type (residential, residential low-income, commercial, institutional and industrial) showing all the CDM programs, both OPA and Board-Approved, that THESL plans to offer from 2011-2014. For each program, please also include the years the program is expected to operate to and from, the total budget for the program, the total number of participants expected to participate in each program, the cost effectiveness results for each program and the total projected energy (GWh) and peak demand (MW) savings for each program. The table below can be used as a guide:

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

Programs	Years	Budget	Participants	Cost Effectiveness		Savings	
OPA				TRC	PAC	GWh	MW
Residential							
Program 1							
Residential - Low-Income							
Program 1							
CI&I							
Program 1							
Board-Approved							
Residential							
Program 1							
CI&I							
Program 1							
TOTAL							

b) In a separate table, please provide the estimated rate impacts for both the overall request included in this application for nine Board-Approved CDM Programs and the overall impact inclusive of both OPA and Board-Approved CDM Programs.

RESPONSE:

a) Please refer to the table below:

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

Program	Years	Budget		Participants	Cost Effectiveness		Savings	
		PAB	Variable Costs		TRC	PAC	MW	GWh
OPA-Contracted Province-Wide Programs								
Customer Type: Residential								
Consumer Program	2011-2014	$13,236,580	N/A				37.8	233.1
peaksaver Extension for 2011	2011-2014	$ 752,600					1.7	-
Customer Type: CI&I								
Commercial & Institutional Program	2011-2014	$32,199,168	N/A				122.8	765.9
Industrial Program	2011-2014	$ 4,006,373					58.5	141.8
Total for OPA-Contract Programs		**$50,194,721**	**N/A**				**220.8**	**1,140.8**
Board-Approved Programs								
Customer Type: Residential								
Multi-Unit Residential Demand Response	2011-2014	$ 2,710,072	$ 17,204,619	218	$10,804,739	$ 775,623	11.7	0.5
Flat Rate Water Heater Conversion & Demand Response	2011-2012	$ 427,889	$ 2,251,599	4,413	$ 1,945,228	$ 1,797,943	1.8	10.2
Community Outreach & Education Initiative	2011-2014	$ 3,699,664	$ 1,960,000	N/A				
Customer Type: CI&I								
Commercial , Institutional & Small Commercial Monitoring & Targeting	2011-2014	$ 1,787,935	$ 3,713,475	107	$ 2,835,833	$ 2,346,929	0.9	40.7
Hydronic System Balancing Program	2011-2014	$ 1,220,434	$ 3,499,734	496	$ 8,583,331	$12,425,075	3.4	62.0
Commercial Energay Management & Load Control	2011-2014	$ 2,124,841	$ 9,560,936	1,164	$ 6,186,836	$ 9,955,657	6.7	13.9
Business Outreach & Education	2011-2014	$ 1,647,585	$ -	N/A				
Greening Greater Toronto Commercial Building Energy Initiative	2011	$ 295,707	$ -	N/A				

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

Notes:

- The budget for OPA-Contracted Province-Wide programs only includes the Program Administration Budget ("PAB"). Variable costs for participant incentives have not been allocated to LDCs by the OPA and will be treated as pass-through costs to LDCs (i.e., the OPA is responsible for paying variable costs on completion of participant applications).
- The number of participants and cost effectiveness tests (TRC & PAC) for OPA-Contracted Province-Wide programs are dealt with by the OPA on a province wide basis. Allocations to each LDC's service territory are not available.

b) The funding required for the CDM programs will be collected from all Ontario customers through the Global Adjustment. For residential and small commercial customers (Designated Customers) the Global adjustment estimates are included as part of the setting of the RPP rate bi-annually. For other customers, the Global adjustment is collected through a monthly kWh charge (Class B customers) or kW charge (Class A customers) determined each month by the IESO. Because of this structure of collection of the Global Adjustment, it is not possible to estimate the rate impacts of THESL's proposed CDM programs.

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

INTERROGATORY 2:

Reference(s): none provided

At section 3.4.1 of the CDM Code the Board states that if the Board approves a CDM program pursuant to an application filed under section 3.1, such approval will include a determination regarding the amount and timing of payments to be made by the IESO under section 78.5 of the Act in relation to Board-Approved CDM Programs. Total budgets are provided by THESL within its application with a total requested amount of $56,327,988 being requested for approval.

a) Please provide the schedule THESL would like to receive payments for each of its Board-Approved CDM program found within the application.

RESPONSE:

THESL proposes the following payment terms for all programs:

1. Fixed costs to be paid in advance and in six month intervals starting with the first payment within 30 days after the Board approves the application. Fixed costs will be defined by a schedule of planned labour costs and will be based on the terms defined in the Board's decision.
2. Variable costs covering third party and participant incentives to be paid by IESO net 30 days based on invoices (supported by evidence of costs incurred) submitted by THESL and on condition that THESL will not pay participants or 3rd parties until it receives payment from IESO.

It is requested that a Board decision approving the programs include a directive for the establishment of a Global Adjustment Mechanism (GAM) settlement process for this application that will be separate from other GAM related financial settlement processes

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

currently in place. The final financial settlement with the IESO for the approved programs in this application should be completed no later than June 30, 2015 so that the final Annual Report to be filed by September 30, 2015 may contain a record of the financial settlement for the four year period ending December 31, 2014 including trailing costs in 2015 for completion of EM&V reporting and final settlements.

THESL further suggests that the Board provide direction on how it wishes THESL to deal with variable costs for participant incentives in the event of over achievement of targets for Board-Approved programs. THESL proposes to manage the program variable participant incentive costs in the amount approved by the Board in the following manner: Program participant applications will state that incentive payments to participants will be conditional on the availability of funding from via regulatory approval from the Board. In the event of a potential program over-achievement THESL will submit an application to the Board to approve an increased incentive budget.

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

INTERROGATORY 3:

Reference(s): none provided

At section 3.1.1 of the CDM Code it states that a distributor shall not apply for Board-Approved CDM Programs until the OPA has established its first set of OPA-Contracted Province-Wide CDM Programs.

a) Please discuss if THESL believes the OPA has established its first set of Province-Wide CDM Programs. Within your response, discuss the nature of THESL's involvement in the establishment of the Province-Wide Programs and its understanding of the current state of the OPA-Contracted Province-Wide CDM Programs.

RESPONSE:

a) Yes, THESL believes that the OPA programs were established before THESL submitted its proposed Board-Approved CDM applications. THESL was very involved in all aspects of the EDA/OPA working groups for each program and had an inherent knowledge of all programs developed or substantially developed at the time of its submission.

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

INTERROGATORY 4:

Reference(s): **none provided**

At section 2.3.2 of the CDM Code it states that distributors shall not apply for Board approval of CDM Programs that duplicate existing OPA-Contracted Province-Wide CDM Programs.

a) Please discuss any and all formal communications between THESL and the OPA about all of THESL's proposed Board-Approved CDM Programs, specifically the nine programs within this application before the Board. Discuss in detail each program separately.

b) Has THESL received any form of confirmation from the OPA that the programs applied for within this application are not duplicative of any existing OPA programs? If yes, please provide the documentation that addresses each program.

c) Please provide a full concordance or mapping of THESL's nine proposed Board-Approved CDM Programs to the OPA-Contracted Province-Wide programs, discussing the similarities and differences of each program in an easy-to-read table. Within the chart, please use comparators such as targeted market segment, the marketing material and/or marketing approach used, program delivery or implementation methods, the specific technologies or measures, timeframe for each program, etc.

RESPONSE:

a) THESL is currently engaged in discussions with the OPA concerning matters related to its proposed Board-Approved CDM programs. THESL will provide parties with any correspondence it receives from the OPA prior to the Oral Hearing.

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

b) See answer to (a).

c) Refer to Appendix A to this Schedule.

Program Name	OPA Programs	OEB Program	Targeted Market Segment	Incremental MW	Incremental GWh	Marketing Approach	Implementation Methods	Time Frame for Program
Hydronic System Balancing Program	Audit Funding - Whole Building Audits (ASHRAE Level 2 and 3) by energy engineers.	System specific evaluation of hydronic systems completed by certified balancing contractors.	C&I various categories - 1984 facilities in Office, Hospitality, MURB and Institutional	3.4	62	Targeted marketing to key facility owners/managers and institutions.	Via approved contractor list	4 years
	Retro-commissioning - Chilled water plant only.	Applies to all hydronic main pumps and booster pumps.						
	Implementation Funding - ERII funding for variable frequency drives. No audit support or market focus. Would be a custom application - inefficient.	Matched funding levels to ERII.						
Commercial Energy Management and Load Control	Existing Peaksaver - poorly designed for < 50 kW class of customer. One time incentive.	Provides ongoing incentives to promote persistence. Applies to a wider segment of customers <200kW. Provides customer with a tool to manage energy and utilizes two way communication.	C&I < 200kW Peak Demand (21,350 facilities)	6.7	13.8	Targeted marketing to key facility owners/managers and institutions.	RFP for Vendor supply and install.	4 years
	New Peaksaver - designed for residential loads. Uses one way communication and load control switches. One time incentive.							
MURB Demand Response	Peaksaver is not applied to this sector.	Provides ongoing incentives to promote persistence. Provides customer with a tool to manage energy and utilizes two way communication.	MURB sector with central cooling (Predominantly 1256	11.7	0.5	Targeted marketing to key facility managers. Direct mail and	RFP for Vendor supply and install	4 years
	Demand Response 1/3 - designed for large commercial/industrial customers that can drop loads all year round.							
Monitoring and Targeting	OPA has an equivalent program for > 15GWh industrial customers only.	Provides incentives for M&T systems and performance incentives for ongoing monitoring.	C&I, Industrial customers [illegible]	0.86	40.7	Targeted marketing to key [illegible]	Via customer selected vendors	4 years
Flat Rate Water Heater	No equivalent program. Consumer program has no equivalent measure. Load control component is incremental to the existing Peaksaver program.	Incentives for switching to metered service.	Residential customers with flat rate water heater	1.79	10.2	Direct mail to existing customers.	Conversion via customer selected vendors.	2 years
Business Outreach and Education	Not covered in OPA marketing plans.	Education and training on CDM programs extends beyond simple awareness-raising marketing and messaging efforts. In general, it requires additional resources to present and sponsor the kinds of events and organizational affiliations that provide access to target customers in a direct way. Education efforts are customized to provide information in a manner that customers attribute value to value based on their needs and interests.	C&I, Industrial customers (estimate 5,824 customer engagements)	Not calculated	Not calculated	Targeted face-to-face interactions with stakeholders including owners, property and facility managers, consultants,	Seminars, workshops, on-site visits, professional associations, and major event keynote addresses delivered by THESL	4 years
Community Outreach and Education	There is no provision for community or school events, police or business improvement area (BIA) partnerships or festive light exchanges in Tier One programs. Tier One residential programs do not consider targeting, outreach or education to hard-to-reach communities or priority neighbourhoods. Limited in-store retail events are covered in the OPA marketing plan, specifically the OPA's Appliance Exchange (an air conditioner and dehumidifier exchange program) available during different dates/times at provincial retailers selected by OPA .	Community, school and local partner events are an important element in Toronto as we need to reach broad and diverse communities. Experience has shown that direct engagement with customers, using a wide range of retailers and community locations, allows us to target high-traffic areas as well as diverse and hard to reach neighbourhoods. While an in-store retail component (Exchange Events) does exist in OPA tier one program, it does not provide: - an incentive applicable to the mass market or an over arching educational component. Exchange Events are specific to window air conditioners/de-humidifiers - the opportunity to reach out to youth and underprivileged communities (i.e. those without cars) as the events are retailer based - the opportunity to tie-in another incentive to drive participation and attendance - the opportunity to select retail partners and consistent event dates/times as the OPA works directly with the retailers and allows them to pick the events and dates. THESL's retail experience indicates consistent dates and times are critical to	Residential customers, including diverse ethnic groups, youth, and those in priority and vulnerable neighbourhoods	Not calculated	Not calculated	Integrated marketing approach including events, advertising, direct marketing, public relations	Working with community partners in Toronto, leveraging existing events, relationships and outreach channels. RFP for third party vendors.	4 years
Greening Greater Toronto Commercial Building Initiative	Not covered in OPA marketing plans.	This program presents a forum where tenants and property managers can interact outside of the normal contractual leasing level of communication, which is otherwise inadequate to foster a dialogue on energy efficiency. This program provides normalized benchmarking tools for participants to gauge their relative energy efficiency and promote achievement of energy efficiency goals.	Large office building commercial tenants and property managers	Not calculated	Not calculated	Owner/tenant working groups, showcase events hosted on site, benchmarking	Sponsorship of Greening Greater Toronto (part of Greater Toronto CivicAction Alliance) to deliver program	1 year

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

INTERROGATORY 5:

Reference(s): none provided

At section 4.1.3 of the CDM Code it states that a distributor shall use the OPA's Measures and Assumptions List to conduct the cost effectiveness tests.

a) Please provide a table, broken down by program, which shows all of the measures that will be used for all Board-Approved CDM Programs. In a column next to each measure, please show the input assumption used for calculating cost effectiveness and indicate the source (i.e. OPA Measures and Assumptions list, specific engineering report, etc.) used for each input assumption.

b) Please discuss if THESL has conducted participation sensitivity analysis for each of its nine Board-Approved CDM programs. Please provide the analysis.

c) Please provide a table that lists each Board-Approved CDM program and shows both the expected participation level and the lowest participation level necessary for each program to remain cost effective.

RESPONSE:

a) Please see table provided in Appendix A to this Schedule.

b) Sensitivity analyses, where provided, are included in the reports in Section 8 of each Application. Please refer to the table provided in Appendix B to this Schedule.

c) Please refer to response in (a) which includes the minimum participant rates required to maintain a TRC and PAC greater than 1.0.

Question 5 OEB Staff (a) and (c)

Program Name	Measures	Input Assumption Description	Input Assumptions	Source	Expected Participation Level	Minimum Participation Level
CEMLC	EMS/Load Control	Free Ridership	10%	OPA (value for Peaksaver with IHD)	5.0%	1.1%
		Unit Incremental Cost	$7,989	Based on weighted average cost of system		
		Operating Life (years)	13	OPA Measures and Assumptions List for Peaksaver		
		Number of Participants	1164	Market penetration per sector		
		Unit Demand Response Capacity (kW)	6.4	Engineering estimate		
		Unit Annual Energy Savings (kWh)	5515	Engineering estimate		
		Program Cost	$11,170,401	Budget sheet		
		Financial Incentives	$515,376	Budget sheet		
M and T	Monitorring and Tracking	Free Ridership	30%	OEB reccomended value for custom programs	4.3%	1.7%
		Unit Incremental Cost - C&I	$42,113	Based on weighted average cost of system		
		Unit Incremental Cost - Industrial	$43,215	Based on weighted average cost of system		
		Operating Life (years)	8	Engineering estimate		
		Number of Participants	107	Market penetration per sector		
		Unit Peak Demand Savings - C&I (kW)	11.19	Engineering estimate		
		Unit Peak Consumption Savings - Industrial (kW)	14.39	Engineering estimate		
		Unit Annual Energy Savings - C&I (kWh)	258075	Engineering estimate		
		Unit Annual Energy Savings - Industrial (kWh)	297411	Engineering estimate		
		Program Cost	$1,787,935	Budget sheet		
		Financial Incentives	$3,713,475	Budget sheet		
FRWH	DHW Conversion to Metered Service/Load Control	Free Ridership - Water Heater Conversion	30%	OEB reccomended value for custom programs	80.0%	14.0%
		Free Ridership - Load Control	10%	OPA (value for Peaksaver with IHD)		
		Unit Incremental Cost	$250	Typical replacement cost - internal		
		Operating Life (years)	13	OPA Measures and Assumptions List for Peaksaver		
		Number of Participants	4431	Market penetration per sector		
		Unit Peak Demand Savings (kW)	0.096	Engineering estimate		
		Unit Peak Demand Response Capacity (kWh)	0.375	Engineering estimate		
		Unit Annual Energy Savings	973	Engineering estimate		
		Program Cost	$1,839,985	Budget sheet		
		Financial Incentives	$839,503	Budget sheet		
HSBP	Variable Frequency Drives/Multistage Pumps	Free Ridership	30%	OEB reccomended value for custom programs	25%/50%/30% (Audits/hydronic/booster)	25%/11%/6%
		Unit Incremental Cost	$41,877	Based on weighted average cost of system		
		Operating Life (years)	10	Engineering estimate (not on OPA M and A list)		
		Number of Participants (audits)	496	Market penetration per sector		
		Unit Peak Demand Savings (kW)	6.5	Engineering estimate		
		Unit Annual Energy Savings (kWh)	143296	Engineering estimate		
		Program Cost	$1,220,434	Budget sheet		
		Financial Incentives	$3,499,734	Budget sheet		
MURB DR	Programmable Thermostat/Load Control	Free Ridership	10%	OPA (value for Peaksaver with IHD)	11.0%	8.0%
		Unit Incremental Cost	$49,890	Based on weighted average cost of system		
		Operating Life (years)	10	OPA Measures and Assumptions List for Peaksaver derated for application type.		
		Number of Participants	218	Market penetration per sector		
		Unit Peak Demand Response Capacity (kW)	59.55	Engineering estimate		
		Unit Annual Energy Savings (kWh)	1263	Engineering estimate		
		Program Cost	$13,586,304	Budget sheet		
		Financial Incentives	$6,328,386	Budget sheet		

Part B

CEMLC				
Location	**Variable Changed**	**Variable Value**	**TRC**	**PAC**
Application Section 8	Base Case		1.5	1.3
VECC Interogatory 5	TRC & PAC Evaluation	TRC & PAC at a measure level	NA	NA

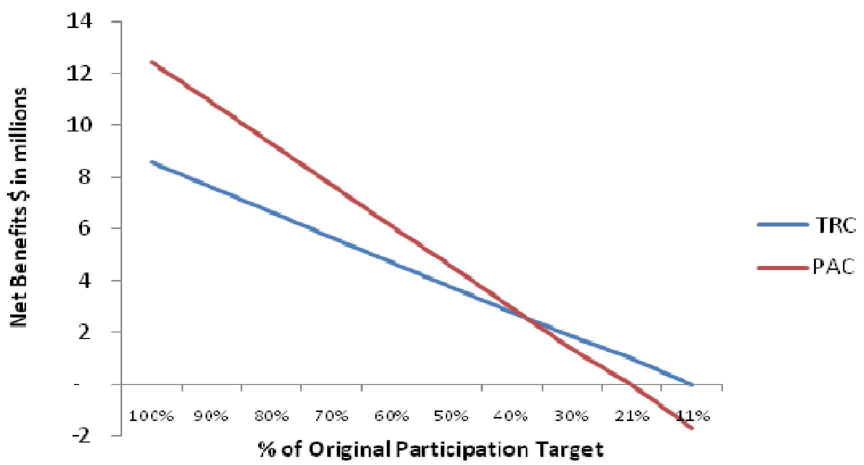
M and T				
Location	**Variable Changed**	**Variable Value**	**TRC**	**PAC**
Application Section 8	Base Case		1.6	1.8
OEB Staff Interrogatory 72	Htg./Clg/Booster Pump Implementation Rate	Htg./Clg. 30-50%, Booster Pump 20-30%	See graphs A & B	See graphs A & B
OEB Staff Interrogatory 69	Minimum Participation Rate	15%	1.1	1.0
	Minimum Free Ridership Rate	85%	1.1	1.0
VECC Interogatory 5	TRC & PAC Evaluation	TRC & PAC at a measure level	NA	NA

FRWH				
Location	**Variable Changed**	**Variable Value**	**TRC**	**PAC**
Application Section 8	Base Case		1.9	1.7
OEB Staff Interrogatory 52	lower participation rates of 80% (70%, 60%, 50%, etc.).	Participation 30-70%	See table 1 & 2	See table 1 & 2
LIEN Interogatory C-4	Coverage of tank conversion	100% conversion cost	1.9	1.6
LIEN Interogatory C-5a	Supply of low flow devices	Supply of low flow devices-installed	2.7	2.5
LIEN Interogatory C-5b	Supply of low flow devices	Supply of low flow devices-not installed	1.9	1.7
LIEN Interogatory C-5c	Coverage of tank conversion & Supply of low flow devices	Coverage of tank conversion & Supply of low flow devices-installed	2.7	2.2
VECC Interogatory 5	TRC & PAC Evaluation	TRC & PAC at a measure level	NA	NA

HSBP				
Location	**Variable Changed**	**Variable Value**	**TRC**	**PAC**
Application Section 8	Base Case		2.2	4.7
OEB Staff Interrogatory 72	Htg./Clg/Booster Pump Implementation Rate	Htg./Clg. 30-50%, Booster Pump 20-30%	See graphs A & B	See graphs A & B
OEB Staff Interrogatory 69	Minimum Participation Rate	15%	1.1	1.0
	Minimum Free Ridership Rate	85%	1.1	1.0
VECC Interogatory 5	TRC & PAC Evaluation	TRC & PAC at a measure level	NA	NA

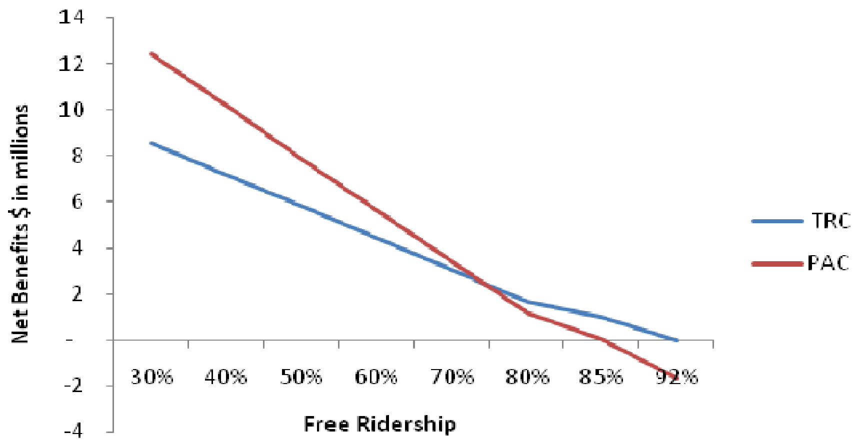
MURB DR				
Location	**Variable Changed**	**Variable Value**	**TRC**	**PAC**
Application Section 8	Base Case		1.3	1.0
VECC Interogatory 5	TRC & PAC Evaluation	TRC & PAC at a measure level	NA	NA

Graph A: M&T and Hydronic System Balancing Program-Variable Participation Rate



As indicated in the above graph, when participation level is higher than 21% of the original target in the Application, the program will be cost effective for both TRC and PAC; when it is lower than 11%, the net benefits will be negative for both TRC and PAC; if participation level is between 11% and 21%, it will pass the TRC test but fail the PAC test.

Graph B: M&T and Hydronic System Balancing Program-Variable Free ridership Rate



As indicated in the above chart, when free ridership is lower than 85%, the program will still be cost effective for both TRC and PAC; when it is higher 92%, the net benefits will be negative for both TRC and PAC; if free ridership is between 85% and 92%, it will pass the TRC test but fail the PAC test.

Flat Rate Water Heater: Variable Participation and Different Incemtive Levels

Board Staff #52 Incentive level at 20 cents/kwh

Participation Rate	Net TRC Benefits		Net PAC Benefits	
80%	$	1,945,228	$	1,797,943
70%	$	1,653,356	$	1,524,482
60%	$	1,361,484	$	1,251,020
50%	$	1,069,613	$	977,559
40%	$	777,741	$	704,098
30%	$	485,869	$	430,637
20%	$	193,997	$	157,176
10%	-$	97,875	-$	116,285

Board Staff #52 Incentive level at 10 cents/kwh

Participation Rate	Net TRC Benefits		Net PAC Benefits	
80%	$	1,945,228	$	2,178,516
70%	$	1,653,356	$	1,857,484
60%	$	1,361,484	$	1,536,451
50%	$	1,069,613	$	1,215,418
40%	$	777,741	$	894,385
30%	$	485,869	$	573,352
20%	$	193,997	$	252,319
10%	-$	97,875	-$	68,714

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

INTERROGATORY 6:

Reference(s): **Program 1-9, Appendix A**
Program 1, Section 5.1, page 11

THESL has noted that the OPA's draft EM&V template has been used to help complete the evaluation plans as shown in each programs' Appendix, but that the final evaluation plan will be prepared by the independent evaluator.

a) Please confirm that what is found in the Appendix for each program constitutes THESL evaluation plans for that particular program.
b) Please discuss when will THESL have its independent evaluator hired?
c) Please confirm that an independent third party will conduct the evaluation of each program and that THESL staff will not be performing this function.
d) Please discuss THESL's plan for how each one of its programs will be evaluated. Within your response, please discuss if each program has its own independent evaluator or will the same evaluator be used for all Board-Approved CDM Programs?
e) Please confirm that THESL has used the OPA's EM&V protocols as a guide when developing its draft evaluation plans. Within your response, please discuss THESL's concerns surrounding net-to-gross ratios for each program, the variability of various participant related input assumptions (e.g. free ridership rate, spill over rate, rebound rate, participation rate, etc.) and the risks associated to each program.
f) Please provide all sensitivity analysis conducted by THESL when evaluating its potential Board-Approved CDM Programs.
g) Please discuss if THESL has developed a program logic model. If one has been developed, please provide.

RESPONSES TO INTERROGATORIES OF ONTARIO ENERGY BOARD STAFF

RESPONSE:

a) The information contained in the Appendices entitled “Program Evaluation Plan” contains the “Draft Evaluation Template” issued by the OPA as part of the EM&V protocol. THESL has, however, commissioned a “Draft Evaluation Plan” for all of the programs in these Applications, and expects to have it distributed to all parties sometime prior to the hearing date.

b) THESL will retain independent evaluator(s) following confirmation of program funding from the OEB.

c) Confirmed.

d) EM&V services will be procured through THESL’s procurement process, which could result in one or several firms providing the services depending on experience, qualifications, and cost effectiveness.

e) THESL has used the latest OPA EM&V protocol that was available at the time of program submission.

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Net to Gross Ratio (Free Ridership)

Program	Net to Gross Ratio
CEMLC	10%[1]
Monitoring and Targeting	30%[2]
Flat Rate Water Heaters	30%[2] Water Heater 10%[2] Peaksaver
Hydronic System Balancing Program	30%[2]
MURB Demand Response	10%[2]

Notes:

1. Assumption for residential demand response programs (OPA uses 96% in the latest business cases)
2. OEB Decision and Order in EB-2007-0096 proceeding on custom programs.

The net-gross ratios used were, as noted above. The 10% free ridership rate was used for the programs, or measures, that are similar to Peaksaver demand response. This value is consistent with the OPA net to gross ratios used in the business cases for the contemplated Peaksaver program.

Similarly, the 30% rate used for the other programs is thought to be conservative given the utilization of the proposed measures noted in the reports.

Participation Rate

As noted in Section 2.2 of the programs, the participation rates were developed based on experience, studies on program impact from other jurisdictions, and the extrapolation of adoption rates from multi-program assessments. Customer value

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proposition and investment criteria / appetite was also taken into consideration. For all programs the participation rates are though to be conservative.

Spill Over and Rebound Rate

There is insufficient information to include the impact of participants completing additional energy conservation measures (spill over) or the impact of energy use increases (rebound rate). This information would be known after the project has been in operation and program evaluations have been completed.

These impacts are accounted for by using conservative estimates of participation rates and free-ridership rates.

f) Where completed, the sensitivity analyses conducted during the program development are included in Section 8 of each report.

g) Program logic models will be provided as part of the Draft Evaluation Plan.

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INTERROGATORY 7:

Reference(s): none provided

THESL has provided program budgets for each of its nine proposed Board-Approved Programs, but has not directly indicated the staffing plan it has for each program.

a) Please discuss THESL's human resources plan relating to all of its CDM programs from 2011-2014, inclusive of OPA and Board-Approved CDM Program activities. Within your response, discuss the number of staff THESL plans to employ to manage its CDM activities and if THESL plans on, or has already hired new staff.

b) If THESL does plan on hiring new staff to manage its suite of Board-Approved CDM Programs, provide a table, broken down by year, which shows how many new, incremental staff will be employed by THESL to help implement its Board-Approved CDM Programs.

c) Please indicate whether or not the new staff hired will be contract or full-time staff and the associated staffing budget for these people.

RESPONSE:

a) The Human Resource (HR) plan includes the use of existing CDM staff as well as hiring new "incremental" contract staff to support the delivery of Board-Approved programs over the implementation period. The current level of staff is a mix of full-time permanent staff and contract staff. As of March 2011 there are 20 full-time employees and ten contract employees assigned to the implementation of new OPA-Contracted programs. The current mix of full-time staff compared to total staff is 67%; contract staff account for the remaining 33%. Contract staff will be the main source of employee growth over the next four years and will peak between 50% and

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55%. The following table outlines THESL's human resource plan for both the OPA-Contracted and Board-Approved CDM programs:

Human Resource Plan - Summary (Average number of employees)

Name	CDM Status	2011 Average	2012 Average	2013 Average	2014 Average	2015 Average
OPA Programs	Full Time	22.0	23.5	23.5	23.0	6.5
	Contract	16.5	21.0	21.0	20.6	0.0
	Total	38.5	44.5	44.5	43.6	6.5
OEB Programs	Full Time	0.0	0.0	0.0	0.0	0.0
	Contract	2.9	9.5	8.8	4.8	1.0
	Total	2.9	9.5	8.8	4.8	1.0
Total For All Programs	Full Time	22.0	23.5	23.5	23.0	6.5
	Contract	19.4	30.5	29.8	25.4	1.0
	Total	41.4	54.0	53.3	48.4	7.5

Programs	2011	2012	2013	2014	2015	Total
OPA Program Labour Cost	$ 4,950,000	$ 5,625,000	$ 5,625,000	$ 5,512,500	$ 975,000	$ 22,687,500
OEB Program Labour Cost	$ 293,750	$ 950,000	$ 875,000	$ 477,500	$ 100,000	$ 2,696,250
Total Labour Cost	**$ 5,243,750**	**$ 6,575,000**	**$ 6,500,000**	**$ 5,990,000**	**$ 1,075,000**	**$ 25,383,750**

Program labour costs are based on fully burdened labour rates.

A breakdown by functional group is provided in the following tables:

Resource Plan for OPA Program by Functional Group

Sales Group (OPA Program)		2011	2012	2013	2014
CDM Status	CDM Role	Average	Average	Average	Average
Full Time	*Management*	1.0	1.0	1.0	1.0
Full Time	*Industrial Sales*	1.0	1.0	1.0	0.9
Full Time	*Commercial Sales*	1.0	1.0	1.0	0.9
Full Time	*Multi-Residential Sales*	1.0	1.0	1.0	0.9
Full Time	*Inside Sales Coordinator*	1.0	1.0	1.0	1.0
Full Time	*Low Income Single Family Homes*	0.8	1.0	1.0	1.0
Full Time	*Commercial Sales*	0.8	1.0	1.0	1.0
Full Time	*Customer Service*	0.5	1.0	1.0	0.9
Contract	*Ally Network Sales*	1.5	2.0	2.0	1.6
Contract	*Technical Sales Support*	3.0	5.0	5.0	5.0
Total Sales		**11.5**	**15.0**	**15.0**	**14.1**

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Technical Services (OPA Program)		2011	2012	2013	2014	2015
CDM Status	CDM Role	Average	Average	Average	Average	Average
Full Time	*Management*	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**
Contract (4 year)	*Technical Support - Industrial*	**1.00**	**1.00**	**1.00**	**1.00**	**0.00**
Full Time	*Technical Support - Commercial*	**1.00**	**1.00**	**1.00**	**1.00**	**0.75**
Full Time	*M and V Specialist*	**1.00**	**1.00**	**1.00**	**1.00**	**0.25**
Full Time	*Program Lead/Special Projects*	1.0	1.0	1.0	1.0	0.8
Full Time	*Technical Support - Industrial*	1.0	1.0	1.0	1.0	0.8
Full Time	*Admin Support*	1.0	1.0	1.0	1.0	0.0
Full Time	*Residential DR/Tech Support*	1.0	1.0	1.0	1.0	0.0
Contract	*Database Migration*	0.3	1.0	1.0	1.0	0.0
Contract	*M and V Specialist*	0.8	1.0	1.0	1.0	0.0
Contract	*Program Support*	1.0	1.0	1.0	1.0	0.0
Contract	*Program Support*	1.0	1.0	1.0	1.0	0.0
Contract	*Program Support*	1.0	1.0	1.0	1.0	0.0
Contract	*Program Support*	1.0	1.0	1.0	1.0	0.0
Contract	*Residential DR Coordinator*	0.8	1.0	1.0	1.0	0.0
Contract	*Demand Response Tech Lead*	0.5	1.0	1.0	1.0	0.0
Contract	*Demand Response Tech Lead*	0.5	1.0	1.0	1.0	0.0
Total Technical Services		**14.3**	**16.0**	**16.0**	**16.0**	**3.5**

Marketing Group (OPA Program)		2011	2012	2013	2014	2015
CDM Status	CDM Role	Average	Average	Average	Average	Average
Full Time	*Management (50%)*	0.5	0.5	0.5	0.5	0.0
Contract (4 year)	*All Markets (100%)*	1.0	1.0	1.0	1.0	0.0
Full Time	*Administration*	1.0	1.0	1.0	1.0	0.0
Full Time	*Residential Market (100%)*	0.5	1.0	1.0	1.0	0.0
Full Time	*Commercial/Industrial (100%)*	1.0	1.0	1.0	1.0	0.0
Full Time	*Commercial/Industrial (50%)*	0.5	0.5	0.5	0.5	0.0
Contract	*All Markets (50%)*	0.5	0.5	0.5	0.5	0.0
Contract	*All Markets (50%)*	0.5	0.5	0.5	0.5	0.0
Full Time	*Commercial/Industrial (50%)*	0.5	0.5	0.5	0.5	0.0
Full Time	*All Markets (100%)*	1.0	1.0	1.0	1.0	0.0
Contract (4 year)	*Residential Market (100%)*	1.0	1.0	1.0	1.0	0.0
Total Marketing		**8.0**	**8.5**	**8.5**	**8.5**	**0.0**

Regulatory & Settlement (OPA Program)		2011	2012	2013	2014	2015
CDM Status	CDM Role	Average	Average	Average	Average	Average
Full Time	*Management*	1.0	1.0	1.0	1.0	1.0
Full Time	*Reg. & Settlement*	1.0	1.0	1.0	1.0	1.0
Full Time	*Reg. & Settlement*	1.0	1.0	1.0	1.0	1.0
Contract (4 year)	*Reg. & Settlement*	1.0	1.0	1.0	1.0	0.0
Contract (4 year)	*Reg. & Settlement*	0.8	1.0	1.0	1.0	0.0
Total Regulatory & Settlement		**4.8**	**5.0**	**5.0**	**5.0**	**3.0**

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Resource Plan: Board-Approved Programs

Avergae Number of Employees		2011	2012	2013	2014	2015
Name	**CDM Role**	**Average**	**Average**	**Average**	**Average**	**Average**
Program Manager - CEMLC	Program Lead	0.3	1.0	1.0	0.5	0.0
Program Manager - MURB DR	Program Lead	0.3	1.0	1.0	0.8	0.0
Program Manager - M and T	Program Lead	0.1	0.5	0.5	0.3	0.0
Program Manager - HSBP	Program Lead	0.5	1.0	0.8	0.5	0.0
Program Manager - FRWH	Program Lead	0.1	1.0	0.5	0.0	0.0
M and V Analyst	Support for OEB Programs	0.0	1.0	1.0	1.0	0.5
Key Account Managers	Support for OEB Programs	1.0	2.0	2.0	0.5	0.0
Marketing Consultant	OEB Programs	0.5	1.0	1.0	0.3	0.0
Regulatory & Settlement	Support for OEB Programs	0.3	1.0	1.0	1.0	0.5
OEB Program Total		**2.9**	**9.5**	**8.8**	**4.8**	**1.0**

Technical Services
Sales Group
Marketing Group
Regulatory & Settlements

b) and c) THESL plans to hire new incremental contract staff to implement its suite of Board-Approved CDM Programs as outlined in the above table. A budget of $2.7 million has been included in the plan to provide for a total of 27 person years for the period starting in 2011 and ending in 2015. The staff and administrative work planned for 2015 is required to complete EM&V, final settlements with the IESO and reporting to the OEB. A budget estimate of $100,000 has been provided in 2015.

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INTERROGATORY 8:

Reference(s): none provided

THESL has applied for nine Board-Approved CDM Programs to help supplement the projected savings it anticipates it will achieve through OPA-Contracted CDM Programs. Board staff is interested in knowing the process that was undertaken by THESL to determine which programs it would apply for approval from the Board.

a) Has THESL contracted any vendors to conduct market analysis of its service area to determine which programs would be the most beneficial and cost effective in meeting its CDM Targets? If yes, please provide the deliverable the vendor provided to THESL.

b) Please discuss the process that THESL undertook when selecting which programs it would apply to the Board for approval of. List all the programs, their cost effectiveness results, projected budgets, projected energy and peak demand savings and the projected participation levels that THESL investigated when preparing this application.

RESPONSE:

a) THESL did not retain external consultants to conduct market analysis studies as the internal THESL CDM team has extensive knowledge of the customer base and has been very active in the CDM process for the past six years. The market analysis was conducted to determine the size and contribution of each sector to the peak demand and consumption. This information was then used as a factor in screening where additional programs may significantly impact demand and consumption and address gaps in the province-wide programs.

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b) A number of different ideas for programs were developed to address THESL's unique aspects. They were then screened to eliminate programs that duplicate province-wide programs, could easily be added to the province wide programs, were not feasible technically, or were too small to be effective.

The programs considered are listed below:

Program Name	**Program Status**	**Notes**
Commercial/ Industrial CDM		
Deep-Lake Water Cooling	Rejected	Not available in 2011-2014 timeframe
Roof-top AC Efficiency Improvement	Deferred	Vendor to apply to OPA for inclusion in Prescriptive list
Small Scale Ice-Storage	Potential Future Application	Potential application in Q3 2011
Data Center Incentive Program	Deferred	Include in Tier 1 programs.
Vending Machines Energy Management	Pilot Program Approved	Under consideration
Hydronic System Balancing	Current Application	
CEMLC	Current Application	
Flat Rate Water Heaters	Current Application	
Monitoring & Targeting	Current Application	
Water Conservation for electric savings	Rejected	Savings link hard to establish and verify

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Program Name	Program Status	Notes
Residential CDM		
Efficiency Upgrade for Central Air-Conditioners	Deferred	Vendor to apply to OPA for inclusion in Prescriptive list
Geo-thermal Cooling/Heating	Rejected	Potential savings too small to justify application cost
Solar Water Heating	Rejected	Not viable without NRCan incentives
MURB Submetering	Rejected	Savings link hard to establish and verify.
Social Benchmarking, M&T	Potential Future Application	Potential application in Q3 2011

The information on participant rates, cost effectiveness, and budget were not determined for these programs.

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INTERROGATORY 9:

Reference(s): **none provided**

In the Executive Summary for each program, THESL states that it has identified a gap with the OPA's Province-Wide CDM programs and / or it has identified an opportunity for increased conservation within its jurisdiction.

a) In regards to allocation of funding between OPA Province-Wide CDM programs and Board-Approved CDM programs, is cost effectiveness for efficiency a factor? If so, please explain how it was a factor for each proposed program. If cost effectiveness for efficiency is not a factor, why not?

RESPONSE:

a) Cost effectiveness for efficiency is a factor for all CDM programs and it was considered in the program administration cost estimates for human resources as well as the procurement for third party services. The CDM human resource plan assumed common resource sharing for all programs within each functional level wherever possible and only incremental resources for the Board-Approved program applications were included in the budget estimates. Incremental resources were determined from the expected back office and front office work volume, program complexities and the need for program-specific technical consulting skills to market/deliver the program, perform project M&V and conduct program evaluations.

THESL's procurement policies will be applied to ensure competitive pricing for third-party services.

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INTERROGATORY 10:

Reference(s): **Addendum to THESL's Board-Approved Program application, filed Feb. 25, 2011**

In THESL's letter to the Board dated February 25, 2011, it requested that the Board approve an additional $343,449 which related to costs of program development and planning for the years 2010 and 2011.

a) Please discuss why THESL thinks it is appropriate for the Board to approve 2010 costs in this proceeding. What relation do these costs have to THESL's application for Board-Approved CDM Programs?

b) Please discuss why the costs requested in THESL's addendum were not included in its original program application.

c) Please discuss the appropriateness of collecting $100,000 to be used for intervenor funds.

d) Please discuss why these program-related costs weren't included in the budgets for each program.

RESPONSE:

a) The 2010 planning and development costs were necessary for the development of the programs contained in THESL Applications. The details of the costs, and the reasons for them, are extensively outlined in the February 25, 2011 Addendum.

b) The Addendum was not included together with the original application because final audited costs for 2010 were not available at the time of filing.

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c) The $100,000 component is meant to recover the expected intervenor cost claims in this proceeding. As THESL is not permitted to fund its CDM activities through distribution rates (see CDM Code, section 5.4). THESL submits that intervenor cost claims in this proceeding should not be recovered from THESL ratepayers through THESL's distribution rates.

d) Program related planning costs were not included in the budgets for each program because the CDM Code does not provide for 2010 planning costs to be embedded within program budgets.

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INTERROGATORY 11:

Reference(s): **Program #1 – Business Outreach and Education**
Program 1, Program 4, Program 6, Program 8

THESL has proposed four educational programs within its application for Board-Approved CDM Programs. It appears to Board staff that these four educational programs broadly target all of the customer types within THESL's service area. THESL has requested a total of approximately $11.83M in educational program funding.

a) Please comment on THESL's position of how educational elements should be built into a suite of CDM programs. Within your response, discuss if THESL investigated building the educational elements found within Programs 1, 4, 6 and 8 directly into programs found in this application that would be delivered to similar customer types.
b) Please discuss the similarities of the educational programs THESL has proposed within this application. Within your response, please discuss the specific need for each individual educational program.
c) Please discuss if THESL conducted any calculations of increased budgets for its non-educational Board-Approved CDM Programs that were inclusive of the program budgets for the education programs referenced above.
d) In a table, please provide revised program budgets for Programs 2, 3, 5, 7 and 9 that include a proportional amount of the educational program that they most closely relate to. For example, Program 1 and 6 appear to be tailored towards the CI&I customer type (Programs 2, 3 and 7) and Programs 4 and 8 appear to be tailored for residential customers (Programs 5 and 9). In the same table, please provide the updated cost effectiveness tests results for Programs 2, 3, 5, 7 and 9.

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RESPONSE:

a) THESL's position is that the educational elements of CDM should be mutually supportive such that Commercial & Institutional and Industrial program communication becomes cross-promotional. Although specific educational elements may be focused on one program, ideally these should not happen in isolation of the broader CDM thrust. This maximizes and reinforces the impact of messaging to the audience regarding the benefit of the entire spectrum of CDM programs.

Yes, THESL considered the opportunity to leverage educational elements identified under Programs 1 and 6, and 4 and 8 into other proposed programs under this application. However, the educational programs proposed under this application are intended to augment the underlying OPA-sponsored province-wide core programming.

b) The business educational programs are similar to the extent that the underlying CDM program elements (eligibility, incentives, application forms and process) are common irrespective of the target group. However, each proposed individual business educational program has a distinct focus and delivery mechanism. Subsequently, the educational programs are as unique as the customers or stakeholders they are designed to reach.

As discussed under the program rationale for Program 1, Section 1.1, the stakeholders serving the business building industry are numerous and varied. This program is designed to reach out to as many different groups as possible within their respective spaces and business habitats. This is face-to-face interaction, which goes beyond simple marketing media.

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As discussed under the program rationale for Program 6, Section 1.1, the GGT is focused on engaging large commercial office tenants in dialogue with building managers through building specific events and forums.

The consumer educational programs are complementary given they both focus on the consumer in a personal and very interactive manner by taking the CDM message to the streets.

As discussed under the program rationale for Program 4, Section 1.3, the intent of this program is to reach out to the non-business community, including schools and hard to reach communities, and within Toronto retail environments.

c) THESL included costs for the educational requirements of the non-educational Board-Approved CDM Programs within the budget of each respective program.

d) Programs 1, 4, 6 and 8 reference educational efforts to support OPA-sponsored province-wide programs only.

Programs 2, 3, 5, 7 and 9 are stand-alone proposals such that any costs attributable to educational requirements have been built into those specific program costs.

In the event that that Programs 2, 3, 5, 7 and 9 are accepted by the OEB, these would be bundled into the delivery of education programs where appropriate. Incremental education costs budgeted within these programs would fund the additional effort involved. As a result, program delivery costs would not change and so the cost effectiveness test results for these programs remain unaltered.

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INTERROGATORY 12:

Reference(s): **Program #1 – Business Outreach and Education, Page 3, Executive Summary**

THESL notes that it is seeking approval from the Board to expend $1.65M to deliver the program between the period of January 1, 2011 and December 31, 2011. Later THESL notes that the program will operate between 2011 and 2014.

a) Please confirm the period of time in which this program will be offered.

RESPONSE:

a) THESL is requesting funding for a 12-month period commencing 30 days after OEB approval of this application.

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INTERROGATORY 13:

Reference(s): **Program #1 – Business Outreach and Education, Page 4, Section 1.1: Program Rationale**

THESL notes that past experience indicates that THESL will need to engage and educate business audiences directly and interactively as a follow-up to the message conveyed through conventional marketing forms.

a) Has THESL, or a third party contracted by THESL, conducted any studies of its market to investigate any barriers that are apparent to engaging consumers in CDM? If so, please provide the studies and/or reports.

RESPONSE:

a) THESL did not contract any third party to conduct market studies to investigate barriers to customer engagement as THESL respectfully submits that this was unnecessary. Notes and comments appearing in THESL's submission are based on THESL staffs' significant collective experience and technical expertise in this arena. Please refer to the response to CEEA Interrogatory 1 for a summary of THESL's experience in the design and delivery of CDM programs.

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INTERROGATORY 14:

Reference(s): **Program #1 – Business Outreach and Education, Page 6, Section 1.3: Program Details**

THESL discusses its hopes for visiting key stakeholders at their workplace (or other designated locations) to offer on-site seminars.

a) Has THESL identified and targeted the businesses and specific participants it plans on delivering its on-site seminars and workshops to?

b) Will THESL require enrolment in one of its commercial programs prior to engaging in an on-site visit?

c) What was the process involved for deciding the best participants for this program?

d) Who will deliver this educational program? Please discuss the involvement of THESL staff.

e) Will THESL offer product giveaways at the educational events?

RESPONSE:

a) THESL has not targeted specific participants for the proposed on-site seminars. To date, THESL has only identified the general category and or market segments of participants that THESL submits bear the greatest opportunity.

b) No, THESL would simply require that participating organizations agree to a minimum number of attendees beforehand. Attendance records indicating participant name and position would be kept.

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c) THESL's intent is not to be exclusionary. On the contrary, the list presented is designed to be as inclusive as possible. The list leverages THESL's experience and familiarity with the Toronto marketplace and its many stakeholder groups by identifying the widest possible array of parties that can influence the decision to positively influence energy efficient project decisions.

d) Educational programs will be delivered by THESL staff hired directly for the task or on labour contract. In addition, THESL may contract out the services, where necessary through a competitive bidding process to deliver these programs on its behalf and direction.

e) No, THESL will not offer product giveaways at educational events.

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INTERROGATORY 15:

Reference(s): Program #1 – Business Outreach and Education, Page 8, Section 2.2: Projected Number of Participants

THESL provides a table with the projected number of participants it expects to be involved with this program

a) Please explain how these participant and engaged pedestrian figures were developed.
b) Please list all of the annual scheduled engagements THESL plans to be present at.
c) Please discuss the percentage of total attendees that THESL plans will enrol in one of its commercial programs and the logic behind those projections.

RESPONSE:

a) Participant and pedestrian engagement estimates were based on THESL's years of qualitative collective sales and marketing experience with customers at similar events in the CDM arena operating within the Toronto marketplace. Quantitatively, the figures are based on the following budget developing guidelines:
    - On-site seminars – average of eight participants per event
    - Association memberships
        - average of six engagements per high value membership
        - average of four engagements per high value membership
        - average of two engagements per high value membership
    - Key event educational sponsorship
        - average of 200 impacts per high cost event
        - average of 30 impacts per medium cost event
        - average of 20 impacts per low cost event

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- Show booth outreach – average of 200 engagements per event

b) THESL has not confirmed a schedule of events. Without limiting the generality of the following, or necessarily committing to it, the list below shows the current list of affiliates that THESL believes would provide opportunity for educational outreach efforts to their respective organizations or memberships.

Segment	Organization
Academic	Association of Universities and Colleges of Canada (AUCC)
Academic	Centre for Urban Energy (CUE), Ryerson University
Academic	Ontario Association of School Business Officials (OASBO)
Academic	Ontario Colleges Facility Managers Association (OCFMA)
Academic	Ontario Association of Career Colleges
Academic	Ontario College Administrative Staff Association (OCASA)
Commercial	Building Owners and Managers (BOMA)
Commercial	Greening Greater Toronto (GGT) / Toronto Summit Alliance
Commercial	International Facility Management Association (IFMA)
Commercial	Toronto Board of Trade
Commercial	Retail Council of Canada (RCC)
Community	Toronto Association of Business Communicators (TABIA)
Community	Partners in Project Green
Community	Conservation Council of Ontario
Community	World Wildlife Fund
Community	Toronto Environmental Alliance
Community	Faith & the Common Good / Greening Sacred Spaces Program / Toronto Chapter
Community	Livegreen Toronto
Consulting	ASHRAE Toronto Chapter

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Segment	Organization
Contractors	Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI)
Contractors	National Association of Electrical Distributors (NAED)
Healthcare	Canadian Healthcare Engineering Society (CHES)
Healthcare	Centre for Environmental Sustainability in Healthcare (CHES)
Healthcare	Ontario Hospital Association (OHA)
Healthcare	Ontario Long Term Care Associatoin (OLTCA)
Healthcare	Toronto and Region Conservation Authority – Greening Healthcare
Hospitality	Ontario Restaurant Hotel & Motel Association (ORHMA)
Hospitality	Greater Toronto Hotel Association (GTHA)
Hospitality	Hotel Engineers of Toronto (HEAT)
Industrial	Canadian Manufacturers & Exporters (CME)
Multi-Residential	Canadian Condominium Institute (CCI)
Multi-Residential	Association of Canadian Managers of Ontario (ACMO)
Multi-Residential	Greater Toronto Apartment Association (GTAA)
Municipal	Enterprise Toronto / City of Toronto Economic Development & Culture Office
Trade/ Industry	Illuminating engineers Society (IES)
Trade/ Industry	Ontario Energy Network (OEN)
Trade/ Industry	Electrical Distributors Association (EDA)
Trade/ Industry	Ontario Electrical League (OEL)
Trade/ Industry	Canadian Green Building Council (CaGBC)
Trade/ Industry	Canadian Marketing Association (CMA)
Trade/ Industry	Continental Automated Buildings Association (CABA)
Trade/ Industry	International Brotherhood of Electrical Workers (IBEW)
Trade/ Industry	Ontario Association of Physical Plant Administrators (OAPPA)

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c) Recognizing that education events sponsored under this application have not been scheduled, participant attendance projections are based on THESL experience at similar events using general event size and anticipated traffic volumes. In particular:

- On-site seminars – average of eight participants per event representing most eligible participants at a stakeholder organization
- Association memberships
    - average of six engagements per high value membership event
    - average of four engagements per high value membership event
    - average of two engagements per high value membership event
- Key event educational sponsorship
    - average of 200 impacts per high cost event based on four sessions
    - average of 30 impacts per medium cost event based on one session
    - average of 20 impacts per low cost event based on one session
- Show booth outreach – based on two days at 100 engagements per day

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INTERROGATORY 16:

Reference(s): **Program #1 – Business Outreach and Education, Page 8, Section 3: Projected MW and MWh Savings**

THESL notes that projected savings are not applicable.

a) Please explain why THESL feels it is appropriate to expend $1.65M solely on an educational program that won't realize any measurable MWh or MW savings.

RESPONSE:

a) Savings have not been claimed under these education programs because they would be impractical to measure and verify retroactively within a defined timeframe. Nonetheless, this makes resulting projects no less real and educational programs no less enabling. THESL submits that future enrolment applications will be submitted by educated participants. Based on THESL's experience when processing enrolment applications and speaking with participants, training is effective and projects will eventually materialize.

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INTERROGATORY 17:

Reference(s): Program #1 – Business Outreach and Education, Page 9, Section 4.2: Collaboration with other LDCs

THESL notes that it will work with neighbouring LDCs to coordinate the timing and location of similar events to ensure these are complementary in location and occurrence.

a) Has THESL engaged in discussions with any other LDCs about possibly organizing joint events? If joint events are undertaken, how will costs be shared?

b) Will THESL provide its events schedule to neighbouring LDCs so that events are timed and located in a complementary nature?

c) Will THESL have program information for its full suite of CDM programs, including OPA and Board-Approved programs, available at all of its educational events for participants to possibly enrol on-site?

RESPONSE:

a) THESL has not engaged in discussions with other LDCs as yet to discuss the coordination of educational events. Consequently, cost sharing discussions have not occurred. However, THESL would anticipate splitting costs evenly in such cases, or alternatively, LDCs could simply extend invitations to neighbouring customers to attend each other’s sessions.

b) Yes, THESL would propose sharing event and location information with neighbouring LDCs to avoid concentrating sessions and to favour as wide dissemination and coverage as possible.

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c) Refer to response to Board Staff Interrogatory 11(a).

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INTERROGATORY 18:

Reference(s): **Program #1 – Business Outreach and Education, Page 12, Section 6: Program Budget**

THESL has provided its program budget with a total of $1.65M requested.

a) Please discuss why THESL has a requirement for annual legal costs for this program.
b) Please discuss why there is a drop in legal costs in 2014.
c) Please discuss the increased EM&V costs in 2014.
d) Please expand on what comprises the Variable Operation Cost and discuss why this amount decreases in 2014.
e) How has THESL addressed staffing within this budget?

RESPONSE:

a) THESL Legal Counsel reviews all contracts and agreements related to CDM activities. Costs listed refer to THESL legal review costs under contracting for services related to marketing, sponsorships, venues, labour, etc.

b) The drop in legal costs reflects the drop in anticipated business outreach activities and the subsequent reduced need for services related to marketing, sponsorships, venues, labour, etc. in the later half 2014 as the CDM program begins to wind down.

c) The increase cost in EM&V reflects the assumption that the intensity of activity and subsequent costs will be higher in the final program wrap-up report provided by the third-party auditor.

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d) Variable cost is comprised of labour, event sponsorship and registration, association membership, dedicated marketing material, travel, and customer hospitality (food) for "Lunch & Learns". Also refer to response to Board Staff Interrogatory 18(b).

e) THESL has estimated the total Full Time Equivalent (FTE) labour requirement based on the sales, marketing, program management, and program administration requirements. Depending on the overall slate of programs ultimately approved by the Board, THESL will evaluate the mix of resourcing between additional incremental staff or sub-contracted labour.

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INTERROGATORY 19:

Reference(s): **Program #1 – Business Outreach and Education, Page 12, Section 7: Cost Benefit Analysis**

THESL references section 4.1.2 of the CDM Code and notes that it is allowed to forego the cost effectiveness tests when submitting a CDM Program designed for educational purposes.

a) Has THESL conducted any in-house TRC or PAC tests for this program? If yes, please provide the results. If not, please run the tests and provide the results.

RESPONSE:

a) No, this is not a requirement of section 4.1.2 of the CDM Code. In addition, THESL is unable calculate a practical TRC or PAC test for its educational programs since there are no defined savings associated with these proposed education programs. Effectively, non-zero savings are required to compute a meaningful TRC or PAC test value.

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INTERROGATORY 20:

Reference(s): **Program #1 – Business Outreach and Education, Page 14, Appendix A – Program Evaluation Plan**

THESL has provided an evaluation plan.

a) Please confirm that Appendix A is the finalized draft evaluation plan.

b) Please discuss how THESL plans to evaluate the perceived value of time invested, the perceived effectiveness of the training delivery and program administration organization and the perceived importance of information received.

c) Please discuss when the final evaluation plan will be prepared and by whom.

d) Please expand on the evaluation description to offer more insight into the specific evaluation that will be conducted on this program.

RESPONSE:

a) See response to Board Staff Interrogatory 6 (a).

b) THESL plans to conduct post event surveys to solicit feedback directly from participants in order to quantify these results.

c) See response to Board Staff Interrogatory 6 (b).

d) See response to Board Staff Interrogatory 6 (a).

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INTERROGATORY 21:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 5, Section 1.3: Program Details**

THESL notes that the vendor will also maintain the customer interface, provide maintenance services and training. THESL also notes that a key success factor for this program is the selection and implementation of a viable system capable of both demand response and energy management.

a) Please expand on the role THESL staff will play in this program. Will THESL staff only be responsible for enrolling participants and the management of the vendor THESL secures to deliver the program?

b) What is the timeline THESL has built for having a vendor selected to provide the energy management system THESL requires?

c) When will the energy management system be finalized and ready for deployment?

RESPONSE:

a) THESL staff will be responsible for all aspects of program management and customer enrolment. Marketing and sales will be done jointly. The vendor will be responsible for the installation and maintenance of the new systems. This is outlined in the submission Section 1.3.4 pages 6 and 7 of the CEMLC Program Application.

b) There are a number of vendors that can provide systems that meet the capabilities described in the program. The timeline to procure a vendor or vendors would be 12 to 16 weeks.

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c) As noted in (b) above, the capabilities are currently available, but must be selected through an RFP process.

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INTERROGATORY 22:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 6, Section 1.3.4: Program Scope**

THESL notes within the discussion on program scope that it will issue an RFP possibly in conjunction with those utilities that wish to participate in the CEMLC program.

a) What utilities has THESL engaged in discussions with about this program?

b) What utilities have shown an interest in offering this program to their customers?

RESPONSE:

a) This program has been discussed with the Coalition of Large Distributors and a discussion regarding program commonality has also taken place with Hydro One.

b) Hydro One is the only utility that has expressed interest in this program. Once approved, it is possible that other utilities will deploy the program.

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INTERROGATORY 23:

Reference(s): Program #2 – Commercial Energy Management and Load Control, Page 7, Section 1.4: Value Proposition

THESL notes, amongst other things, that an EMS will be provided at no cost and that this will enable participants to monitor and control their energy consumption.

a) What are the eligibility requirements potential participants need to meet in order to qualify for the program and all of its benefits?

RESPONSE:

a) The Participant Qualifications are noted in Section 5.2 of the Application and are extracted below for reference:

> To be eligible for this program a participant must meet the following criteria:
>
> - Be located in THESL service territory and must be an active account holder with an average monthly peak electricity demand less than 200kW.
> - Agree to provide access to electricity billing information for the duration of the program.
> - Have a functional roof-mounted cooling system(s) with at least 5 tons of cooling capacity per unit.
> - Be contractually committed to remain in the program until no earlier than December 31st, 2014. This condition is intended to support the persistence of demand response savings. Customers

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with an existing EMS may be enrolled in the program subject to technical review by THESL.

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INTERROGATORY 24:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 9, Section 2.2: Market Penetration**

THESL provides a table within its discussion on market penetration that shows the various members of the sector it wishes to enrol in the program.

a) Is THESL aware of any other utilities or jurisdictions that offer a similar program to the one proposed here which targets the same segment of the market that THESL has identified as best suited for this offering?

b) Has THESL conducted any market analysis of this sector to confirm the penetration rates listed in the table referenced above are reasonable?

RESPONSE:

a) THESL's research has not found a similar program that combines load control and web-based control in these market segments.

b) THESL conducted market analysis of the sectors involved to determine information on customer numbers, market size and overall demand/consumption contribution. This information was then used to extrapolate potential savings for each sector.

   The penetration rates, as noted in Section 2.2 of the Application, were estimated from the participation rates of direct install programs and the Peaksaver program modified for the proposed program design elements.

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INTERROGATORY 25:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 11, Section 3.2: Achievable Electricity Demand and Consumption Savings Potential**

THESL provides its expected demand and energy consumption savings based upon its expected market penetration in a table. THESL also notes that the values were determined using the U.S. Department of Energy setback calculator.

a) Please provide all of the variables that went into the calculation of expected savings. Within your response, please provide the statistical and program logic that supports the expected market penetration and savings.
b) Please discuss the potential concerns THESL has with the variability of its input assumptions that were built into the calculations of these expected savings.
c) Please provide the details of the U.S. Dept. of Energy setback calculator.

RESPONSE:

a) The variables are shown in Appendix A to this Schedule. The market penetration rates are explained in Section 5.2 of the Application.

b) The values used throughout the analysis are conservative and the costing is largely variable; therefore, the cost effectiveness results for the program are expected to be robust.

c) The setback calculator was developed by the US Department of Energy to estimate the impact of using unoccupied temperature settings. It is available at:

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www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorProgrammableThermostat.xls - 2010-02-25

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Appendix A: Variables Used in CEMLC Savings Calculation

CEMLC Program

Savings and Market Penetration Assumptions

Item	Number	Notes
Potential market	21350	Total number
Potential market Load	964	MW
Total Usage	3920	GWh
Demand Savings per Roof Top Unit	1.4	kW (based on a 5 ton unit)
Typical Savings / RTU	605.0	kWh
Number of Partipants	1164	
Penetration %	5%	
Total Consumtpion Savings	6419	MWh, for the market penetration
Saving / site	5.5	MWh
Average Cost	$1,500	per PCT

Market Analysis and Sector Penetration

Sector	Sites QTY	Total MW	Total GWh	RTU Load (MW)	RTU Consumption (GWh)	Penetration	Potential MW	Potential GWH	RTU kW Ave/Site	No. of Advanced Stats	No of Sites	KWH Savings	No Of DR Units	m3 Savings
Offices	1,305	112.7	536.2	46	67	20%	2.6	1.5	35	7	261	1,474,545	1827	242,593
Retail	1,390	115.2	548.8	52	137	20%	2.7	3.0	38	7	278	3,020,343	1946	258,394
Hospitality	729	54.7	267.4	18	56	5%	0.2	0.3	24	4	36	308,557	146	19,360
Inst.	1,124	90.3	350.0	19	75	5%	0.2	0.4	17	3	56	410,141	169	22,387
Other	1,410	98.8	442.0	29	64	5%	0.4	0.4	21	4	71	353,359	282	37,445
kWh Metered <50kw	15,392	492.7	1775.4	145	258	3%	1.3	0.9	9	2	462	851,612	924	122,627
Total	**21,350**	**964.4**	**3,920**	**309**	**657**	**5%**	**7.4**	**6.4**			**1,164**	**6,418,557**	**5293**	**702,805**

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INTERROGATORY 26:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 11, Section 3.3: Savings Summary**

THESL provides a table that shows the projected net demand and consumption savings it expects to see from 2011-2014.

a) Please discuss in detail how the participant numbers were developed and discuss and potential variability's within these assumptions.

RESPONSE:

a) The participant numbers were determined based on the estimated market penetration in each market sector as shown in Section 2.2 of the Application. The overall penetration rate for the program target market is quite small so it is not anticipated that variability within any of the sectors will have a large impact on overall program cost effectiveness.

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INTERROGATORY 27:

Reference(s): Program #2 – Commercial Energy Management and Load Control, Page 13, Section 4.2: Marketing Objectives

THESL notes the key program drivers and lists four messages it hopes to convey to customer in order to drive participation.

a) Please expand on how THESL believes the CEMLC will aid TOU customers in power shifting to better manage their electricity bills.

RESPONSE:

a) TOU customers (currently less than 50kW) will have the ability to schedule and control set points. This is something they currently may not be able to do, so it is expected that a percentage of the program participants will use this capability to lower their on-peak electricity consumption.

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INTERROGATORY 28:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 15, Section 5.3: Incentives**

THESL provides a brief summary on how participants will receive incentives as well as provides an example of the structure of how the incentives will be paid out based on participant type.

a) Please confirm that a participant can expect to have a maximum of 5 load control event activations per year.

b) Is there a minimum number of load control events that a participant agrees to allow?

RESPONSE:

a) The five load control events ("LCEs") are the basis of payment for the incentives related to activations. The current rules would allow up to 40 hours of activation during the period of May 1 to September 30. There are also provisions for emergency and test activations, but historically the number of activations is as shown below.

Year	Number of LCEs
2010	7 LCE 1 Test
2009	4 LCE 1 Test
2008	5 LCE 1 Test

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b) There is no minimum requirement for participation. The participants will be required to participate in all LCEs.

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INTERROGATORY 29:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 17, Section 6.1: Operational Program Evaluation Plan**

THESL describes its operational plan and notes that the data provided from the centralized web software will provide a comparison between the normalized baseline consumption versus the actual consumption throughout the load control event. THESL goes on to state that the feedback received will be used to determine if the program has to be modified to meet the target savings.

a) Does THESL have a modification contingency plan in place now?

b) If the answer to a) is no, what is the expected timeframe for preparing modified plans to address any differences between baseline and actual results?

RESPONSE:

a) The statement refers to the requirement to continuously monitor the performance of the program. In most programs the aggregate demand reduction is not determined until well after the measures have been installed. In the CEMLC program results will be seen soon after activations; therefore the need to adopt more aggressive demand control strategies can be readily determined.

b) Demand response strategies will be monitored and updated throughout the program as the need arises.

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INTERROGATORY 30:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 19, Section 7: Program Budget**

THESL provides its program budget in a table on page 19 with a total requested amount of $11.69M shown.

a) Please discuss what comprises the following items:
   i) Fixed Costs – Sales
   ii) Variable Costs – Vendor Cost
b) Please explain why THESL projects the total incentive costs to increase each year of the program.

RESPONSE:

a)
   i) Sales costs are for the allocation of a portion of key account manager time.

Year	Percent Allocation
2011	20%
2012	10%
2013	10%
2014	7%

   ii) The vendor cost includes the supply, installation and maintenance of the systems for the estimated number of participants. The fee also includes annual operational costs for communication, web subscriptions and activation fees.

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b) The incentives will increase each year as the number of program participants receiving load control incentives increases. For example, the participant base that will receive load control event incentives in 2013 is the number of enrollments in that year of the program plus the 2011 and 2012 participants.

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INTERROGATORY 31:

Reference(s): **Program #2 – Commercial Energy Management and Load Control, Page 20, Section 9: Non-Duplication of OPA-Contracted Provincial Programs**

THESL discusses how its proposed program does not duplicate that of an OPA Province-Wide program. Within its discussion it cites the limited participation levels in the OPA's small commercial initiative over the last three years as well as the fact that THESL's proposed program covers the monthly fee required to allow the customers to have access to the full use of the EMS that is installed on their premises.

a) Please confirm that THESL's main point for non-duplication is the fact that there have been limited enrolment figures from past OPA programs. Discuss how this makes the programs distinctly different.

b) Has THESL discussed this proposed program with the OPA?

c) Although this program is not targeted at residential customers, discuss how by simply offering a program incentive at no cost, in this case the EMS, makes two very similar programs distinctly different.

RESPONSE:

a) The CEMLC program applies to commercial and institutional customers with a demand less than 200kW. Of this market segment, the existing Peaksaver program only applies to customers less than 50kW; THESL has experienced limited penetration as the program was designed for the residential single-family market.

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The future Peaksaver program expected to be launched in July 2011 does not include program elements to serve the small commercial market.

For facilities with demands between 50 and 200 kW there is no equivalent province wide program.

b) This program has been discussed with the OPA. See response to Board Staff Interrogatory 4.

c) To achieve useful results in the identified market sectors, there has to be a reason, other than energy efficiency, for the business owner to adopt the program as their focus is customers and tenants. Part of the benefit to the business owner is providing the EMS system, which will afford the owner the opportunity of controlling energy costs; this did not exist before. This is a significant benefit, which is provided to the owners in exchange for the ability to control their loads during periods when there are supply issues. As these are business entities, the incentives need to be ongoing and promote the importance of savings.

This is considerably different from the Peaksaver program, which provides a load control switch that has no feedback, no monitoring capability, and has no benefit to the participant other than the initial incentive.

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INTERROGATORY 32:

Reference(s): Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 4, Executive Summary

THESL provides a brief description of the program and discusses its potential savings and program features.

a) Prior to filing this application with the Board, did THESL engage in discussions with Hydro One Networks Inc. to discuss this program as it has many similarities to HONI's Monitoring and Targeting Initiative?

b) If THESL did not, please discuss why and if it plans on possibly working jointly with HONI, if each program is approved, to deliver the programs in the most cost effective manner.

RESPONSE:

a) Yes, THESL engaged in conversations with Hydro One Networks to align its program offering.

b) THESL plans to work with Hydro One Networks, and any other utilities that intend to deploy a similar program, so that cost efficiency of program deployment and delivery can be optimized.

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INTERROGATORY 33:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 8, Section 1.3: Program Scope**

THESL notes the various tasks involved in the pre-applications stage, amongst them is selecting the monitoring and tracking software and analyzing data to establish practical conservation targets.

a) Please discuss the various options of software that is available. Will this be something that THESL has designed specifically for its needs in this program?
b) What data, and from what period of time, will THESL be analyzing when establishing the conservation targets within this program?
c) Is the establishment of practical conservation targets something that is done by both THESL and the prospective participant?
d) Are there penalties the participant will witness for not meeting its agreed to targets?

RESPONSE:

a) There are a number of "off the shelf" software solutions that can be customized and modified to meet the needs of the proposed program.

b) THESL will analyze the most recent available data when formulating the baseline as applicable to development conservation targets. Typically, this will comprise of a minimum 12-month actual or composite period.

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c) Proposal of conservation targets would be the responsibility of the participant (in conjunction with their chosen energy consultant), although THESL would be in a position to approve the application and savings estimates.

d) There are no penalties associated with missing the minimum target. However, the participant will not collect any incentives for that year.

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INTERROGATORY 34:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 10, Section 1.3: Program Scope**

THESL notes that as building operators will have the ability to investigate and recognize sub-optimal performance and because they know their own operating requirements, abnormal or unexpected energy loading will quickly be flagged for follow-up and possible corrective actions.

a) Please explain if it will be the responsibility of the building operator to flag and follow-up abnormal and unexpected energy loading issues or will THESL also be involved in this process?

RESPONSE:

a) Yes, it will be the responsibility of the building operator to follow-up on these issues and provide explanations in their reporting to THESL. Operators will make use of the monitoring and targeting software installed under this program to accomplish this.

In general, reduced energy consumption is a key performance metric for most building operators, therefore building operations staff will be motivated to act in order to save energy and lower operating costs. Additionally, a Targeting incentive will be payable upon achievement of savings targets.

THESL will be reviewing the initial results as well as annual energy reports and therefore expects to spot any abnormalities in the course of its reviews.

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INTERROGATORY 35:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 11, Section 1.4: Conformance with OPA Measures**

THESL notes that although the M&T operational technique does not appear on the OPA Measures and Assumptions List, this conservation measure is consistent, but not duplicative, with the approach used by the OPA Industrial Accelerator Program.

a) Please list the differences between THESL's M&T program and the OPA's Industrial Accelerator Program.

RESPONSE:

a) The primary differences between THESL's M&T program and the OPA's Industrial Accelerator Program are summarized as follows:

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Aspect	THESL's M&T program	OPA's Industrial Accelerator Program
Eligibility	• Minimum three-year old building • Peak Demand Exceeding 200kW • Less than 15GWh annual consumption	• Energy Manager required • Greater than 15GWh annual consumption

Incentives	• Monitoring Incentive:
	  • $0.20/kWh savings
	  • Cap of 50% project cost up to $75,000
	• Target Incentive:
	  • $0.025/kWh savings per year when savings >8%
		• One-time funding cap of 80% project cost up to $75,000

Application & Requirements	• Multi-stage: Engagement, Pre-Application, Application, Implementation Post-Implementation, and Anniversary • Description of proposed M&T system required • Commit until Dec. 31, 2014 • Requires evidence of senior management commitment to change in standard operating procedures	• Commit to projects with less than one-year simple payback • Commit to savings within 24-month period of installation • Commit to minimum energy and 200 kW demand savings
Reporting	• Automated (normalized) savings reporting is a requirement of software • Annual reporting until end of term	• Provide reporting for a period of five years managed by Energy Manager

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INTERROGATORY 36:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 11, Section 2.1: Sector Analysis**

THESL notes that the general mindset of the building operations and operator group has been particularly difficult to engage with regard to M&T and that the general mindset of this group is to maintain the status quo rather than proactively seeking to improve efficiencies.

a) THESL references a study by Marilyn A. Brown from 1996 to supports its claim that the general mindset is to maintain the status quo. Please discuss the validity of this study for 2011.

b) Has THESL conducted or reviewed any studies that offer a more recent insight into the mindset of this group?

RESPONSE:

a) The economic parameters which govern decision making have not changed considerably in the last two decades. If anything, THESL is aware that the ongoing pressure to reduce operational staffing costs in buildings has lowered their operational capacity, capabilities and standards.

b) THESL has not conducted any additional studies. However, based on its experience in the marketplace, THESL would submit that this position is widely held. Additional studies that further support the premise of this program are as follows:

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- *Elevating the Role of the Multifamily Building Operator: How Operators Can Save Energy, Minimize Waste, and Improve the Bottom Line*, James Barry, Nick Prigo, and Robert Muldoon, Local 32BJ Thomas Shortman Training Fund 2010 ACEE
- Rocky Mountain Institute – *Energy Efficiency Research in Corporate Real Estate-Charrette Meeting Report, August 1, 2006*
- *EPRI and McKinsey Reports on Energy Efficiency: A Comparison*, 2008
- Lawrence Berkeley National Laboratory – *High Performance Healthcare Buildings: A Roadmap to Improved Energy Efficiency,* October 2009

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INTERROGATORY 37:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 14, Section 2.2: Market Penetration**

THESL notes that when establishing the projections they have relied upon the experience from other jurisdictions with programs similar in scope.

a) What jurisdictions has THESL investigated? Please list and discuss the similarity in programs.

RESPONSE:

a) The literature referenced by THESL includes results from California, the U.S. Department of Energy, Natural Resources Canada, and the United Kingdom. THESL also notes that related programs are offered by other Canadian electrical utilities including BC Hydro (Continuous Optimization) and Manitoba Hydro (Commercial Building Optimization Program). While programs may vary in details, as a base premise, all programs share the concept of operational improvements achieved through investigation, optimization of operations, corrective action, and ongoing monitoring.

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INTERROGATORY 38:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 15, Section 3: Projected MW and MWh Savings**

THESL provided a table summarizing the net total energy and peak demand with a total of 0.86 MW and 40,723 MWh savings realized in 2014.

a) Please confirm that the MW savings shown will persist from one year to the next.
b) Please discuss why THESL found it appropriate to use a free-ridership rate of 30% when calculating projected net savings?
c) Did THESL rely on any studies or market surveys to determine what the appropriate free-ridership rate for this program should be?

RESPONSE:

a) The program design offers some assurances that savings will persist well beyond the formal end of the program in 2014. First, the program aims to permanently alter building operating characteristics through building operator tools, training and behaviour modification. Second, the program requires that a building's standard operating procedure modifications be signed off by a senior building manager for a minimum of 5 years. As a result, the new, lower energy performance will become the performance benchmark moving forward. It is unlikely that operating standards will degrade especially since this would reflect poorly on building management and result in higher energy costs.

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b) The free ridership rate was chosen to be consistent with the OEB's direction for custom programs. The 2009 OPA Evaluation Report indicates a free ridership of 37% and 34% across the Equipment Replacement Incentive Initiative (ERII) and BOMA CDM (ERII), respectively. A less demanding, yet still conservative, rate of 30% was selected for this program because THESL is of the opinion that this energy saving measure is unexploited in the marketplace and would not otherwise occur.

c) THESL found no other research outside of the OPA results to support a different free ridership and therefore assumed a 30% rate based on the reasoning presented above.

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INTERROGATORY 39:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 18, Section 5: Program Rules**

THESL notes that the program rules have been vetted against the Board's CDM Code.

a) Please provide the program rules.

RESPONSE:

a) The program rules as designed are contained under Section 5 of the proposed program Application, inclusive of Sections 5.1 (Eligibility), 5.2 (Incentives), and 5.3 (Activation Rules & Requirements). The particular CDM Code sections against which the program rules are vetted is noted in "Appendix C – CDM Code Requirements" of the application on page 31.

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INTERROGATORY 40:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 18, Section 5.2.1: Monitoring Incentive**

THESL discusses the mechanics of the implementation incentive and notes that it will be calculated as the lesser of either $0.20/kWh multiplied by the customer's annual estimated savings in kWh; 50% of the projected cost, or up to $75,000.

a) Please provide the dollar amount that THESL projects as the average implementation incentive awarded to a participant.

b) How does a participant qualify for the maximum incentive of $75,000?

c) Please discuss THESL's strategy to deal with higher and/or lower participant numbers regarding incentives? If THESL finds that program participation is much higher than expected, how will THESL address the need for increased incentive dollars? Conversely, what will THESL do with remaining incentive dollars if participation is lower than its projection?

RESPONSE:

a) THESL projects that that the average implementation incentive awarded to a participant will be approximately $21,100.

b) Assuming that a participant's application is otherwise in order, to qualify for an implementation incentive of $75,000, the application would need to demonstrate an implementation cost of $150,000 and minimum projected energy savings of 375,000

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kWh per year. These savings would need to represent at least 8% of the normalized baseline.

c) In the event that forecast participation is higher than expected and cost effectiveness tests remain favourable, THESL would re-apply to the OEB for additional funds to continue the program. In the event that forecast participation is lower than expected, the unspent funds would be returned.

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INTERROGATORY 41:

Reference(s): Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 19, Section 5.2.2: Targeting Incentive

THESL notes that in order to encourage a sustained level of effort during the term of the program, building operators and management customers will also be eligible for an energy savings incentive at a rate of $0.025 for each kWh saved as defined by the baseline.

a) How was the baseline determined?
b) Will individual customers be involved in setting site specific baselines? If so, how will this be done? If not, what process will THESL employ?

RESPONSE:

a) See response to Board Staff Interrogatory 33(a). To be appropriate, the baseline should be representative of normal building operation.

b) The baseline will be proposed by the participant or the energy consultant acting on their behalf and submitted during the post-implementation project phase and approved by THESL.

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INTERROGATORY 42:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 23, Section 6: Program Evaluation**

THESL notes that its savings report will provide savings results in conformance with IPMVP standards and/or OPA EM&V protocols.

a) Please discuss the reasonableness for using the IPMVP standards?
b) Please confirm that THESL will conduct its EM&V in accordance with the CDM Directive and CDM Code which directs LDCs to use the OPA's EM&V Protocols.

RESPONSE:

a) The International Performance Measurement and Verification Protocol (IPMVP) is the *de facto* standard for calculating energy savings at the project level and is an important component of the overall program evaluation. The OPA EM&V protocols are also based on this standard.

b) Confirmed.

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INTERROGATORY 43:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 24, Section 7: Program Budget**

THESL provides the projected program budget for the Monitoring and Targeting Program with a total requested amount of $5.5M.

a) Please expand on what comprises the Fixed Costs – Sales line item.

RESPONSE:

a) The Fixed Cost – Sales line item included in the budget for this program accounts for the incremental sales effort across various sales individuals required to promote this new program across the marketplace. In this case, promotion broadly includes:

- education and training as it pertains to
    - explaining the application process (eligibility, incentives, requirements, and various program stages)
    - signoff of standard operating procedures
    - long term operational benefits
    - different incentive levels
    - distinctiveness of this new program relative to the existing array of OPA-sponsored CDM programs;
- assisting in the completion of customer applications;
- maintaining contact with customer through the study and project delivery stages to assure continued eligibility within the program; and

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- ongoing contact with customers leading to preparation of anniversary savings reporting and review of performance relative to savings targets.

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INTERROGATORY 44:

Reference(s): **Program #4 – Community Outreach & Education, Page 5-6, Section 1.3: Program Details**

THESL provides a program description and notes the various parts of the program that make up the complete offering such as in-store retail campaign, festive light exchange, Toronto Police outreach and school education and outreach.

a) Please discuss the specific differences between this program and the OPA's province-wide educational program. Has THESL investigated addressing the program details found within this application through the OPA's program?

b) Please discuss the specific differences between this program and the more specific "In-Store Engagement and Education Initiative" (Program #8). In a table, compare and contrast both programs highlighting similarities and differences.

RESPONSE:

a) OPA Tier 1 programs do not include a school outreach program, a police (porchlight) outreach and education program, or a festive light exchange. OPA does have an in-store program, but its limitations are outlined below. There is opportunity for greater and broader education and unique, compelling, and targeted incentives (porchlights, festive lights) to support outreach activities throughout the THESL service territory. This program (in-store engagement, festive light exchange, Toronto Police partnership, and in-school education and outreach) is distinct and will allow THESL to reach the diverse population that its service area is comprised of. THESL programs directly engage with customers through a wider range of Toronto-centric retailers and community locations, targeting high-traffic areas (based on historical

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program data) as well as diverse and hard to reach neighbourhoods such as the identified 13 low-income neighbourhoods. The OPA Low Income Program has yet to be finalized. THESL is unable to address any potential duplication at this time.

OPA programs are focused on summer peak demand savings. These THESL programs offer annual energy savings as they provide education and tools to help customers conserve year round. The *Green Energy and Green Economy Act, 2009* does target both peak and energy reductions.As the only LDC with almost all customers on Time-Of-Use rates, THESL also has a responsibility to educate and assist customers in managing these rates and by linking them to these programs, THESL can help. OPA programs do not consider nor address TOU rates.

While an in-store retail component (Exchange Events) does exist under the OPA Tier 1 residential programs, it does not:

- Provide an incentive for any customer that drives them to events, rather it is specific to those with window air conditioners and/or dehumidifiers
- Provide for other incentive/product giveaway to drive engagement and participation
- Reach certain customer segments including youth and those unable to visit retailers
- Allow for LDC input on local retailer selection. The OPA procured retail partners directly and allowed retailers to select their event dates and times. With different event dates and times and retailer control of programs, it becomes onerous and confusing for THESL to communicate to customers. THESL's retail experience indicates consist dates and times are critical to

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consumer comprehension and satisfaction with such a program, it also makes for more cost effective marketing costs when promoting simple, consistent event dates and times

- Allow retail partners to simply participate in these events. OPA required retailers to participate in more than just Exchange Events, limiting potential retail partner pool.

b) THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 45:

Reference(s): **Program #4 – Community Outreach & Education, Page 9, Section 3: Projected MW and MWh Savings**

THESL notes that the projected savings are not applicable.

a) Please explain why THESL does not project any savings for this program.

b) Please discuss if THESL will be distributing any energy efficient products.

RESPONSE:

a) This program is designed for education; products such as CFL bulbs for the Police initiative and LED strings for the Festive Light Exchange are generally used during off peak times with no associated MW peak savings. However, there are annual energy savings from these programs. Retail give-aways historically have had peak savings. THESL desires to entice behavioural change by featuring new, energy-efficient products that customers have not tried, and which may not yet be included on the OPA measures list.

b) THESL will distribute energy-efficient products including CFL bulbs and LED light strings.

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INTERROGATORY 46:

Reference(s): Program #4 – Community Outreach & Education, Page 10, Section 4.1.2: Primary Target Market

THESL notes that its primary target market is residential customers in the City of Toronto especially new immigrants, English as a second language, visible minorities, and vulnerable Torontonians.

a) Please discuss the specific manner in which THESL plans to engage with the groups referenced above.

b) What specific events does THESL have planned?

c) Discuss who will be responsible for facilitating the local events. Within your response, please address whether this will be implemented by THESL staff or an external third party.

RESPONSE:

a) Onsite THESL representatives will communicate in a number of Toronto's top ten languages. Community partners will be engaged including TABIA/BIA, Toronto Police, United Way, City of Toronto, and local retailers. Youth will be engaged through School and Academic programs and programs will be run across the City including priority neighbourhoods.

b) Light the Night events will be arranged in Spring/Summer once TPS/TAVIS identify areas in need. Festive Light Exchanges take place prior to Christmas. The number of events is dependant on the budget and Business Improvement Area requests; retail events will also take place at local retailers.

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c) Certain local events will be facilitated with community partners, specifically Toronto Police and Toronto Association of Business Improvement Areas and THESL Staff. For the retail events, where dozens of events take place during the same timeframe, a third party vendor will be procured, overseen and with participation from THESL staff.

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INTERROGATORY 47:

Reference(s): Program #4 – Community Outreach & Education, Page 13, Section 7: Program Budget

THESL provides a table showing the overall budget for this program with a total of $5.66M requested. Within the marketing budget line, THESL notes that this includes staff.

a) Please discuss how many new staff will be hired to implement this program. Within your response, discuss the nature of these staff members (e.g. contract, full-time, etc.).
b) Please discuss what makes up the Fixed Cost – External Cost budget line.
c) Please discuss what makes up the incentive/premiums budget line. If this includes product giveaways, please discuss how many and what products THESL will be providing at these events.

RESPONSE:

a) Please refer to the response to Board Staff Interrogatory 7. A contract marketing consultant will be hired and shared across all Board-Approved programs. The approximate share based on the average employee count per year and total equivalent average over the four-year period is listed in the table below:

	2011	2012	2013	2014	Total
Average # of Contract Employees	0.3	0.6	0.7	0.4	2.0

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b) Fixed Costs – The External Costs budget line refers to third-party program and/or event management. External Costs covers third-party vendors including program and event management.

c) The details of the incentives budget line are as follows:

- The incentive budget is $490,000 each year for four years. Incentives include CFLs, festive light strings, and a unique energy-efficient premium product to be selected and procured each year, for example an LED light bulb. THESL anticipates giving out 65,000 products each year.

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INTERROGATORY 48:

Reference(s): **Program #4 – Community Outreach & Education, Page 13, Section 8: Cost Benefit Analysis**

THESL references section 4.1.2 of the CDM Code and notes that it is allowed to forego the cost effectiveness tests when submitting a CDM Program designed for educational purposes.

a) Has THESL conducted any in-house TRC or PAC tests for this program? If yes, please provide the results. If not, please run the tests and provide the results.

RESPONSE:

a) See response to Board Staff Interrogatory 19.

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INTERROGATORY 49:

Reference(s): **Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 6, Section 1.2: Program Objectives**

THESL mentions that flat rate water heater conversions are anticipated to be completed by the end of December 31, 2012 provided approval is received by the end of March 2011.

a) With approval not apparent until sometime in May 2011 at the very earliest, please provide an updated schedule for when THESL plans to have its projected conversions completed by.

RESPONSE:

a) The program will require 24 months to complete commencing 60 days after a Board approval date.

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INTERROGATORY 50:

Reference(s): **Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 6, Section 1.3: Program Details**

THESL notes that an element of this program is that each participant will receive an incentive of $0.20/kWh of the estimated electricity savings. THESL further notes that the rationale for providing an incentive higher than the OPA's province-wide programs is to make the conversion an attractive proposition and to encourage the desired behavioural changes.

a) Please list all of the differences and similarities between the proposed FRWHDR program and the OPA's province-wide programs noted above.

RESPONSE:

a) There is no equivalent OPA province-wide program. The reference noted above is to the incentive rate only; it is only stated as a reference that the rate in this program is higher than the rate of $0.10 per kWh used in many OPA programs.

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INTERROGATORY 51:

Reference(s): **Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 7, Section 1.4: Value Proposition**

THESL notes that the value proposition for the customer is they will reduce electricity used for generating domestic hot water by 20.5% on average.

a) Please discuss how THESL can make this statement as it appears as though the level of savings each customer witnesses will entirely depend on that customer's usage patterns.

b) Please comment on if it is more appropriate to say that customers will now be charged in accordance to how much they use.

RESPONSE:

a) Yes, the interpretation is correct. The electricity usage to generate hot water for each customer will depend on the amount of hot water they use. Similarly, with most consumer programs, the basis for savings assumptions is to use averages that represent the customer group. It would not be cost effective to install metering on each tank and provide incentives based on their individual usage.

b) Yes, that is the basis of the program.

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INTERROGATORY 52:

Reference(s): Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 8, Section 2.2: Market Penetration

THESL notes that the expected incentives will encourage 80% of the remaining 5,561 tanks to convert.

a) Please discuss if THESL tested other incentive levels to see if this would drive participation rates higher. If THESL did do this analysis, please provide the details.

b) Please discuss the sensitivity of program cost effectiveness in relation to both lower and higher incentive levels and lower participation rates of 80% (e.g. 70%, 60%, 50%, etc.).

c) Please provide further support on why THESL believes an expectation of 80% conversion rate is appropriate.

RESPONSE:

a) During the process of program design, two levels of incentives were considered: one consistent with the province wide programs at $0.10 per kWh and the other at $0.20 per kWh. Since the incentives at $0.10 per kWh would represent less than half the typical conversion cost, it is not expected that this will be a sufficient driver to prompt owners to convert to a metered service.

b) The impact of differing participation levels and incentives is shown below:

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Table 1: Incentive at 20 cents/kWh as in the application

Participation Rate	Net TRC Benefits	Net PAC Benefits
80%	$ 1,945,228	$ 1,797,943
70%	$ 1,653,356	$ 1,524,482
60%	$ 1,361,484	$ 1,251,020
50%	$ 1,069,613	$ 977,559
40%	$ 777,741	$ 704,098
30%	$ 485,869	$ 430,637
20%	$ 193,997	$ 157,176
10%	-$ 97,875	-$ 116,285

Table 2: Incentive at 10 cents/kWh

Participation Rate	Net TRC Benefits	Net PAC Benefits
80%	$ 1,945,228	$ 2,178,516
70%	$ 1,653,356	$ 1,857,484
60%	$ 1,361,484	$ 1,536,451
50%	$ 1,069,613	$ 1,215,418
40%	$ 777,741	$ 894,385
30%	$ 485,869	$ 573,352
20%	$ 193,997	$ 252,319
10%	-$ 97,875	-$ 68,714

c) THESL believes that an 80% conversion rate is achievable based on its experience in dealing with this customer class. The track record of converting flat rate water heaters to a metered service, while using only customer communications, has been impressive with 67% of the 34,790 flat rate water heater accounts converting to metered service since 2007. This was achieved by sending out customer communications in eight groups (consisting of pamphlets, letters, and automated

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phone calls, first notice letter and pamphlet, reminder, phone call, second reminder letter, etc.) over the three years. Even though there continues to be persistent communication with the customer base, the number of conversion has declined significantly as shown below:

Year	**Number of Tanks Converted**
2008	11,318
2009	9,679
2010	2,435

Based on past results of using a pure communication strategy, the use of incentives combined with a reinvigorated communication strategy will yield the planned participation rates.

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INTERROGATORY 53:

Reference(s): **Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 10, Section 3.2: Savings Summary**

THESL provides a table showing its projected net MW and MWh reductions.

a) Please discuss why THESL believes a 30% free ridership rate is appropriate?

b) Please explain the reasons for why no savings are shown for 2013 and 2014 under the "Net MWh Reduction" portion of the table.

c) Please discuss the various risks involved in projecting specific savings levels as shown by THESL in this table. What is the sensitivity of these figures?

RESPONSE:

a) The free ridership rate is based on past OEB direction for custom programs.

b) It is expected that this program will be complete in two years so no additional incremental savings would be expected in Years 3 and 4 of the program.

c) The savings are projected based on measured results and usage calculations that were accepted by the OEB as part of THESL's 2007 LRAM Application. The consumption numbers based on comparison with other data appear to be representative.

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INTERROGATORY 54:

Reference(s): **Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 12, Section 4.1: Marketing Strategy**

THESL notes as one of its key program drivers that participation in the *peaksaver* program allows customers to help Ontario meet its CDM goals.

a) Will this program be advertised as the *peaksaver* program?

RESPONSE:

a) No, it will not be advertised as part of the *peaksaver* program.

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INTERROGATORY 55:

Reference(s): **Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 12, Section 5.2: Enrolment Process**

THESL notes that one of the program rules, and as part of the enrolment process, eligible participants will need to sign up for the *peaksaver* program, but will not be eligible for *peaksaver* program incentives.

a) Please explain this process in greater detail and specifically discuss why participants won't be eligible for *peaksaver* program incentives.

RESPONSE:

a) The flat rate water heater program was originally conceived by THESL to provide load curtailment during periods of high electricity demand. As one of the program elements it was decided to include the electric heater load to increase the overall effectiveness of the program. The hot water loads can then be controlled in concert with THESL's existing *peaksaver* assets.

The *peaksaver* program provides a one-time incentive for enrollment. It was not thought that customers should receive two incentives as part of this program. Once approved, these details will be worked out with the OPA.

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INTERROGATORY 56:

Reference(s): **Program #5 – Flat Rate Water Heater Conversion & Demand Response, Page 14, Section 6.1: Project M&V**

THESL notes that project M&V will be limited to confirming the impact of the conversion on 30 customers per year over the life of the project.

a) Please discuss the rationale for only confirming the impact of the conversion on 30 customers per year. Why will THESL not confirm the impacts on a greater number of customers to ensure it has verified the impacts?

b) Please confirm that THESL will provide program savings results in conformance with the OPA EM&V Protocols.

c) Please discuss the appropriateness and rationale for proposing to provide results in conformance with the IPMVP standards.

RESPONSE:

a) A sample size of 30 per year, based on the expected participation rate, will yield the required level of accuracy and is well within the OPA QA/QC sampling protocols used in the province wide programs.

b) Confirmed.

c) IPMVP is the standard used for reporting project savings results as referenced in the OPA EM&V protocols. As noted in b) above, the results will be reported in conformance with the OPA EM&V Protocol.

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INTERROGATORY 57:

Reference(s): **Program #6 – Greening Greater Toronto Commercial Building Energy Initiative, Page 5, Section 1.2: Program Objectives**

THESL provides some notes on the barriers it hopes to improve by the implementation of this program, including sponsoring a measurement standard for building energy efficiency to facilitate energy performance efforts.

a) Please define and elaborate on what THESL means by a “measurement standard”.

RESPONSE:

a) The concept of benchmarking building operational efficiency is a compelling behavioural motivator in the commercial building management industry. In order for building energy benchmarking to be credible, however, it also needs to fair. The measurement standard adopted by GGT for the purpose of its Commercial Building Energy Initiative is based upon a commercial industry standard methodology.

   The measurement standard is a process that translates raw energy performance into a normalized performance metric that can be used to compare buildings on an equitable basis. The methodology accounts for variations in building area, different energy sources, weather, annual vacancy, occupancy density, and operating hours. It also provides an adjustment to account for exceptional high intensity energy spaces.

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INTERROGATORY 58:

Reference(s): **Program #6 – Greening Greater Toronto Commercial Building Energy Initiative, Page 8, Section 2.3: Projected Number of Participants**

THESL notes that participation is driven through membership in GGT. The current membership of the Leadership Council of GGT includes landlords that own and or manage approximately 40% of the commercial office space and tenants that occupy approximately 40% of the commercial office space in the GTA.

a) Please discuss how many buildings and how many landlords make up 40% of the commercial office space in the GTA.

b) Please discuss how many tenants THESL expects to engage and have enrol in this program.

RESPONSE:

a) Approximately 40% of the office space in the GTA is represented by 17 landlords. GGT has specific data on a number of buildings that are represented by nine of the landlords and representing 177 buildings. GGT estimates that the remaining eight landlords represent between 100 and 200 buildings for a total of between 277 and 377 buildings.

b) It is difficult to predict exactly how many tenants will enrol as it is hard to determine how many landlords outside of the Leadership Council will participate in the program. If an average of five tenants per building enrolled and only half of the Leadership Council's buildings participated, THESL would have between 690 and

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940 tenants participating. GGT and THESL believe that this is a very conservative estimate and expect a much greater enrolment.

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INTERROGATORY 59:

Reference(s): **Program #6 – Greening Greater Toronto Commercial Building Energy Initiative, Page 10, Section 4.2: Collaboration with other LDCs**

THESL notes that it will introduce other regional LDCs to the program.

a) Has THESL been approached or engaged in any discussions with other LDCs about this program? Please discuss the nature of these discussions.

RESPONSE:

a) THESL has approached the Coalition of Large Distributors ("CLD") to introduce the work of GGT to other LDCs and potentially advance and extend the program into other regions of the GTA. THESL has raised this as a future agenda item for discussion with the CLD working committee.

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INTERROGATORY 60:

Reference(s): **Program #6 – Greening Greater Toronto Commercial Building Energy Initiative, Page 11, Section 4.4: Tactics**

THESL provides a list of tactics it plans to employ when delivering this program.

a) Please discuss whether or not THESL staff will be participating in any events within the program or if that responsibility lies solely with members of the GGT.

RESPONSE:

a) GGT staff and members participate in the events and are solely responsible for organizing and running GGT events. THESL participates as an active member at meetings and uses the various events to promote the suite of available CDM programs.

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INTERROGATORY 61:

Reference(s): **Program #6 – Greening Greater Toronto Commercial Building Energy Initiative, Page 11, Section 4.5: Key Messaging**

THESL notes that the Corporate Challenge is a four-year program that aims at reducing total energy usage in commercial offices in the Toronto region by a nominal 10%.

a) Please discuss how the corporate challenge will continue for four years when THESL is only seeking one year of funding.

RESPONSE:

a) The funding request for 2011 reflects the sponsorship contribution for one year. As program needs and budgets evolve over time, THESL anticipates returning to the OEB to apply for additional funding in the event it is necessary to continue the work of the organization to meet the Corporate Challenge goals and objectives.

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INTERROGATORY 62:

Reference(s): **Program #6 – Greening Greater Toronto Commercial Building Energy Initiative, Page 13, Section 6: Program Budget**

THESL provides its program budget with a total of $295,707 requested.

a) Please discuss the details of what comprises the Variable Costs – Operation Costs budget line.

RESPONSE:

a) The Operation Costs budget line totalling $250,000 is the sponsorship contribution payable to the Greening Greater Toronto of the Greater Toronto Civic Action Alliance to support the Commercial Building Energy Initiative program delivery costs.

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INTERROGATORY 63:

Reference(s): **Program #6 – Greening Greater Toronto Commercial Building Energy Initiative, Page 13, Section 7: Cost Benefit Analysis**

THESL references section 4.1.2 of the CDM Code and notes that it is allowed to forego the cost effectiveness tests when submitting a CDM Program designed for educational purposes.

a) Has THESL conducted any in-house TRC or PAC tests for this program? If yes, please provide the results. If not, please run the tests and provide the results.

RESPONSE:

a) No, THESL has not conducted any TRC or PAC cost-effectiveness test. See response to Board Staff Interrogatory 19.

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INTERROGATORY 64:

Reference(s): **Program #7 – Hydronic System Balancing Program, Page 4, Section 1.1: Program Rationale**

THESL notes that the basis of the HSBP is the assertion that most hydronic systems and domestic cold water booster pumps are oversized and operating against balancing valves that throttle flow and unnecessarily increase energy consumption.

a) Please provide a reference for where THESL found the assertion noted above.

b) Has THESL conducted or reviewed studies of hydronic systems within its service area to better understand the make-up of this market?

RESPONSE:

a) The assertion is based on the mechanical systems design experience of the THESL's engineering team who have extensive design experience and are familiar with hydronic design practices.

Below are sources referenced in the report.

- U.S Department of Energy, Energy Efficiency and Renewable Energy (EERE). (2008) *Save energy now – data assessment tool*
- Haasl, T., Potter, A., Irvine, L., & Luskay, L., (2007) Retrocommissioning's greatest hits. *Energy Systems Laboratory – Texas A&M University*
- Friedman, H. California Public Utilities Commission, Portland Energy Conservation Inc. (PECI) (2006) *Retrocommissioning case study –San Diego Marriott Hotel & Marina*. San Diego Retrocommissioning Program.

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- Portland Energy Conservation Inc (PECI). *Example Retrocommissioning measure – opening throttled discharge valves.* 2008
- Veness, J. (2007) *Pump energy reduction – a systems approach*. Pro-Ven Solutions Ltd. UK.
- Sing, G. & Mitchell, J., (1998). Energy Savings From Pump Impeller Savings, ASHRAE Journal.
- Canada Mortgage and Housing Corporation, Research Highlights – Technical Series 01-108, Domestic Cold Water Booster Pump Control Monitoring Pilot Program. 08-11-07.

b) THESL has developed an inventory of the buildings within its territory and used engineering assumptions to determine the size of the pumps within.

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INTERROGATORY 65:

Reference(s): **Program #7 – Hydronic System Balancing Program, Page 6, Section 1.3.1: Incentives**

THESL discusses the elements of its proposed program incentives and notes the second to be the support of customer investment in identified measures.

a) Please provide some examples of measures that will be identified during the assessment.

b) Please discuss if there is a maximum dollar amount per participant for investment in measures for a participant.

RESPONSE:

a) The measures that will be identified during the assessment include:

- pump flow rebalancing (using impeller trimming or variable frequency drives)
- retrofit of existing booster pumps with multi-stage pumps
- retrofit of existing booster pumps with variable frequency drives
- application of pressurized storage for domestic hot water systems for low use periods
- conversion to variable hydronic flow

b) There is no maximum dollar amount per participant for investment in measures in a project.

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INTERROGATORY 66:

Reference(s): **Program #7 – Hydronic System Balancing Program, Page 8, Section 1.5: Conformance with OPA Measures**

THESL notes that the measures proposed by and implemented under the HSBP are consistent with the OPA program measures.

a) Please provide a table that lists all of the measures that will be implemented in this program and the source of the input assumptions.

RESPONSE:

a) Please refer to the response to Board Staff Interrogatory 5.

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INTERROGATORY 67:

Reference(s): Program #7 – Hydronic System Balancing Program, Page 10, Section 2.2: Market Penetration

THESL notes within section 2.2.2 that when establishing its market penetration projections, it relied on the experience from other jurisdictions with programs similar in scope.

a) Please discuss what other jurisdictions THESL has investigated, the similarity of programs between THESL's proposal and those from other jurisdictions and the key points it took away when developing this program.

RESPONSE:

a) This program was identified due to the experience of THESL's design engineers – it was shown to be an area that could be developed into an effective program for energy efficiency. The experience of THESL's design engineers is provided in the resources noted in Section 3 of the Application. While working in Toronto Hydro Energy Services Inc., THESL's retail affiliate, the engineering teams completed a number of performance-based energy design build retrofit projects. Hydronic system balancing was often a measure identified and implemented as part of these comprehensive retrofit projects.

   THESL further investigated numerous sources to see if there was a similar conservation program to serve as a model to this program. The research did not reveal an identical program; however, there are a number of retro-commissioning programs that contain elements of the proposed program.

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It is considered that this program is part of the spectrum of operational and low cost measures that represent the next phase of energy efficiency as the focus changes from equipment replacement to operational efficiency.

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INTERROGATORY 68:

Reference(s): Program #7 – Hydronic System Balancing Program, Page 12, Section 2.2.2: Market Penetration – Implementation

THESL provides a table where it shows the implementation rate of heating and cooling pumps it expects from the segments of the market it is targeting (i.e. offices, hospitals, multi-residential, and institutional).

a) Please discuss the reasonableness and variability of THESL expectation of total implementation rates of 50% for heating and cooling pump implementation and 30% for booster pump penetration rate.

b) Please discuss if THESL has conducted sensitivity analysis around these figures. If THESL has, please provide the analysis. If THESL has not, please discuss the rationale for not doing so.

c) Please discuss if THESL has calculated cost effectiveness with lower implementation rates than the ones found in the table referenced above. If THESL has done these calculations, please provide the results.

RESPONSE:

a) As noted in the Application, the 50% and 30% implementation rates are a subset of customers that have completed the audits. This indicates that they are interested in the concept and will have received sufficient information to know the typical cost and payback of the potential retrofits. There are also a number of references in Section 2.2.2 that indicate the penetration rate is well within the economic criteria of most organizations.

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b) Sensitivity analysis was conducted using lower savings rates not the penetration rates. The majority of costs in the TRC model are related to the implementation cost, which varies with the penetration rate. This results in the cost effectiveness being more sensitive to changes in savings than penetration rates. As noted in Section 8 a reduction in savings of 25% will result in a positive TRC and PAC.

c) Please refer to response to Board Staff Interrogatory 5.

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INTERROGATORY 69:

Reference(s): **Program #7 – Hydronic System Balancing Program, Page 16, Section 5.2.2 – Implementation Incentives**

THESL notes that the implementation incentive will be provided to the customer at $0.10/kWh up to 50% of project cost.

a) Is there a maximum dollar amount associated with the 50% figure noted above?

RESPONSE:

a) There is no maximum dollar amount listed. Due to the limited nature of the retrofits, the typical project size will be between $10,000 to $60,000. If desired, a maximum limit could be included in the project rules.

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INTERROGATORY 70:

Reference(s): Program #7 – Hydronic System Balancing Program, Page 21, Section 6.1: Project M&V

THESL notes that its savings report will provide savings results in conformance with IPMVP standards and/or OPA M&V protocols.

a) Please discuss the reasonableness for using the IPMVP standards?

b) Please confirm that THESL will conduct its EM&V in accordance with the CDM Directive and CDM Code which directs LDCs to use the OPA's EM&V Protocols.

RESPONSE:

a) The International Performance Measurement & Verification Protocol is the international standard for determining savings from energy retrofit projects. It is the method by which project level savings are to be calculated and is noted as such in the OPA EM&V protocols. The correct wording in the sentence should read "and" not "and/or".

b) Confirmed.

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INTERROGATORY 71:

Reference(s): **Program #7 – Hydronic System Balancing Program, Page 22, Section 7: Program Budget**

THESL provides its budget table summarizing the costs for the program which total $4.72M.

a) Please discuss what comprises the Fixed Cost – Sales line item.
b) Please discuss what comprises the Variable Cost - Operation Cost line item and discuss why the amount for this fluctuates each year.

RESPONSE:

a) The Fixed Cost – Sales line item refers to the labour allocation of a Key Account Manager's time. Due to the nature of this program and using the vendor channel for sales, this is less than a full-time position.

b) Operation Costs refer to the costs for a Program Manager and allocations of time from senior managers and monitoring and verification staff. It also includes the contractor training sessions. The amount varies from year to year as estimated staff allocations change with the volume and nature of work.

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INTERROGATORY 72:

Reference(s): **Program #7 – Hydronic System Balancing Program, Page 23, Section 8: Cost Benefit Analysis**

THESL provides the cost benefit results for this program in a table as well as describes the input assumptions used in the calculation.

a) Please discuss the sensitivity analysis associated with this program and show what the minimum number of participants is required to maintain overall program cost effectiveness.

b) Please discuss if THESL has calculated cost effectiveness with higher free ridership rates. If THESL has, please provide this analysis. If THESL has not, please do so.

RESPONSE:

a) Please refer to response to Board Staff Interrogatory 5 found at Exhibit J, Tab 1, Schedule 5.

b) No, THESL has not conducted cost effectiveness with higher free ridership rates.

The table below shows the impact of higher free ridership rates on cost effectiveness results.

Free Ridership	30%	40%	50%
Net TRC Benefits	$ 8,583,331	$ 7,209,457	$ 5,835,582
Net PAC Benefits	$ 12,425,075	$ 10,167,343	$ 7,909,611

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INTERROGATORY 73:

Reference(s): Program #8 – In-Store Engagement and Education, Page 5, Section 1.2: Program Objectives

THESL notes that this program aims at reaching Toronto's diverse, often over-exposed and sometimes hard-to-reach population. THESL also notes that a significant group includes a large population of vulnerable customers in designated priority neighbourhoods.

a) Please discuss the specific events and program elements that THESL plans to use to address the vulnerable customers in designated priority neighbourhoods.
b) Please expand on who THESL defines as vulnerable customers and what neighbourhoods it had identified as a priority.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 74:

Reference(s): Program #8 – In-Store Engagement and Education, Page 6, Section 1.3: Program Details

THESL provides a table in which it shows the participation rate at its similar in-store engagement program from 2005-2010.

a) Please discuss why there were large decreases in participants in 2007 and 2009.

b) Please provide the associated budgets for each of the years shown in the table referenced above.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 75:

Reference(s): **Program #8 – In-Store Engagement and Education, Page 7, Section 2.2: Market Penetration**

THESL notes that its proposed educational initiative will target the residential sector or 'mass market' which represents 2.5 million people in the City of Toronto.

a) Please discuss if an events schedule for this program has been finalized. If one has, please provide it.

RESPONSE:

a) THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 76:

Reference(s): Program #8 – In-Store Engagement and Education, Page 8, Section 4.3: Take-to-Market Approach

THESL notes that direct-to-customer, event-based marketing will be used to facilitate face-to-face customer interaction and education.

a) Please discuss if THESL staff or a third party vendor will be implementing this program.

RESPONSE:

a) THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 77:

Reference(s): **Program #8 – In-Store Engagement and Education, Page 11, Section 7: Program Budget**

THESL has provided its program budget with a total of $4.22M requested.

a) Please discuss why THESL has a requirement for annual legal costs for this program.
b) Please discuss the increased EM&V costs in 2014.
c) Please discuss what comprises the Fixed Costs – Marketing budget line as THESL notes this includes staff. What staff does this include? THESL or third party staff?
d) Please expand on what comprises the Fixed Costs – External Costs budget line.
e) Please discuss the details of the incentives budget line. How many products does THESL plan to giveaway over the course of this event?

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 78:

Reference(s): **Program #8 – In-Store Engagement and Education, Page 11, Section 8: Cost Benefit Analysis**

THESL references section 4.1.2 of the CDM Code and notes that it is allowed to forego the cost effectiveness tests when submitting a CDM Program designed for educational purposes.

a) Has THESL conducted any in-house TRC or PAC tests for this program? If yes, please provide the results. If not, please run the tests and provide the results.

RESPONSE:

a) THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 79:

Reference(s): Program #8 – In-Store Engagement and Education, Page 14, Appendix A – Program Evaluation Plan

THESL has provided an evaluation plan.

a) Please confirm that Appendix A is the finalized draft evaluation plan. If not, discuss the usefulness of Appendix A.

b) Please discuss when the final evaluation plan will be prepared and by whom.

c) Please expand on the evaluation description to offer more insight into the specific evaluation that will be conducted on this program.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 80:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, Page 3, Executive Summary**

THESL notes that the cooling load contributed by this sector will not be addressed by the province-wide programs and the *peaksaver* program has not been targeted at this sector specifically.

a) Please discuss how THESL classifies this program as non-duplicative of the OPA's *peaksaver* program.
b) Please expand on what THESL means when it says that the *peaksaver* program has not been targeted at the multi-unit residential sector specifically. Is THESL aware of this sector being targeted in any way by OPA province-wide programs?
c) Is the only difference between this program and the OPA's *peaksaver* program the fact that this program is being targeted at multi-unit residential buildings?
d) Has THESL targeted this segment of the market in the past with any of its programs?
e) If yes, what were the results from those programs? If no, has THESL conducted any studies of the potential participants from this sector to better understand their needs and potential risks involved with a program of this nature?

RESPONSE:

a) As the architect of the original *peaksaver* program, THESL has inherent knowledge of the program and its applicability to each market sector and segment. *Peaksaver* is a program that employs load control switches and one-way communication to disable residential-style central air conditioners in single-family dwellings. THESL classifies the MURB DR program as non-duplicative based on the following reasons:

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1) The *peaksaver* program is not designed or intended to address the MURB market or mechanical system configuration of high-rise multi-residential buildings.
2) The use of one-way load control switches is not feasible in the MURB environment where thermostatic control needs to be integrated with the central cooling plant mechanical controls to create load reduction and certainty of energy demand savings.

The importance of developing load reduction in the MURB sector is highlighted in the application due to its large and growing contribution to THESL's peak summer demand.

b) The *peaksaver* program is not applicable to the MURB sector as noted above. The OPA has expressed interest in a form of DR for the MURB sector; however, THESL has not been engaged in development. Based on the timeframe to develop and deploy programs it is expected that this program will not be available to affect THESL's efforts to achieve the Board-mandated CDM savings targets for 2011 to 2014.

c) No. Please refer to answers a) and b) above.

d) Yes, by way of THESL's network of channel partners. This includes the City of Toronto, which served this sector prior to the release of the province-wide programs.

e) THESL achieved 5.5 MW in savings in this sector between 2008 and 2010 based on 135 projects. The program is designed based on THESL's experience in this sector

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and in its belief that the risk in deploying this program can be mitigated by its phased introduction.

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INTERROGATORY 81:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, Page 6, Section 1.3: Program Details**

THESL notes that load control devices and programmable communicating thermostats (PCT) will be installed within the condominium units of participating buildings. THESL also notes further into its program details that owner/occupants will be able to manually modify or override the initial settings of the PCT on a limited basis. THESL continues to state that the system will be installed by a vendor that will be selected by an RFP process, on behalf of THESL or in conjunction with other utilities.

a) Please discuss if approval from each individual owner/tenant will be required to install any devices inside a unit.

b) Please define what "on a limited basis" means. How much control over the PCTs will owner/occupants have?

c) Please discuss if the RFP process has begun. If it has, please discuss the schedule for when THESL plans to have a vendor selected.

d) Please discuss if other LDCs have shown interest in this program and if THESL has had discussions with other LDCs about offering this program in their service area.

RESPONSE:

a) Yes, enrollment will be required by each interested participant.

b) The owners will be provided with a pre-programmed PCT that will reflect their occupancy patterns as noted on their signup form. The suite owner will have some ability to change temperatures within a limited dead band of the occupied and

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unoccupied set point. Access will be limited to prevent the owners from defeating the energy savings intent of the program or degrading the amount of dispatch-able load available.

c) No. The RFP process can only begin when there is funding to support the program. The program involves a calibration stage for which a contractor will be in place six months post Board approval.

d) The program concept was presented to the Coalition of Large Distributors, and some interest was shown as the program would be applicable to the larger urban centers. It would be expected that once the program is approved and operational, other LDCs may elect to pursue this program.

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INTERROGATORY 82:

Reference(s): Program #9 – Multi-Unit Residential Demand Response, Page 7, Section 1.3.1: Program Scope

THESL lists the steps that are included in program scope that range from the calibration stage to the post-implementation stage.

a) Please provide a schedule indicating the anticipated completion date for each step within program scope.

RESPONSE:

a) Please refer to the response to SEC Interrogatory 49.

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INTERROGATORY 83:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, Page 8, Section 1.5: Conformance with OPA Program Measures**

THESL notes that the manner proposed in this document to reduce central chiller load is no included in the OPA Measures and Assumptions List.

a) Please list the assumptions THESL proposing to use for the measures included in this program. Also, please provide the rationale for the appropriateness for each assumption listed.

RESPONSE:

a) Please refer to the response to Board Staff Interrogatory 5.

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INTERROGATORY 84:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, Page 9, Section 2.2: Market Penetration & the Table on page 10**

THESL notes that based on similarity of the program design elements and the penetration rates achieved with *peaksaver*, and the provision of a higher incentive rate than that paid to customers participating in the *peaksaver* program, a 40% participation rate is expected for the individual suites in each participating condominium.

a) Please discuss what research or study or other referential support THESL has relied upon when submitting its expectation of participation rates.

b) Has THESL investigated the possibility of participation rates being realized at lower levels than 40%?

RESPONSE:

a) As there are no MURB demand response programs in other jurisdictions with which to compare, the participation rates have to be estimated based on the penetration of *peaksaver* in the residential market. To promote participation in the program, the program design elements include:

- incentives for the condominium corporations to prompt condominium boards to promote the program within the facility
- suite level incentives to keep the suite level participants active in the program

b) The minimum participation rate for each MURB was set at 40%. At participation levels lower than this, it would not be cost-effective to include a MURB in the program.

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INTERROGATORY 85:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, Page 13, Section 5.1: Eligibility**

THESL lists the eligibility criterion that participants must meet. Within, THESL notes that there must be at least a 40% take-up rate of total suites in a building for a condominium to participate.

a) Please discuss if the building corporation is responsible for getting suite owners/tenants to participate and discuss how they will be assisted by THESL in doing so.

RESPONSE:

a) THESL will work with the condominium corporation and provide marketing materials and direct support to assist interested MURB facilities to sign-up the required number of suites. The building corporation is not directly responsible for getting suite owners to participate; however, the incentives will encourage the building corporation to work cooperatively to sign-up participants.

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INTERROGATORY 86:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, Page 13-14, Section 5.3: Incentives**

THESL provides a description of the various incentives available to both those participants who own a suite within a participating condominium and incentives for the condominium corporation or other entity.

a) Please provide further clarity on how the $25 fee will be prorated based on the percentage of events participated in during the course of the year.

b) In the case of non-THESL suite metered sites, please discuss how THESL will work with the existing service provider to reach a reasonable settlement methodology and provide the settlement for the suite owner.

RESPONSE:

a) The rules will include a provision for the owner to opt out of one load control event each season with the incentive being reduced by the ratio of the number of events participated in divided by the total number of events.

b) THESL will work with the existing service provider to develop a mechanism for providing the incentives to the individual owners. Similarly, in bulk metered condominiums or rental properties, THESL would work with the condominium board/owner to have incentives disbursed to the participating suites owners/tenants.

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INTERROGATORY 87:

Reference(s): Program #9 – Multi-Unit Residential Demand Response, Page 16, Section 6: Project M&V

THESL notes that its savings report will provide savings results in conformance with IPMVP standards and/or OPA EM&V protocols.

a) Please discuss the reasonableness for using the IPMVP standards?
b) Please confirm that THESL will conduct its EM&V in accordance with the CDM Directive and CDM Code which directs LDCs to use the OPA's EM&V Protocols.

RESPONSE:

a) The International Performance Measurement & Verification Protocol (IPMVP) is the international standard for determining savings from energy retrofit projects. It is the method by which project level savings are to be calculated and is noted as such in the OPA's EM&V protocols. The correct wording in the sentence should read "and" not "and/or".

b) Confirmed.

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INTERROGATORY 88:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, page, 17, Section 7: Program Budget**

THESL provides a budget summary table for this program with a total requested amount listed as $19.9M.

a) Please discuss what makes up the Fixed Costs – Sales line item.

b) Please discuss the rationale for a $60,000 Program EM&V budget in 2014. Will this amount cover the EM&V of 2013 and 2014 program results?

c) Please elaborate on components of the Variable Costs, particularly, the vendor costs of $10.88M and the factors that will affect these figures.

RESPONSE:

a) The Fixed Costs – Sales line item identifies costs required to support the program and reflects the additional sales effort required to work with each property manager, developer, association, as well as each individual condominium board to promote the merits of this program. The costs take into account the relative complexity of demand response offerings while recognizing that these customer groups are typically non-technical in composition and therefore require a greater degree of support.

b) No, the EM&V amounts are shown correctly to reflect the effort budgeted for each of the years 2012, 2013 and 2014 and the cost to be borne through the work of the third-party EM&V evaluator.

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c) The vendor cost is related to the supply, installation and operation of the load control system and components. This number is proportional to the number of installations. The remainder of the variable costs is a split of the labour costs to run the program.

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INTERROGATORY 89:

Reference(s): Program #9 – Multi-Unit Residential Demand Response, Page 18, Section 8: Cost Benefit Analysis

THESL provides the cost benefit analysis as well as a sensitivity analysis showing the results of the cost effectiveness tests with 20% fewer buildings enrol.

a) Has THESL determined the minimum number of participants required to have both TRC and PAC remain cost effective (e.g. 1.0+)? Please provide this analysis.

b) Please discuss the rationale and appropriateness for including a free ridership rate of 10%.

RESPONSE:

a) Please refer to response to Board Staff Interrogatory 5 found at Exhibit J, Tab 1, Schedule 5.

b) The free ridership rate used was equivalent to the rate used by the OPA in its Peaksaver analyses. This factor is thought to be conservative as there is no mechanism for a MURB facility to participate in a demand response program on its own.

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INTERROGATORY 90:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response, Page 19, Section 9: Non-Duplication of OPA-Contracted Provincial Programs**

THESL notes that the proposed program will not be duplicating any OPA-Contracted programs as the *peaksaver* and DR1 programs are not applicable to this market segment.

a) Please discuss if THESL engaged in conversations with the OPA about inclusion of the MURDR program in the province-wide suite of programs.

b) Please discuss the differences, other than market segment targeted, between the MURDR program and the OPA's *peaksaver* and DR1/DR3 programs.

RESPONSE:

a) Preliminary conversations have taken place with the OPA about using this program as the basis for a future province-wide program. This would be consistent with previous program efforts, such as, *peaksaver* where THESL developed and launched the program. After the *peaksaver* program was successfully established in Toronto, it was adopted by the OPA for province-wide deployment. THESL is open to program collaboration with the OPA including educational sessions to support a province-wide program.

b) The new *peaksaver* program, scheduled for launch in July 2011, uses load control switches and a one-way paging system. It is exclusively aimed at the single-family air conditioning load where the air conditioning unit can be turned off during load control events. The *peaksaver* on/off control approach is not technically feasible in a

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MURB facility wherein the units are controlled by a suite-mounted thermostats integrated with the building's central mechanical cooling plant (i.e. chiller), and where the load reduction manifests at the central chilled water plant.

DR-1/DR-3 are annual (summer and winter) load control programs that rely on loads being reduced at the participating facilities. These programs rely on loads being available year round, which is not possible for a condominium as it can typically only shed limited loads in the winter.

The proposed MURB DR program will provide a means for THESL to address the large and growing MURB cooling load that comprises approximately 22% of the estimated total peak cooling load in Toronto. Achieving results in this sector is crucial if THESL is going to reach the mandated conservation targets.

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INTERROGATORY 1:

Reference(s): none provided

Please complete the following Table:

				Cost Effectiveness Ratio	
Program	Budget	Total Projected MW Savings	Total Projected MWh Savings	TRC	PAC
Total					

RESPONSE:

Please refer to response to Board Staff Interrogatory 1.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 2:

Reference(s): none provided

Please complete the following Table to show the projected savings and budget by customer type as reflected in THESL's nine proposed programs:

Program	Customer Type	Annual Electricity Consumed (MWh)	Annual Electricity Consumed ($)	Projected MW Savids	% of Projected MW Savings	Projected MWh Savings	% of Projected MWh Savings	Proposed Budget $	% of Budget
Total									

RESPONSE:

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

Program	Customer Type	Annual Consumption (MWh)*	Projected Savings MW	% of MW Savings	Projected Savings MWh	% of MWh Savings	Proposed Budget	% of Budget
Monitoring & Targeting	Commercial, Industrial & Institutional	8,238,000	0.86	3.53%	40,700	31.97%	$5,501,410	10.56%
Hydronic System Balancing Program	Commercial & Institutional	1,014,000	3.40	13.93%	62,000	48.71%	$4,720,167	9.06%
Multi-Unit Residential Demand Response	Multi-Unit Residential	3,401,000	11.71	47.93%	500	0.39%	$19,914,690	38.22%
Flat Rate Water Heater Conversion & Demand Response	Residential	25,595	1.79	7.31%	10,190	8.01%	$2,679,488	5.14%
Commercial Energy Management & Load Control	Commercial & Institutional	3,920,000	6.67	27.31%	13,900	10.92%	$11,685,777	22.43%
Business Outreach & Education	Commercial, Industrial & Institutional	12,501,523	NA		NA		$1,647,585	3.16%
Community Outreach & Education Initiative	Residential	5,037,153	NA		NA		$5,659,664	10.86%
Greening Greater Toronto	Commercial & Institutional	6,949,647	NA		NA		$295,707	0.57%
Grand Total			**24.42**	**100%**	**127,290**	**100%**	**$52,104,488**	**100%**

*Consumption values are exclusive to the individual program

**Based on $0.9034/kWh - Source, THESL Consolidated Financial Statement 2010

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 3:

Reference(s): none provided

Please complete the following Table:

Program	Customer / Participant Type	Total # in THESL's Service Area	Program Target Market	Total Forecasted Participants by end of 2014	% of Target Market
Total					

RESPONSE:

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

Program	Customer Type	Total # in THESL's Service Area-Facilities*	Total # in THESL's Service Area-Customers	Program Target Market	Total Forecasted Participants by End of 2014-Facilities	Total Forecasted Participants by End of 2014-Customers	% of Target Market-Facilities	% of Target Market-Customers
Monitoring & Targeting	Commercial, Industrial & Institutional	2,476		Medium and large-sized facilities in the Office, Retail, Institutional and Industrial sectors with average monthly peak demand exceeding 200 kWper month, but not exceeding 15 GWh in annual electricity consumption.	107		4.3%	
Hydronic System Balancing Program	Commercial, Multi-Residential & Institutional	1,984		Medium and large-scale commercial, Institutioal and Muti-Residential facilities with either a hydronic heating and cooling system and/or a DCW booster pump system.	496		25.0%	
Multi-Unit Residential Demand Response	Multi-Unit Residential	1,983	338,824	Air-conditioned condominium buildings.	218	13,453	11.0%	4.0%
Flat Rate Water Heater Conversion & Demand Response	Residential	5,516		Single Family Homes with flat rate water heaters will be the primary focus.	4,413		80.0%	
Commercial Energy Management & Load Control	Commercial & Institutional	21,350		Small and medium size General Service rate class customers with an average monthly peak demand below 200 kW.	1,164		5.5%	
Business Outreach & Education	Commercial, Multi-Residential, Industrial & Institutional	78,554		Broadly target stakeholders within the Commercial and Institutional sectors across Medium to Large Businesses and Multi-residential buildings, as well as the Industrial sector.	13,384		17.0%	
Community Outreach & Education Initiative	Residential and Mutli-Residential Customers.	2,500,000		Entire residential market	1,000,000		40.0%	
Greening Greater Toronto	Commercial & Institutional	1,549		Major office landlords, building owners and property managers both in the private and public sectors within the "Commercial-Institutional"	620		40.0%	
Grand Total			**338,824**		**1,020,402**	**13,453**		

*Customer values are exclusive to the individual program

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 4:

Reference(s): none provided

Please confirm THESL's peak summer demand.

RESPONSE:

The official THESL peak summer demand for 2009 specified in the annual report is 4,607 MW.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 5:

Reference(s): none provided

Please provide an excel or other data file containing hourly metered load for THESL in 2010 and 2009 including a breakdown of hourly metered load by class where possible.

RESPONSE:

THESL total electricity consumption files are provided for 2009 and 2010. This is the aggregate for THESL and is not broken down into metering class.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 6:

Reference(s): none provided

Please provide the percentage of projected MW Savings and MWh savings attributable to THESL's proposed OPA programs and proposed Board Approved CDM Programs in order to meet THESL's CDM target.

RESPONSE:

The estimated demand and consumption savings are shown below:

Program(s)	Peak Electricity Demand Savings (MW)	Electricity Consumptions Savings (GWh)	Percentage of Demand Target (%)	Percentage of Consumption Target (%)
Province Wide Programs	219.0	1,140.8	77%	86%
OEB Funded Programs (this application)	24.4	127.3	9%	10%
Total	**243.4**	**1,268.1**	85%	95%
THESL Target	286.0	1,330.0		
Shortfall	**42.6**	**61.9**	15%	5%

The noted shortfall will be made up with additional OEB funded programs and, where possible, modifications to the province wide programs via the change management process.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 7:

Reference(s): none provided

Please provide the percentage of THESL's proposed 2011 to 2014 CDM budget that is dedicated to residential, commercial and industrial customers for the OPA and Board Approved programs.

RESPONSE:

Please refer to the table below for the percentage of THESL's proposed 2011 to 2014 CDM budget dedicated to residential, commercial and industrial customers.

Program	Residential	Commercial	Industrial
OPA Programs	28%	64%	8%
Board-Approved Programs	54%	44%	2%

For further information on budget, refer to the response to Board Staff Interrogatory 1 .

The percentage of 2011 to 2014 CDM budget that is dedicated to industrial customers for Board-Approved programs is based on the assumption that 15% of the budget for Commercial, Institutional & Small Commercial Monitoring & Targeting will be used for industrial customers.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 8:

Reference(s): none provided

Please provide the proposed and actual MW savings, MWh savings and budget for each customer class (residential, commercial and industrial) for each THESL CDM program by year prior to 2011.

RESPONSE:

CDM programs delivered prior to 2011 were delivered in distinct phases with different and evolving rules:

1) CDM Programs approved by the Board under the third Tranche (2005 – 2007)
2) OPA contracted programs under the Toronto Directive (2007 – 2010)
3) OPA contracted province-wide programs under the LDC Directive (2007 – 2010)

Over the six-year period there were different and evolving criteria over time that make reporting comparative data between the three phases extremely difficult to match in a standardized manner that will provide relative consistency of reported MW and MWh savings. This stems from the evolution of measures, protocols for program evaluation and M&V, TRC models, free-ridership to name the more significant criteria.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 9:

Reference(s): **none provided**

Please discuss the process and market analysis THESL undertook or studies relied upon to understand its overall CDM potential and the CDM potential for each customer type in order to arrive at the estimated participation rates and budget for each program.

Please provide copies of any reports/studies/surveys undertaken or used by THESL.

RESPONSE:

Overall CDM Potential

The process THESL followed to determine the CDM potential within its service territory was:

1) Data Gathering – annual energy and demand information was obtained for all customers via THESL's Customer Information System.
2) Data and Market Segmentation – the customers where then identified and placed into market segments relative to their business type e.g., Retail or Office and further by energy rate classes.
3) End Use Loads – for each sector an estimate of the end-use loads was developed. For example, lighting, process, fans, pumps, etc. This was based on typical indices and knowledge of the sector.
4) Potential Savings – based on our knowledge of each sector, and the references attached, an estimate of the potential savings in each sector was determined. This was then fine-tuned to reflect the expected impact of the province-wide programs.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

5) Need for Additional Programs – the analysis of the market indicated there are gaps within the province wide programs that will need to be addressed if THESL is to meet our targets. Based on this analysis, programs were developed to address these gaps.

Program Development Process

The process of developing programs is explained in detail in the response to CCC Interrogatory 2.

Participation Rates

The development and estimation of penetration rates is discussed in Section 2.2 of the applications and in the response to GEC Interrogatory 5.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 10:

Reference(s): none provided

Please provide the criteria and analysis THESL used to prioritize the proposed mix of CDM programs.

RESPONSE:

Please refer to the response GEC Interrogatory 8.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 11:

Reference(s): none provided

a) Please complete the following Table regarding proposed staffing.

Program	# of FTEs 2011		# of FTEs 2012		# of FTEs 2013		# of FTEs 2014		Total	
Total										

b) For each year with new FTEs, please provide a summary of the positions – Title, Contract or Permanent.

RESPONSE:

a) The following table provides the HR plan for Board-Approved programs. The table lists the average number of employees by year required for each program and shared support for all programs (EM&V technical services, sales, marketing and regulatory reporting & settlements). Employees required for the implementation of Board-Approved programs will be new contract employee hires.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

1 b)

Resource Plan: Board-Approved Programs

Avergae Number of Employees		2011	2012	2013	2014	2015
Name	CDM Role	Average	Average	Average	Average	Average
Program Manager - CEMLC	Program Lead	0.25	1.00	1.00	0.50	0.00
Program Manager - MURB DR	Program Lead	0.25	1.00	1.00	0.75	0.00
Program Manager - M and T	Program Lead	0.13	0.50	0.50	0.25	0.00
Program Manager - HSBP	Program Lead	0.50	1.00	0.75	0.53	0.00
Program Manager - FRWH	Program Lead	0.06	1.00	0.50	0.00	0.00
M and V Analyst	Support for OEB Programs	0.00	1.00	1.00	1.00	0.50
Key Account Managers	Support for OEB Programs	1.00	2.00	2.00	0.50	0.00
Marketing Consultant	OEB Programs	0.50	1.00	1.00	0.25	0.00
Regulatory & Settlement	Support for OEB Programs	0.25	1.00	1.00	1.00	0.50
OEB Program Total		2.94	9.50	8.75	4.78	1.00

Technical Services
Sales Group
Marketing Group
Regulatory & Settlements

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 12:

Reference(s): **none provided**

Please complete the following Table regarding proposed salary costs.

Program	Projected Budget ($)	Salary Costs including Benefits ($)	Non-Salary Costs ($)
Total			

RESPONSE:

Please refer to the table below.

Program	Projected Budget ($)	Salary Costs including Benefits ($)	Non-Salary Costs ($)
Commercial , Institutional & Small Commercial Monitoring & Targeting	5,501,410	648,158	4,853,252
Hydronic System Balancing Program	4,720,167	267,043	4,453,124
Commercial Energay Management & Load Control	11,685,777	353,898	11,331,878
Multi-Unit Residential Demand Response	19,914,690	795,331	19,119,359
Flat Rate Water Heater Conversion & Demand Response	2,679,488	197,877	2,481,611
Community Outreach & Education Initiative	5,659,664	202,605	5,457,059
Business Outreach & Education	1,647,585	122,670	1,524,915
Greening Greater Toronto Commercial Building Energy Initiative	295,707	8,668	287,039
Total	**52,104,488**	**2,596,250**	**49,508,238**

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 13:

Reference(s): none provided

Has THESL considered the use of a variance account to record the difference between the funding awarded for Board-Approved CDM Programs and the actual spending incurred to carry out these programs?

RESPONSE:

In accordance with section 5.5 of the OEB's CDM Code, any actual expenditure of approved funding for Board-Approved CDM Programs will be tracked and recorded in a variance account for future disposition.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 14:

Reference(s): **Program #1 – Business Outreach and Education, page 8, Section 2.2, Projected Number of Participants**

The projected number of participants is displayed in a Table. Please show the breakdown in participation rates by targeted customers for this program.

RESPONSE:

See response to Board Staff Interrogatory 14(a).

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 15:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), Page 5, Program Objectives**

The second bullet provides an objective to contribute 6.3 GWh in cumulative net electricity savings. The Table on page 4 shows cumulative energy savings of 13.864 GWh.

Please explain the difference between these two figures.

RESPONSE:

The correct value is 13.864 GWh. The 6.3 GWh is a typographical error.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 16:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), Page 5, Section 1.3 Program Details**

THESL indicates that "The EMS system will be installed on a turn-key basis by a vendor that will be selected by an RFP process, on behalf of THESL and possibly in conjunction with other utilities deploying the same program?

a) Should the Board approve this program, how much time does THESL anticipate is required to i) issue an RFP to select a vendor; and ii) have a vendor in place?
b) Is THESL aware of other utilities that are deploying this same program within the same timeframe? If so, please indicate how many and which LDCs?

RESPONSE:

a) THESL will be in a position to issue an RFP within three months of program approval. It is anticipated that the vendor will be in place within one month of conclusion of the RFP process.

b) At this time, THESL is aware of only one other utility (Hydro One Networks Inc.) that is interested in pursuing this program in the same time frame and is in discussion with THESL to examine cost efficiencies in design, development and delivery of the proposed program.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 17:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), Page 6, Section 1.3 Program Details**

THESL indicates that "A key success for this program is the selection and implementation of a viable system capable of both demand response for the provincial electricity grid and energy management for the participants, in terms of functionality, system reliability and robustness. System functional requirements and technical specifications will be prepared, and RFP responses will undergo a rigorous evaluation process to ensure such a system is selected and implemented for program deployment".

a) Has THESL completed the system functional requirements and technical specifications? If no, when will they be available? If yes, please provide.

b) Please provide the performance criteria that will be part of the RFP evaluation process.

RESPONSE:

a) The full system functional requirements and technical specifications will be developed during the RFP process.

b) The full performance criteria will be developed as part of the RFP; however, some preliminary key performance criteria are:
    - Supervisory Communication
    - Site Level Communication
    - Load Control Functionality
    - Energy Management Functionality
    - Participant Functionality

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 18:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), Page 6, Section 1.3.2 EMS Capabilities**

The evidence states that "If applicable, included with the provision of the EMS will be an allowance for third party monthly access fees until the program end date to ensure sustained use of the systems".

Please explain this provision further and identify how much the monthly access fee will be.

RESPONSE:

The majority of systems that have been presented to THESL thus far utilize a web hosted interface, which requires a monthly access fee. The estimated month access fee is $18 per month. The final values will be subject to the RFP process.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 19:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), Page 5, Section 2.1 Sector Analysis**

THESL provides a breakdow of the customers that make up the target market of 21,350 customers.

a) Please provide THESL's definition of the hospitality sector.

b) b) Under "Other", 1,410 sites are identified. Please provide a breakdown of this sector.

RESPONSE:

a) The hospitality sector is composed of those accounts that serve hotels, motels and restaurants.

b) This category is composed of accounts that are not in the primary categories included in the table. This sector includes mixed-use facilities and unclassified facilities in the commercial account category.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 20:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), Page 9, Section 2.2 Market Penetration**

The Table shows the estimated market penetration and for each sector. Please provide the calculation and underlying assumptions used to determine the penetration percentage.

RESPONSE:

As noted in Section 2.2, the overall penetration is estimated to be 5% for the applicable market segment. This is based on the impact of the existing Peaksaver program and takes into account the impact and value proposition of the enhanced program elements that will increase penetration.

The overall penetration rate of 5% was then distributed among the sub-segments. Based on the experience of THESL's sales and marketing teams, a higher success rate is expected.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 21:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), Page 11, Section 3.2 Savings Summary**

Please complete the following table to show the number of participants by sector by year:

Sector	2011	2012	2013	2014	Total
Offices					
Retail					
Hospitality					
Institutional					
Other					
kWh Metered <50kW					
Total					

RESPONSE:

Sector	2011	2012	2013	2014	Total
Offices	39	78	91	52	261
Retail	42	83	97	56	278
Hospitality	5	11	13	7	36
Institutional	8	17	20	11	56
Other	11	21	25	14	71
kWh Metered <50kW	69	139	162	92	462
Total	**175**	**349**	**407**	**233**	**1,164**

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 22:

Reference(s): **Program #2 – Commercial Energy Management and Load Control (CEMLC), CEMLC Program Page 12, Section 4.1 Marketing and Sales Plan**

The evidence states that “The selected EMS system will meet the functional and technical requirements of both THESL and the program participants.

a) How will THESL determine the functional and technical requirements of the program participants?

b) When will THESL make this determination?

RESPONSE:

a) THESL will evaluate the customers’ functional and technical requirements through direct engagement to assess application and operation requirements. This information will be used to develop EMS specifications and criteria to ensure that the system will be functional from both THESL’s and the host’s perspectives and for a future RFP process.

b) THESL will develop the specifications post-OEB approval for inclusion in a future RFP process.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 23:

Reference(s): **Program #3 – Commercial, Institutional and Small Industrial Monitoring and Targeting, Page 24, Program Budget**

Please provide information the allocation of total expenditures incurred by each targeted customer type for each direct projected expenditure.

RESPONSE:

The table below summarizes the estimated total direct expenditure for each target sector based on the average installed system costs noted.

Sector	Number of Anticipated Participants	Typical System Cost	Total M and T Installation Cost	Installation Incentives	Total Installation Cost less Incentives
Offices	55	$42,113	$2,316,215	$1,158,108	$1,158,108
Institutional	24	$42,113	$1,010,712	$505,356	$505,356
Retail	17	$42,113	$715,921	$357,961	$357,961
Industrial	11	$43,125	$474,375	$237,188	$237,188
Total	**107**		**$4,517,223**	**$2,258,612**	**$2,258,612**

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 24:

Reference(s): Program #4 – Community Outreach & Education, Page 6, Section 1.3 Program Details

THESL provides a table on page 6 that summarizes THESL's customer participation at retail events over the past six years. Participation rates are significantly lower in 2007 and 2009. Please explain.

RESPONSE:

Participation rates were lower in 2007 and 2009 because in 2007, THESL was in contract negotiation with OPA until May when the contract was signed. It was then too late for THESL to run one of its mass market campaigns (using RFP process, etc.). In 2009, THESL gave away specialty CFLs, which were of higher dollar value than previous standard (spiral) CFLs giveaways. As such, THESL distributed less of this product.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 25:

Reference(s): **Program #4 – Community Outreach & Education, Page 6, Section 1.3 Program Details**

THESL indicates that "Given Toronto is such a densely populated City with a diverse, ethnic base we have ambassadors that can communicate in the five most commonly spoken languages".

How many "ambassadors" does THESL currently have on staff? How many additional ambassadors will be retained as part of this program? Will they be contract or permanent staff?

RESPONSE:

THESL employs event staff on an as-needed basis to support the planned events via a third-party. These positions are part-time, so they could not be classified as either contract or permanent positions. During peak campaign periods there will be up to 100 part-time representatives. This is equivalent to THESL's last major educational campaign (Beat the Peak Fall 2010), where there were 100 representatives hired for the event, 40 of which spoke at least one other language.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 26:

Reference(s): **Program #4 – Community Outreach & Education, Page 13, Section 7, Program Budget**

a) Please provide details on the $55,000 in legal costs.

b) The Marketing costs of $2,020,000 include staff. Please identify the staff positions included.

RESPONSE:

a) Legal must review/approve or write all RFPs, contracts and data protection agreements. All marketing material is reviewed by Legal before release. For more information please see response to Board Staff Interrogatory 18(a).

b) Please refer to responses to the two interrogatories regarding the human resource plan:
   1) Board Staff Interrogatory 7 found at Exhibit J, Tab 1, Schedule 7
   2) Association of Major Power Consumers in Ontario Interrogatory 11 found at Exhibit J, Tab 2, Schedule 11

   Marketing consultant resources are shared across all Board-Approved programs.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 27:

Reference(s): **Program #8 – In-Store Engagement and Education, Page 13, Section 7, Program Budget**

The evidence indicates that "Through the communications plan (paid media) we strive to reach 80% of our target audience (adults 18+ who pay an electricity bill in the City of Toronto) a minimum of 6 times. Impressions are in the range of 20 million".

a) Please explain the nature of the charges under paid media and the corresponding costs.

b) Please define impressions. Please provide the analysis of the 20 million impressions (paid media) and unpaid media used to arrive at the projected number of participants (i.e., a minimum of 50,000 Torontonians each year).

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 28:

Reference(s): **Program #8 – In-Store Engagement and Education, Page 9, Section 4.3 Take-To-Market Approach**

The evidence states that "Events will take place over pre-arranged consecutive weekends. Retail and other partners will be selected through an RFEI or RFP process".

a) Should the Board approve this program, how much time does THESL anticipate is required to i) issue an RFP; and ii) have a vendor in place?

b) What is the estimated value of the FRP?

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 29:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response (MURB DR), Page 10, Section 2.2 Market Penetration**

The Table on Page 10 shows the Building Penetration Rate (%) for the rental and condo sector. Please explain the rationale for the penetration rate of 0% for the rental sector.

RESPONSE:

THESL does not expect any participation in the rental apartment sector because the vast majority of rental apartment buildings are not centrally-cooled. This makes them unsuitable for a demand response program. Even in cases where a rental facility has a significant portable window-based air conditioning population, the issues around controlling these loads do not lend themselves to this program.

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 30:

Reference(s): Program #9 – Multi-Unit Residential Demand Response (MURB DR), Page 11, Section 4.2 Marketing Objectives

Please provide the complete title of the following acronyms: ACMO, CCI, GTAA.

RESPONSE:

ACMO – Association of Condominium Managers of Ontario

CCI – Canadian Condominium Institute

GTAA – Greater Toronto Apartment Association

RESPONSES TO INTERROGATORIES OF ASSOCIATION OF MAJOR POWER CONSUMERS IN ONTARIO

INTERROGATORY 31:

Reference(s): **Program #9 – Multi-Unit Residential Demand Response (MURB DR), Page 13, Section 5.2 Enrollment Process**

The evidence states that the Condo Corporation or owner will enrol via THESL's website, direct mail or at CDM promotional/educational events.

Please provide a breakdown of the number of anticipated participants for each of the above.

RESPONSE:

Once a condominium corporation is interested in pursuing the program, the enrolment of individual suite owners will be predominantly via the website. Direct mail and educational events will raise awareness and promote enrolment via the website or paper-based forms.

Based on THESL's experience with Peaksaver, it is estimated that 50% of enrolments will be at promotional/educational events, 30% via the web site, and 20% by mail.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 1:

Reference(s): **none provided**

Please provide one schedule setting out all of the OPA programs that THESL is undertaking, all of its proposed "Board-Approved" programs, the cost of each of those programs and the expected CDM savings.

RESPONSE:

Please refer to response to Board Staff Interrogatory 1 found at Exhibit J, Tab 1, Schedule 1.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 2:

Reference(s): **none provided**

THESL is planning to spend $56.3 million on its Board-Approved Programs. Please describe, in detail, the process that THESL undertook to develop the programs and the specific program budgets. How can the Board be assured that the programs have been developed in the most cost effective-way possible? Please explain why THESL has determined that $56.3 million is an appropriate level of spending for its CDM spending.

RESPONSE:

All Programs – Program Development Process

Since 2005, THESL has been delivering conservation and demand management (CDM) programs on target and on budget. As the architect and implementer of many award-winning and emulated programs, THESL has a team of experienced staff dedicated to helping customers with energy efficiency, conservation and demand response. THESL has demonstrated leadership in the development of programs such as *peaksaver***,** which boasts over 65,000 installations in Toronto and was adopted as a province-wide program. THESL has consistently applied innovation in many of the programs in the residential mass market and business market. THESL has demonstrated its leadership through collaboration with numerous local partners and agencies along with the Coalition of Large Distributors (CLD) on numerous initiatives and collaborated on DSM programs with gas companies. For further information on THESL's CDM experience and CDM program success, please refer to the response to CEEA Interrogatory 1.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

Process for Board-Approved Programs

1) Market Analysis

To develop the strategy document which was submitted to the OEB in November 2010, THESL evaluated its customer base and developed information to determine the potential for energy and demand savings in each sector. For reference to Market Analysis, please see response to AMPCO Interrogatory 9. From this analysis, it is anticipated that the province-wide programs will not meet the mandated conservation targets.

2) Additional Programs

To meet the mandated targets, additional programs were developed to address gaps or shortfalls in the province wide programs. These programs were then reviewed against the following criteria:

- Overlap with province wide programs
- Suitability for inclusion in province wide programs
- Technical feasibility
- Program effectiveness
- Cost effectiveness

Programs that reviewed favourably against the criteria noted were developed into full programs.

3) Program Development

The programs were then developed from concepts into a full analysis of the anticipated program impact by identifying:

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

a) Market Potential

The specific target market for each program was extracted and analyzed for specific key information such as customer numbers, total consumption, contribution to peak demand and estimated end use loads.

b) Potential Savings

Case studies, engineering calculations and other sources were researched to determine expected savings for the proposed program measures.

c) Market Penetration

Market penetration was estimated for each program using references, where available, or past experience. The penetration rates were then applied against the number of facilities in the market to determine the total number of participants.

d) Program Cost

Each program was budgeted to determine the incremental labour costs required based on additional staffing needs. Where external vendor costs are involved, system costs were estimated and cross-referenced with contractors or industry experts.

e) Program Cost Effectiveness

The cost, savings and budget were then applied to the OPA cost effectiveness tool to determine program cost effectiveness.

4) OEB Application

Applications were developed and submitted to the OPA for review.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

Process for Education Programs

For the education and outreach programs, THESL's participation on the marketing working group set-up by the OPA allowed THESL to identify areas where the province-wide marketing efforts will miss key aspects of the Toronto market. Some of the key areas were then developed into applications using the following process:

1) Identify Gaps in the Province Wide Marketing Plans
   Areas that the OPA province-wide marketing will not address, or structural problems with the proposed marketing programs that will limit their effectiveness were identified.
2) Develop Program Scope
   THESL's experience in developing and delivering education and outreach programs was used to develop a scope of events that would achieve the program objectives for the areas not addressed by the OPA marketing plans.
3) Develop Program Cost
   The program cost was developed using THESL's experience in delivering similar programs in the marketplace.

All Programs – Program Cost Effectiveness

THESL has delivered CDM programs in its service territory since 2005 and has consistently achieved its targets within the approved budgets. The proposed OEB-funded programs for the 2011-2014 period are based on this former program design experience and actual program feedback. In fact, THESL has one of the most experienced CDM delivery teams in the province and encompasses experience in all aspects of program design and delivery from marketing and engineering through to governance and control.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

Some examples of how THESL has achieved cost efficiency include:

- The Community Outreach and Education Initiative budget has been reduced by $200,000 based on the experience of running similar programs. This program also leverages existing outreach, events and partnerships to find efficiencies.
- The Building Incentive Program has delivered demand reduction at a higher net to gross ratio than other similar programs in THESL's service territory.
- Existing partnerships and relationships with local community/government groups allow for cost sharing of event costs and reinforcing existing successful programs, which allows THESL to deliver educational efforts more cost effectively than by recreating programs.

Overall Budget

The overall budget for the programs was developed by using an extensive bottom-up approach. This, combined with conservative estimates of savings, has yielded programs that exceed the minimum cost effectiveness requirement. This was accomplished within the constraint of these programs being much more complex than past conservation efforts. The requirement for complex programs is a function of the THESL service territory having a more mature energy retrofit market, which requires solutions that are beyond the traditional equipment replacement programs.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 3:

Reference(s): none provided

Please explain the extent to which THESL worked with other LDCs in the development of its programs. If collaboration was not undertaken please explain why.

RESPONSE:

THESL collaborated with Hydro One Networks Inc. in the development of two programs:

a) Commercial Energy Management and Load Control
   Extensive collaboration occurred on this program, principally by the chief architects and subject matter experts in this field who led the development and implementation of the ***peaksaver*** Demand Response program in 2005. The dialogue included review of available technology and software, pricing and economies of scale, program rules and eligibility, and ways of achieving deeper penetration into this small commercial sector.

b) Commercial, Institutional and Small Industrial Monitoring and Targeting
   THESL and Hydro One worked closely to harmonize the objectives of the program and develop common program design assumptions. This sharing of knowledge allowed development of incentive regimes jointly. Additional opportunities for collaboration were explored in the delivery of the programs and for cost effectiveness through efficiency gains in areas including procurement of product and services.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 4:

Reference(s): none provided

Please explain why THESL could not meet its CDM targets using a portfolio of OPA programs only.

RESPONSE:

The analysis THESL has undertaken of the various components of the market indicate that the target will not be achieved through the efforts of Tier 1 programs exclusively. There are a number of factors that impact the achievable savings in THESL's service territory:

a) previous CDM efforts have achieved significant market penetration, which has saturated portions of the market
b) large and significant sectors of the market are not addressed by the OPA programs
c) proactive leadership by many of the firms and institutional accounts have resulted in there being widespread adoption of energy efficiency measures in THESL's service territory

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 5:

Reference(s): none provided

Please provide a complete list of the residential programs (providing details on program design) that were considered by THESL and rejected. Please explain why those programs or program concepts were rejected.

RESPONSE:

Four residential programs were considered for development into programs:

1) Residential Monitoring and Targeting
   This program will combine the benefits of social benchmarking with a monitoring and targeting program at the residence level. This is being developed for possible submission in the fall of 2011.
2) Residential Air Conditioning Control – the application of an “add-on” air conditioning control device to reduce residential air conditioning energy use was considered for a separate program. It was thought that this is more appropriately applied as a prescriptive measure. The manufacturer is following up with the OPA for addition to the prescriptive measures list.
3) Solar Water Heating – with the removal of Federal subsidies the applicability and penetration would be too small to justify a program application.
4) Residential Ground Source Heat Pumps – the concept was to provide prescriptive incentives for residences that install ground source heat pump systems. This was rejected as a potential program due to the limited applicability of this program for the THESL market. The market is limited due to the small number of new house builds and the limited applicability of this technology in retrofit applications.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

For more information, please refer to the response to Board Staff Interrogatory 8.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 6:

Reference(s): **none provided**

Please provide detailed evidence to support the proposition that THESL's selection of programs represents the best way to achieve its CDM targets that have been established by the Board.

RESPONSE:

THESL evaluated a number of potential programs to address areas specific to the loads within THESL's service territory. These concepts were then vetted to determine whether they were non-duplicative with OPA programs, available in the 2011-2014 time frame, or whether they would be more suitable for inclusion within the province wide programs. Please refer to the response to GEC Interrogatory 11.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 7:

Reference(s): none provided

Please explain the relationship between THESL's existing CDM programs and the proposed programs? Please explain why the existing programs could not have met the proposed targets?

RESPONSE:

The proposed programs are to provide incremental savings to that which will be achieved with the province-wide programs. The proposed programs address end uses and sectors that are not covered by the province-wide programs. Please refer the response to CCC Interrogatory 4 for a further explanation as to why the province-wide programs will not address the proposed targets.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 8:

Reference(s): none provided

Please explain how THESL intends to differentiate between CDM related costs to be recovered from the Global Adjustment Mechanism and those recovered through rates. Please explain how THESL will “fully allocate” CDM costs in a way consistent with the Board’s CDM Code.

RESPONSE:

THESL does not intend to recover any CDM related costs through distribution rates. THESL is seeking to recover all costs related to Board-Approved CDM activities through the Global Adjustment Mechanism, and all such costs are either allocated within individual program budgets or submitted as supplementary costs as part of THESL’s February 25, 2011 Addendum. All CDM related costs will be tracked and reported separately by OPA-Contracted Programs and Board-Approved Programs, as well as by program initiative. Time reporting will allocate, track, and report all marginal and allocable labour costs by program initiative using THESL’'s project work order and financial systems.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 9:

Reference(s): none provided

Please provide a list of all THESL employees that have been involved in the development of its CDM programs and those employees that will be involved in any further program development. Please provide a list of employees that will be involved in the delivery of THESL's CDM programs. How are the costs of those employees accounted for in the 2011 proposed revenue requirement?

RESPONSE:

The following is a list of staff involved in the development of the Board-Approved programs:

- Chief Conservation Officer
- Commercial Marketing Consultant
- Manager, CDM Regulatory & Settlements
- Manager, CDM Program Delivery
- Manager, CDM Projects & Technical Support
- Manager, Customer Experience & Marketing
- Manager, Demand Response
- Market Research Consultant
- Project Analyst, CDM Development
- Project Manager, CDM Development
- Technical Energy Consultant

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

The same employees are also involved in the delivery of programs (i.e. employees listed as program development and program delivery are interchangeable in function and the same employees can be utilized to do both program development and contribute towards program delivery).

Future program development work will be dependent on a number of factors including how well established programs are doing as well as the decision rendered by the Board on this application. If there is further program development work to be done then it will most likely be sourced from within the same group of employees and possibly supported by either additional resources or external third party contractors.

The costs of these employees are not included in the 2011 Revenue Requirement.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 10:

Reference(s): none provided

For each of THESL's proposed Board-Approved programs please describe, in detail, how the free-ridership rates were established. For each of the programs please explain how actual free-ridership will be determined.

RESPONSE:

Free-ridership rates were established using similar rates used by the OPA in the province-wide programs. Please see the table below listing the free-ridership rate assumptions used for each Board-Approved program.

Program	Free Ridership
Multi-Unit Residential Demand Response	10%
Flat Rate Water Heater Conversion & Demand Response	30% for water heater; 10% for ***peaksaver***
Commercial , Institutional & Small Commercial Monitoring & Targeting	30%
Hydronic System Balancing Program	30%
Commercial Energay Management & Load Control	10%

Actual free-ridership rates for each program will be determined by program evaluations using the OPA EM&V protocols which require net-to-gross adjustment factors to be revised as information is gained from each program.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 11:

Reference(s): none provided

Please describe the process that THESL will undertake to update its input assumptions during the four-year plan term.

RESPONSE:

During the course of the program life, THESL will be monitoring the key program variables (cost, achieved savings, free ridership rates, incentives, customer mix, etc.) to determine that the program is maintaining the cost effectiveness criteria of the original report. This information will be a function of the internal tracking of program effectiveness combined with feedback from the independent EM&V reporting.

This feedback will then be used to determine what program changes are required to cost effectively deliver the demand and consumption savings defined in the program applications.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 12:

Reference(s): none provided

With respect to THESL's Water Heater Conversion Program would it not be more cost effective to replace the electric flat rate water heaters to natural gas? If not, why not?

RESPONSE:

It is more expensive to convert to natural gas water heating due to the logistics of adding natural gas service and venting in a retrofit project. The meter conversion cost is typically $250 because it only involves changing the electrical service, while using the existing electrical tank. On the other hand, a typical natural gas conversion (assuming the unit can be vented and natural gas is available) would cost between $750 and $1000 for standard conditions.

RESPONSES TO INTERROGATORIES OF CONSUMERS COUNCIL OF CANADA

INTERROGATORY 13:

Reference(s): none provided

THESL has filed a draft evaluation (EM&V) plan, but states that "the eventual evaluation plan will be prepared by the independent auditor". In its decision on certain preliminary questions, in EB-2010-0331 and EB-2010-0332, the Board stated that "in the absence of a complete evaluation plan, for each program, the application is incomplete and the proceedings should be adjourned until the evaluations plan is filed". Please explain why THESL's application should be treated differently?

RESPONSE:

A "Draft Evaluation Plan", as defined in the OPA EM&V protocols, will be filed for each application prior to the hearing. The Applications included "Draft Evaluation Templates", which will be expanded into full "Draft Evaluation Plans" in accordance with the Board's direction in EB-2010-0331and EB-2010-0332. Please see response to Board Staff Interrogatory 6(a).

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 1:

Reference(s): none provided

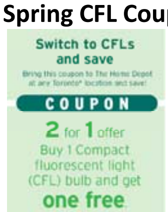
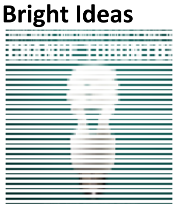
The Canadian Energy Efficiency Alliance (The Alliance) acknowledges Toronto Hydro's extensive experience in developing, delivering and implementing CDM programs particularly from 2005 to 2010. Please provide completed evaluations of its previous programs and sample copies of presentations, or other documentation that have been provided to other agencies or utilities which have emulated any of its previous programs.

RESPONSE:

Since 2005, THESL has been delivering conservation and demand management (CDM) programs on target and on budget. As the architect and implementer of many award-winning and emulated programs, THESL has a team of experienced staff dedicated to helping customers with energy efficiency, conservation, and demand response. THESL has demonstrated leadership in the development of programs such as *peaksaver*, which boasts over 65,000 installations in Toronto and was adopted as a province-wide program. THESL has consistently applied innovation in many of the programs in the residential mass market and business market. THESL has demonstrated its leadership through collaboration with numerous local partners and agencies, the Coalition of Large Distributors (CLD),and gas companies.

The tables below list CDM programs executed by THESL, by year (results are not cumulative), highlighting collaboration and successes. Note that values are rounded.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2005 Toronto Hydro CDM Programs Produced first CDM Progress Report in collaboration with CLD			
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
Spring CFL Coupon 	First coupon offering - 2 compact flourescent light bulb (CFL) bulbs for the price of one	The Home Depot	Over 24,000 CFLs in-market
RAC Recycling Program 	Bring in a room air conditioner (RAC) and get a $25 gift card	The Home Depot Clean Air Foundation (CAF), City of Toronto, Ministry of the Environment	Over 5,000 room air conditioners off the grid and recycled
Bright Ideas 	Get two free CFL bulbs	The Home Depot	Over 350,000 CFLs distributed to almost 180,000 householders Over 100,000 in incremental CFL sales achieved
Seasonal LED Light Exchange 	Bring in 1 string of traditional holiday lights and get a $7 voucher towards light emitting diode (LED) lights	The Home Depot	Almost 19,000 traditional strings off the grid and recycled and over 19,000 Seasonal LEDs purchased
Cool Shops Program 	Small business outreach to identify and implement in-store energy management measures	Clean Air Foundation (CAF)	Flagship program in Toronto Lighting audits conducted. Over 1,600 CFLs distributed

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2005 Toronto Hydro CDM Programs

Produced first CDM Progress Report in collaboration with CLD

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
TAPS	Energy efficiency installations, targeting homes with electric water heaters, electric heating	Enbridge Gas (and contractor network)	Almost 8,000 homes visited with over 30,000 CFLs distributed
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
Festive Light Exchange 	Bring in two traditional lights strings and get one free string of Seasonal LEDs	City of Toronto, Toronto Association of Business Improvement Areas (TABIA)	7,200 traditional strings off the grid and recycled and 3,600 Seasonal LEDs given away
Fridge Unplugged 	Old fridges picked up from homes for recycling and 'Power Pacs' (containing energy efficient products) provided	1-800 Got Junk, Total Home Comfort	Almost 2,000 working fridges collected during three month campaign
peaksaver	Switch installed on CAC to cycle down unit during peak times $25 cheque for enrollment		Toronto Hydro designed program Almost 600 installations for the program which was launched mid-year
Business Incentives **power WISE® Business Incentive Program**	Incentives for over 50 kW customers. CLD collaboration to launch powerWISE Business Incentive Program (PBIP)	CLD, Enbridge Gas, City of Toronto	Launched incentives for business customers. Completed initial lighting retrofits and other energy efficiency measures such as chillers and motors

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2005 Toronto Hydro CDM Programs

Produced first CDM Progress Report in collaboration with CLD

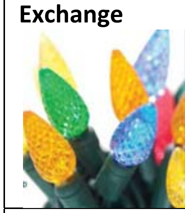
PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
DAP 	Design Advisory Program (DAP) for the installation of energy efficient equipment during construction	Enbridge Gas, City of Toronto	Designed in 2005 for 2006 rollout
Low Income Program	Initiatives (lighting retrofits and appliance replacements) by SHSC and TCHC targeting low income sector	Toronto Community Housing Corp. (TCHC) Social Housing Services Corp. (SHSC)	Initiated partnerships and launched program

2006 Toronto Hydro CDM Programs

Received EDA Innovations Award PR (all CDM campaigns)
With CLD, received Ontario Energy Association — Company of the Year

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
peaksaver	Same program as 2005	CLD	Platt's Global Energy award winner and one of the first programs Premier Dalton McGuinty and then-Minister of Energy rolled out across Ontario. Over 25,000 installed devices
RAC Recycling Program 	Same program as prior year	The Home Depot, CAF, Ministry, NRCAN, Conservation Bureau	Over 6,600 RACs off the grid and recycled

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2006 Toronto Hydro CDM Programs Received EDA Innovations Award PR (all CDM campaigns) With CLD, received Ontario Energy Association — Company of the Year			
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
Summer Challenge 	Developed by Toronto Hydro staff this was the first program of its kind in Canada Asked customers to save 10% get 10% off their bill		Launched with then-Minister of Energy and one of the first programs then directed to be rolled out across Ontario. Winner of CPRS ACE Awards, CMA Award, IABC Silver Leaf Award, Green Toronto Award. 28% of customers received credit
Bright Ideas fall multi-retail 	Expanded offering from campaigns past: free CFL 2-pack; exchange old halogen floor lamps; exchange festive lights; get coupons (leveraged high traffic of THESL events to offer OPA coupons); sign up for peaksaver.	228 events (largest number of events to date) and first campaign with multiple retailers: The Home Depot, Costco, Home Hardware, Wal-Mart OPA EKC	Almost 142,000 CFLs distributed Almost 4,700 halogen torchieres and 15,000 incandescent festive light strings turned in. 398 peaksaver signups. Incremental sales (OPA coupons): over 200,000 CFLs and 2,300 thermostats; almost 12,000 dimmers and 700 motion sensors
Festive Light Exchange 	Same program as 2005	City of Toronto, TABIA	8,800 traditional strings off the grid and recycled 4,500 Seasonal LEDs distributed
Cool Shops Program 	Same program as 2005	The Home Depot, CAF	Audited over 750 businesses

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2006 Toronto Hydro CDM Programs **Received EDA Innovations Award PR (all CDM campaigns)** **With CLD, received Ontario Energy Association — Company of the Year**			
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
TAPS Thanks for turning on to TAPS Saving water and energy in your home	Same program as 2005	Enbridge Gas	Over 12,000 homes visited, almost 50,000 CFLs distributed
Business Incentives **power WISE® Business Incentive Program**	Same program as 2005	CLD, Enbridge Gas, City of Toronto	Over 75 projects
DAP 	Same program as 2005	Enbridge Gas, City of Toronto	Seven buildings
Low Income Program SOCIAL HOUSING SERVICES CORPORATION	Same program as 2005	Toronto Community Housing Corp. (TCHC) Social Housing Services Corp. (SHSC)	Over 48,000 stoves and refrigerators installed at TCHC buildings
2007 Toronto Hydro CDM Programs **International Association of Business Communicators, Gold Quill Award of Excellence and CPRS Ace National Gold Award for THESL Talk Box (used at CDM events to engage customers in a dialogue about conservation)**			
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
peaksaver peak saver peaksaver IS GOOD FOR THE ENVIRONMENT	Same program as 2005, with incentive of a $25 cheque for installation		Almost 13,000 installed devices (almost 1,000 of these were commercial)

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2007 Toronto Hydro CDM Programs International Association of Business Communicators, Gold Quill Award of Excellence and CPRS Ace National Gold Award for THESL Talk Box (used at CDM events to engage customers in a dialogue about conservation)			
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
RAC Recycling Program  	Same program as prior years	The Home Depot Clean Air Foundation (CAF)	Over 6,000 inefficient units collected and recycled over 4 weekends in June
Business Incentives power WISE® Business Incentive Program	Same PBIP program as 2005 THESL transitioned to new BIP program below under OPA	CLD, Enbridge Gas, City of Toronto	40 projects
BIP think BIP	Business Incentive Program (BIP) Launched revamped program in August 2007 under OPA	OPA directive disallowed THESL working with Enbridge or City of Toronto unlike PBIP above	14 projects within first six months of launch
DAP 	Same program as prior years	Enbridge only (OPA directive disallowed THESL working with City of Toronto)	Ten buildings

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2007 Toronto Hydro CDM Programs

International Association of Business Communicators, Gold Quill Award of Excellence and CPRS Ace National Gold Award for THESL Talk Box (used at CDM events to engage customers in a dialogue about conservation)

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
Festive Light Exchange 	Same program as prior years	TABIA and Cavalcade of Lights	IABC Communications Award Almost 18,000 sets of incandescent seasonal lights turned in and almost 8,500 SLEDs given in exchange
Summer Challenge for Business 	Building off of residential Summer Challenge success, launched program for business first of its kind in Canada		Two IABC (International Association of Business Communicators) and two CPRS (Canadian Public Relations Society) Awards, as well as Chartwell and the Canadian Marketing Association (CMA). Almost 13,000 business customers got 10% credit.
Summer Savings 	Same premise as Toronto Hydro's Summer Challenge, now overseen by OPA	OPA	THESL collaborated with OPA as they rolled out a program province-wide based on Toronto Hydro's program 31% of THESL's eligible residential customers got a 10% credit
The Great Refrigerator Round Up (TGRR) 	Have your old, second fridge picked up for free out of your home	OPA	OPA rolled out this CLD program province-wide Over 5,000 appliances picked up in Toronto

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2007 Toronto Hydro CDM Programs

International Association of Business Communicators, Gold Quill Award of Excellence and CPRS Ace National Gold Award for THESL Talk Box (used at CDM events to engage customers in a dialogue about conservation)

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
TAPS	Same program as prior years Partnership ended in 2007, as THESL transition to OPA programs	Enbridge Gas	Over 33,000 CFLs distributed
Low Income Program	Same program as prior years until THESL transitioned to new program under OPA	SHSC and TCHC (OPA directive disallowed THESL working with TCHC on a go-forward basis, so TCHC partnership ended) OPA	Under THESL's old program: -Almost 8,000 old fridges and stoves replaced at TCHC buildings -Lighting retrofits at seven SHSC locations Under THESL's new OPA program: -Over 20,000 CFL bulbs installed at 55 SHSC buildings

2008 Toronto Hydro CDM Programs

Chartwell Best Practices Award, Marketing

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
Peaksaver 	Same program, various incentives		Over 10,000 installed devices (109 of these were commercial)
Summer Sweepstakes	OPA program	OPA	Almost 1,300 registered customers achieved 10% consumption reduction

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2008 Toronto Hydro CDM Programs

Chartwell Best Practices Award, Marketing

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
TGRR	Have your old, second fridge picked up for free out of your home	OPA	Over 5,700 appliances collected
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
Festive Light Exchange 	Same program as prior years	TABIA and Cavalcade of Lights	Bronze Award winner for CPRS Ace Toronto - Community relations campaign of the year. Almost 19,000 strings of incandescent lights exchanged for approximately 9,500 strings of LED lights
Low Income Program	Same program as 2007, but introduced Community Champion component	SHSC	Over 57,000 CFL bulbs installed in over 12,000 tenant units. Community Champion program saw 13 individuals attend 14 hours of training sessions at Seneca College's Centre for Built Environment
Take a Load Off Toronto – Spring Multi-retail 	Get a free retractable clothesline; get discounts on cold water laundry detergent and specialty CFLs; get EKC coupons; sign up for peaksaver	149 in-store events with: Costco Wholesale, The Home Depot, Wal-Mart and Zellers	Premier McGuinty launched program with THESL. Winner of three IABC awards, a CMA award and eight CPRS awards including creative PR campaign of the year. 75,000 clotheslines distributed, almost 18,000 specialty CFLs sold, over 3,000 cold water laundry detergent sold. Over 1,500 peaksaver signups.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2008 Toronto Hydro CDM Programs

Chartwell Best Practices Award, Marketing

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
RAC Recycling Program 	Same program as prior years, tied in peaksaver program	The Home Depot Clean Air Foundation (CAF)	Two CPRS and an IABC Award Over 7,500 inefficient units collected and recycled Over 400 peaksaver signups
BIP	Same program		Over 100 projects

2009 Toronto Hydro CDM Programs

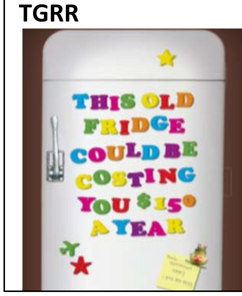
PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
Peaksaver	Same program, various incentives with incentive increase to $75		Over 10,000 installations (mainly residential customers)
Summer Challenge	Similar to Toronto Hydro's original Summer Challenge, except with registration criteria		Over 2,200 registered customers achieved the 10% reduction

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2009 Toronto Hydro CDM Programs

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
RAC Recycling Program 	Same program	The Home Depot Clean Air Foundation (CAF)	Collected approximately 5,900 inefficient room air conditioners and approximately 1,300 old dehumidifiers
BIP	Same program		Almost 130 projects
PSB 	Power Savings Blitz (PSB) First full year of program (launched late 2008)		Completed approximately 16,000 lighting retrofits and achieved more than double the annual energy savings target set by OPA
DCIP	Data Centre Incentive Program (DCIP) Based on an OPA-approved PowerStream program	PowerStream, IT community	Approved 11 project applications in 2009

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2009 Toronto Hydro CDM Programs			
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
Festive Light Exchange 	Same program	28 events with TABIA and Cavalcade of Lights	Collected approximately 22,000 strings of old Christmas lights, distributed approximately 10,000 LED strings
Spring Turn On 	Receive a specialty CFL plus THESL coupons Education on phantom power and time-of-use rates	100 events at The Home Depot and Canadian Tire	Distributed approximately 40,000 specialty CFLs Over 4,500 specialty CFLs and over 2,300 power bars with timers/sensors sold
Low Income Program SOCIAL HOUSING SERVICES CORPORATION	In-suite light replacement program and the Community Champion program	SHSC and Green Light on a Better Environment (GLOBE)	Installed approximately 58,000 CFLs in approximately 10,700 social housing units across Toronto By the end of 2009, 80 Community Champions and 170 individuals, including housing providers and staff, were trained
TGRR 	Same program		Created a unique PR campaign to promote program, winning two CPRS and three IABC Awards. Collected approximately 5,700 appliances

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2010 Toronto Hydro CDM Programs

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
peaksaver®	Same program as prior year		Toronto Hydro peaksaver creative won 2010 NAMMU award Over 7,000 installations (mainly residential) About 35% of enrollments came from Toronto Hydro event sign ups
The Great Exchange 	Toronto Hydro designed. Broadened retail partners and collection outside of retailers		Collected 8,300 inefficient room A/C units and 1,600 old dehumidifiers
BIP	Same program		Over 200 projects
PSB 	Same program		12,600 lighting retrofits
DCIP	Same program as previous year	PowerStream, IT community	Approved 26 project applications and delivered 17 projects

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2010 Toronto Hydro CDM Programs			
PROGRAM	**PROGRAM DEVELOPMENT**	**PARTNER COLLABORATION**	**PROGRAM HIGHLIGHTS & SUCCESSES**
Festive Light Exchange 	Same program		Collected 18,000 strings of old Christmas lights in exchange for 8,700 LED strings or gift cards
Take A Load Off 	Toronto Hydro designed program. Purchase an ENERGY STAR washing machine and receive an instant $80 rebate, a free drying rack ($68 value) and a $60 mail-in rebate	Caplan's Appliances and The Home Depot City of Toronto Water Department	Sold 1,500 ENERGY STAR washers and distributed 4,700 dying racks
Beat the Peak 	Designed and applied by Toronto Hydro to OPA through custom program mechanism. Leveraged high traffic THESL events to offer OPA coupons	Walmart, Sears, Canadian Tire, Staples, school boards, Ontario Electronics Stewardship (OES) OPA	Winner of EDA Innovation Award Distributed 72,000 power bars with timers
Great Refrigerator Round Up 	Same program	OPA	Collected over 5,600 refrigerators and freezers

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

2010 Toronto Hydro CDM Programs

PROGRAM	PROGRAM DEVELOPMENT	PARTNER COLLABORATION	PROGRAM HIGHLIGHTS & SUCCESSES
HELP Low Income Program	THESL custom program which provides low income single family homes with: insulation; furnace upgrade; low flow toilets; power bars; CFLs; drying racks; window a/c replacement; timers	City of Toronto; Enbridge; City of Toronto Water Department	Program launched in fall 2010 Program is ongoing
Vending Miser 	THESL custom program encouraging businesses to take advantage of a $150 incentive for an energy management system for refrigerated vending machines		500 installed
GreenEats	Custom program is a collaboration between partners to offer existing programs (BIP/PSB) to segment through trusted industry association. Educations on TOU rates, time shifting and CDM programs	Ontario Restaurant Hotel and Motel Association; Enbridge	Over 75 leads generated during three month initiative
Ice Bear Pilot	Pilot rolled out at selected small commercial building sites in THESL and Veridian territory for the installation of Ice Energy (energy storage solution)	OPA, Veridian, Summerhill, IceBear	Twelve installations during fall 2010 Pilot is ongoing

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 2:

Reference(s): none provided

While the Alliance complements Toronto Hydro in participating in the redevelopment of the Ontario Power Authority ("OPAU)-Contracted Province-Wide Conservation and Demand Management Programs (OPA Programs), what process was followed to develop these programs? Did the OPA provide Toronto Hydro with any financial resources to cover the cost of staff time associated with these processes?

RESPONSE:

The process is as follows:

1) The EDA established a Joint Steering Committee (JSC) and CDM Caucus to govern the re-development of the OPA province-wide programs.
2) Working groups were established with membership from large, medium and small local distributors companies (“LDCs”) who were assigned to support program development.
3) The working groups met routinely to advance the development of each program.
4) Program development work was brought before the CDM Caucus and ultimately the JSC for approval and recommendation to all LDCs.

Yes, the Master CDM Program Agreement between the OPA and the LDCs allow for the recovery of all Eligible Expenses associated with the 2010 working groups and will form part of the LDC’s 2011 Program Administration Budget.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 3:

Reference(s): none provided

What limitations, if any, did Toronto Hydro encounter in participating in redeveloping the OPA programs including availability of resources, timely access to information, particularly respect to the proposed program designs, projected program budgets, cost/benefit analysis of plans, programs and specific measures as well as estimated targets. What evaluations of earlier OPA programs were provided to Toronto Hydro? Please file copies of all evaluations of OPA programs provided to Toronto Hydro.

RESPONSE:

THESL submits that by its application submission date it had all the required information to accurately file its proposed Board-approved programs in compliance with the OEB's CDM Code. To THESL's knowledge, no evaluation of earlier OPA programs was provided to Toronto Hydro.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 4:

Reference(s): none provided

The OEB's CDM Code requires each LDC to file a CDM Strategy and provides a template for doing so, which Toronto Hydro appears to have conformed to in its application. Did the OPA provide similar documentation to Toronto Hydro? If so please file any shared OPA documents that would approximate what is included in the OEB template requirements.

RESPONSE:

No, THESL did not receive any CDM Strategy or similar documentation from the OPA.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 5:

Reference(s): none provided

It appears to the Alliance that Toronto Hydro has conformed to the spirit of the Code. Were there practical difficulties in fully conforming to the letter of the Code? In particular, were there practical difficulties in reconciling requirements such third party evaluations from an OPA vendor list in advance of Board Approval of it s programs and the funds to retain such third parties? Was this also a difficulty in retaining vendors to develop implementation plans?

RESPONSE:

THESL submits that it has conformed to all aspects of the OEB Code and has provided additional evidence to clarify any ambiguity identified in other related OEB procedural orders.

As it relates to expending funds to develop the proposed OEB Board-approved programs in advance of OEB approval, it is THESL's position that the costs contained in its February 25, 2011 Addendum to the CDM Applications were prudently incurred and will be fully considered for recovery by the OEB.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 6:

Reference(s): none provided

Does Toronto Hydro believe that the OPA programs (with the exception of the Low Income Program) have been established as required by the CDM Code? If not what criteria does Toronto Hydro consider to be an appropriate and reasonable test for the establishment of programs?

RESPONSE:

Please refer to the response to Board Staff Interrogatory 3.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 7:

Reference(s): **none provided**

Has the recent OPA advertising campaign advising consumers to contact their local utility had any impact on Toronto Hydro's Call Centre activities? Has Toronto Hydro experienced any situations in which its customers would be better served by one of its non-duplicative programs than by the OPA programs? What advice did you give to such customers?

RESPONSE:

At the time of this response, THESL cannot report call centre impacts as a result of the OPA advertising campaign. The OPA CDM residential and commercial programs were recently launched on March 3, 2011. As such, it is too early to evaluate the impact on THESL's Call Centre.

No, THESL has not experienced a situation in which a customer would be better served by one of its Board-Approved programs. THESL's proposed Board-Approved programs have been designed and submitted to address a CDM market opportunity that was not identified in the OPA province-wide programs and/or is unique to THESL's customer base and/or market. THESL's proposed Board-Approved programs have been designed to be complementary and not an alternative to the OPA province-wide programs.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 8:

Reference(s): none provided

The Code requires Toronto Hydro to use the OPA measures and assumptions lists as well as its cost effectiveness tests. Is Toronto Hydro aware of any requirement in the Code to calculate rate impacts of the implementation of OPA Programs or Board approved Programs? Does Toronto Hydro have the data required to perform such rate impact calculations given that the costs associated with both types of programs will come out of the Global Adjustment Fund and applied to all customers and the benefits of such programs depend on the future supply mix in the province? Are there additional costs associated with any phase of program planning, development, implementation or evaluation that will be charged to Toronto Hydro distribution customers that are not included in the application?

RESPONSE:

THESL is not aware of any section within the CDM Code which would require the filing of rate impact calculations, and THESL does not have all the required data to perform such calculations. Please see response to Board Staff Interrogatory 1b.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 9:

Reference(s): none provided

Is Toronto Hydro aware of any requirement in the Code to perform sensitivity analyses for its programs? Is Toronto Hydro aware of any requirement in the Code to develop a program logic model, particularly given how the Code has differentiated OPA programs and Board approved Programs?

RESPONSE:

THESL is not aware of any explicit OEB Code requirements to perform or provide a sensitivity analysis or program logic modeling. For all submitted Board-approved applications, THESL followed the requirements as defined specifically under Section 3.0, item 3.1.4 of the CDM Code.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 10:

Reference(s): none provided

Does Toronto Hydro anticipate the need for any changes to the Board's COM Code as a result of having gone through the first iteration of program design?

RESPONSE:

THESL respectfully declines to provide an answer to this interrogatory as the question does not pertain to any of the issues on the Issues List. The CDM Code has been approved by the OEB in its current form, and any revisions or amendments would be more properly addressed in a generic policy proceeding.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 11:

Reference(s): none provided

The funding for OPA programs, particularly for those programs with high incentive levels is virtually open ended for a distributor that achieves higher levels of participation than expected by the OPA for the province on average. Is Toronto Hydro prepared to overachieve on its targets if the OPA programs deliver more than expected by the OPA? If such a mechanism were in place for Board approved programs, would Toronto Hydro use it overachieve on the results it expects to achieve from its own program? The evidence suggests that Toronto Hydro is developing additional programs - will these only be submitted for approval is it appears that its share of the provincial target will be met?

RESPONSE:

THESL is prepared to overachieve on its targets if the OPA programs deliver more than expected.

Yes, if such a mechanism were in place for Board approved programs, THESL would use it to overachieve on the results it expects to achieve from its own program.

THESL is considering submitting additional programs for OEB approval later in 2011. The submission of the additional programs would not be delayed to assess reports that confirm THESL’s share of the provincial target will be met by current OPA and any pending Board-Approved programs.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 12:

Reference(s): none provided

How will Toronto Hydro manage the integrations of staff working on the OPA programs with those assigned to the Board approved programs to avoid any customer confusion?

RESPONSE:

Each program is unique to address a target market sector.

Three levels of customer support will be provided:

1. THESL's Web pages will provide information specific to each program and customer care telephone numbers:
   http://www.torontohydro.com/sites/electricsystem/residential/Pages/default.aspx
2. Customer Care staff will be trained to assist and respond to customers for all program initiatives and direct them to program specialists or information sources.
3. Business and technical support staff will provide customers with specialized and program specific guidance and support.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 13:

Reference(s): none provided

Ministerial conservation-related directives since the passage of the Green Energy and Green Economy Act to both the OPA and the Board have ensured that LOC targets include both peak reductions and energy reductions. In Toronto Hydro's view, how has this impacted both the design and select ion of OPA programs and it s requested programs, particularly with respect to programs and budgets allocated to OPA demand response programs which deliver no energy saving results?

RESPONSE:

In THESL’s view, the design and selection of the OPA programs were based on a two staged design approach. The first stage was to develop programs that targeted summer peak demand megawatt (MW) reductions to support the primary goal identified in Ontario’s Long Term Energy Plan, formerly OPA’s Integrated Power Supply Plan (IPSP); to phase out coal generation by 2014. Energy end-use assets were identified in all market sectors and targeted using incentive programs to encourage investment up-take. While this effort will contribute to the success of displacing summer peak generation (e.g. coal generation) summer peak demand hours are limited and results in minimum energy consumption (megawatt-hours) reduction and do not support the *Green Energy and Economy Act* goal of the developing a conservation culture in Ontario. Therefore, the second design stage was to develop programs specifically for energy consumption reductions to help customer identify and invest in energy efficiency to lower their overall energy bills and to promote a sustainable conservation culture.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

THESL was very involved in the development of the OPA programs in 2010 through the Electrical Distribution Association (EDA) and OPA CDM program development working groups. As one of the working group members, THESL had an inherent knowledge of all available OPA province-wide programs and selected a portfolio of programs; a combination of OPA Province-wide and potential Board-Approved programs, based on its comprehensive understanding of its markets and customer needs.

THESL views the demand response (DR) programs as a key program and critical to the success of achieving its CDM targets. THESL's overall CDM strategy is to target demand and consumption reductions using a combination of energy efficiency incentive programs, as well as gain control of the energy assets for purposes of demand response.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 14:

Reference(s): **none provided**

In Toronto Hydro's letter to the Board dated February 25, 2011, it requested that the Board approve an additional $343,449 which relates to program planning and development costs for the years 2010 and 2011. What would this number have been if Toronto Hydro had also incurred program implementation and evaluation planning costs in advance of approval of the programs?

RESPONSE:

THESL submits that this is a hypothetical question at this time. However, THESL has consistently discussed estimates in the range of approximately $350,000 to staff members of the Board and Ministry since early 2010 when the need for funding for planning and development purposes was first identified.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 15:

Reference(s): none provided

Is Toronto Hydro aware of any industry standards for the ratio of program planning and development to total program costs?

RESPONSE:

THESL is not aware of any industry standards for the ratio of program planning and development to total program costs.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 16:

Reference(s): **none provided**

How much of this amount represents any of the costs associated with Toronto Hydro's participation in the redevelopment of OPA programs?

RESPONSE:

THESL submitted an Addendum to its Application for 2011-2014 Board-Approved CDM Programs which detailed the requested recovery of costs incurred in the planning and development of the proposed nine programs. The amount requested was for $343,449 including estimated costs for regulatory proceedings. It does not include any redevelopment of OPA programs. The amount requested represents 0.6 % of the total budget of $56,327,988 for the nine programs.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 17:

Reference(s): none provided

Will these costs increase if Toronto Hydro does not get timely approval of its programs or if the estimates of regulatory costs are greater than estimated?

RESPONSE:

THESL submits that a delay in the approval of its programs will affect the potential savings expected to be achieved and places greater risk on its ability to achieve the OEB assigned targets. Achieving lower than projected savings in peak demand (MW) and electric energy consumption (GWh) would reduce participant incentive costs. It would also reduce the overall program effectiveness and the cost effectiveness test ratios.

Delays and increased regulatory cost would have the potential to increase the requested recovery amount submitted in the Addendum to THESL's Application for 2011-2014 Board-Approved CDM Programs.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 18:

Reference(s): Program #1: Business Outreach and Education

Some of the target markets for this program have been partially served by the OPA's Toronto-specific program that was implemented by BOMA Toronto. How will Toronto Hydro overcome any lost momentum in the availability of programs given that the BOMA delivered program ended in 2010?

RESPONSE:

THESL has been working with BOMA to continue to support BOMA Toronto's CDM success in the commercial market segment. Through a channel partner relationship with THESL, BOMA will be charged with CDM targets and activities associated in achieving those targets in the commercial market segment. THESL and BOMA have been working together to maintain momentum in the market place by continuing to provide information to their customers while working on a formal agreement.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 19:

Reference(s): Program #1: Business Outreach and Education

How does this market segment for your service territory differ from the segment for the province as a whole?

RESPONSE:

THESL believes that the commercial market segment in Toronto is slightly more advanced along the energy efficiency timetable in comparison with other "average" commercial markets in Ontario, as Toronto has typically been an early mover in the area of CDM. This is based on the recognition that the commercial marketplace in Toronto is very competitive, which has played a driving role in the uptake of CDM activities as a means of differentiation between building owners. For example, lighting is often referred to as "low hanging fruit" or the first CDM activity that a customer will attempt. In fact, most of this opportunity has been completed by the majority of the downtown commercial core. These customers are looking to invest in deeper CDM technologies. THESL aims to have program options that will enable this objective to be met.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 20:

Reference(s): **Program #2 – Commercial Energy Management and Load Control**

Please explain the difference between customers being eligible for a program versus a program which targets specific customers. For example, low income customers are eligible for all OPA current residential programs, but nevertheless, a province wide program is under development for low income customers because the current programs are not designed to meet their needs. Is this comparable to your analysis with respect to this program?

RESPONSE:

Targeted programs are reflective of situations where improved participation rates can be achieved by focused sales and marketing, or by enhancing the value of any available offering to the customer.

The example cited above for the low-income programs is a similar situation to that of the CEMLC program. The CEMLC program is designed to reduce the energy use and peak summer demand in the office, retail, institutional, and hospitality sectors in facilities with an average monthly demand less than 200kW. This market sector is an important target group for CDM programs for the following reasons:

- There has been only limited application of energy savings measures beyond lighting upgrades, and this class of facility has typically not adopted building automation technology.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

- Current demand response capacity is negligible for customers with an average demand ranging between 50kw and 200kW. As an example, THESL's experience to date demonstrates that in small commercial facilities that are under 50kW, participation rates have been disappointing (i.e., less than 2% participation in *peaksaver*).

THESL believes there are significant CDM opportunities in this market segment that are currently not addressed by province wide programs and market specific targeting is the only way to achieve these objectives.

Although *peaksaver* and the demand response programs 1 and 3 could, in theory, be applied to this market group, they are designed for single-family residences and large industrials respectively. Without a load control program as an enticement in the less than 200kW class of customers there will be negligible results in this sector.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 21:

Reference(s): **Program #2 – Commercial Energy Management and Load Control**

Do you anticipate that your RFP for vendors to deliver this program will result in all vendors offering similar approaches or do you anticipate that vendors will bring alternative implementation plans or deployment approaches such as proprietary software, marketing innovations and technologies that will differentiate the proposals on matters other than price? Do you also anticipate that the EM&V required will vary from one proposal to the other, particularly in response to alternative implementation plans? Is it possible that the approach, cost and effectiveness of EM&V could vary significantly given the implementation plan? For example, if the successful vendor offered real time monitoring results, would the EM&V require less sampling than a vendor who offered a program based on engineering estimates?

RESPONSE:

a) THESL anticipates that the vendor responses will be relatively uniform in terms of approach and implementation. THESL expects that there will be considerable variation in the technology solutions both at the field level and at the supervisory level.

b) THESL does not believe that there will be significant variations to the EM&V as the requirements for vendor participation in the program EM&V will be defined in the RFP.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

c) THESL does not anticipate that the cost and effectiveness of the EM&V will vary across the proposals. The ability to handle and store data from demand response events will be one of the key criteria in the services provided by the successful respondent. There will also be the ability to automate the results using THESL's billing system as required.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 22:

Reference(s): **Program #3 Commercial, Institution and Small Industrial Monitoring and Targeting**

In its submission in EB-2010-0215, Toronto Region Conservation Authority shared its lessons learned from performance based conservation:

i) performance based conservation delivers far greater energy savings than previous approaches to energy (and water) conservation,
ii) the larger part of the savings is found in low/no cost improvements,
iii) successful and sustainable conservation has more to do with good management than with technology,
iv) conservation programs have to support building managers with information, tools and resources so that they can recognize the unique set of conservation opportunities in their facilities,
v) benchmarking can identify buildings with high conservation potential, inform target setting and point to where savings are to be found in each building, and
vi) monthly savings reporting flags variances in predicted savings, identifies measures which do not perform as intended, verifies savings which have been achieved and guides continuous improvement

a) How will this program relate to the Green Energy and Economy Act requirements for energy management plans in the broader public sector?

RESPONSE:

THESL believes the Monitoring and Targeting program is an enabler for energy management planning in all markets segments including the broader public sector. The

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

program is consistent with the lessons quoted above and is designed to serve as a management tool for facilities and operations staff. Increasing the knowledge and information of where energy is consumed and the awareness level of efficiency opportunities goes hand in hand with energy management planning.

RESPONSES TO INTERROGATORIES OF CANADIAN ENERGY EFFICIENCY ALLIANCE

INTERROGATORY 23:

Reference(s): **Program #3 Commercial, Institution and Small Industrial Monitoring and Targeting**

On page 14 of this program description (section3), Toronto Hydro indicated that it had used the more conservative estimate for savings based on a CIPEC report. Please confirm that this report was limited to the industrial sector and might not be representative of the full market.

RESPONSE:

The savings attributable to M&T systems vary with studies noting 5-15% savings based on experience in the UK, USA and Canada. The specific reference in the CIPEC is attributable to an overall recommendation of 8% and is not exclusive of the industrial segment.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 1:

Reference(s): none provided

Please provide a tabular summary with:

- the MW and MWh savings expected from each proposed program and from THESL delivery of OPA province-wide programs in each of the four years and persisting at the end of 2014
- the Directive targets that have been allocated to THESL

RESPONSE:

Please refer to response to Vulnerable Energy Consumers Coalition Interrogatory 1 found at Exhibit J, Tab 10, Schedule 1.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 2:

Reference(s): **none provided**

For each proposed CDM program, please list the *annual* MWh savings that will persist and occur in each of 2014 and 2015 and 2020 from the combined effect of the four years of program effort.

RESPONSE:

Program Name	Annual MWh Savings			Equipment Life (years)	Free Ridership (%)
	2014	2015	2020		
CEMLC	5,777	5,777	5,777	15	10
Flat Rate Water Heaters	1,763	1,763	1,763	13	30 Conversion 10 *peaksaver*
HSBP	39,368	39,368	39,368	10	30
Monitoring and Targeting	28.047	28.047	28,047	8	30
MURB DR	248	248	248	10	10

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 3:

Reference(s): none provided

For each proposed program please provide the completed evaluation plan showing the particular data that will be collected for each measure and each participant and for each program.

RESPONSE:

See response to Board Staff Interrogatory 6 parts (a), (b), and (c).

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 4:

Reference(s): none provided

For each proposed program that includes energy or capacity savings, please describe how THESL has estimated free ridership and describe any evaluation that will occur to monitor free ridership.

RESPONSE:

A free-rider rate of 30% was used in the analysis for the following programs: Hydronic System Balancing, Monitoring and Targeting and Flat Rate Water Heaters (conversion only). This is the default free-rider factor for custom projects noted in page 9 of the OEB’s Decision and Order in proceeding EB-2007-0096. A nominal 10% free-ridership factor has been applied to the CEMLC, FRWH (peaksaver component) and MURB DR programs to be consistent with the values used by the OPA in evaluating peaksaver.

Monitoring of free-ridership is incorporated in both the evaluation templates provided and described in the Draft Evaluation Plans that will be provided prior to the hearing.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 5:

Reference(s): **none provided**

For each proposed program please describe how participation rates were estimated and provide any studies or data relied upon.

RESPONSE:

The estimated penetration rates are discussed in Section 2.2 of the Applications. The reports used to estimate the penetration rates are noted in the table below and attached as Appendices A-E.

Program	References
CEMLC	None. Based on experience with peaksaver and Direct Install programs.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 5:

Reference(s): none provided

For each proposed program please describe how participation rates were estimated and provide any studies or data relied upon.

RESPONSE:

The estimated penetration rates are discussed in Section 2.2 of the Applications. The reports used to estimate the penetration rates are noted in the table below and attached as Appendices A-F.

Program	References
CEMLC	None. Based on experience with peaksaver and Direct Install programs.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

Program	References
M&T	1) PECI and Summit Building Engineering. California Commissioning Collaborative, (2007).California retro-commissioning market characterization 2) DeCanio, Stephen. (1993). Barriers within firms to energy-efficient investments. Energy Policy, 21, 906-914. 3) Anderson, S.T., & Newell, R.G. (2004). Information programs for technology adoption: the case of energy-efficiency audits. Resource and Energy Economics, 26, 27-50. 4) Leslie, Keith. (2010, November 21). Huge investments to update power system, plus green energy, behind rate hikes. The Canadian Press. 5) Gillingham, K, Newell, R.G, & Palmer, K. (2009). Energy efficiency economics and policy. Resources for the Future. 6) Zak, Juan, & Ramirez, Edwin. (1999). Introduction to monitoring and targeting. Proceedings of the Ministry of Economy and Planning (Cuba).
FRWH	None. Based on results from previous communication campaigns.
HSBP	1) PECI and Summit Building Engineering. California Commissioning Collaborative, (2007).California retro-commissioning market characterization 2) DeCanio, Stephen. (1993). Barriers within firms to energy-efficient investments. Energy Policy, 21, 906-914. 3) Anderson, S.T., & Newell, R.G. (2004). Information programs for technology adoption: the case of energy-efficiency audits. Resource and Energy Economics, 26, 27-50. 4) Leslie, Keith. (2010, November 21). Huge investments to update power system, plus green energy, behind rate hikes. The Canadian Press.

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Program	References
MURB DR	Same as CEMLC response.
Business Outreach & Education	Event driven participation rates. Based on experience from 2005 – 2010. See response to OEB staff question No. 15.
Greening Greater Toronto – Commercial Building Energy initiative.	Membership driven. Governing council includes members that represent over 40% of commercial space in Toronto.
Community Outreach & Education	Event driven. Base on experience in running education and outreach programs from 2005 – 2010.

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Information programs for technology adoption: the case of energy-efficiency audits

Soren T. Anderson[a], Richard G. Newell[b,*]

[a] University of Michigan, Ann Arbor, MI, USA
[b] Resources for the Future, 1616 P St. NW, Washington, DC 20036, USA

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Abstract

We analyze technology adoption decisions of manufacturing plants in response to government-sponsored energy audits. Overall, plants adopt about half of the recommended energy-efficiency projects. Using fixed effects logit estimation, we find that adoption rates are higher for projects with shorter paybacks, lower costs, greater annual savings, higher energy prices, and greater energy conservation. Plants are 40% more responsive to initial costs than annual savings, suggesting that subsidies may be more effective at promoting energy-efficient technologies than energy price increases. Adoption decisions imply hurdle rates of 50–100%, which is consistent with the investment criteria small and medium-size firms state they use.

JEL classification: Q41; Q48; O33; O38; C25

Keywords: Energy efficiency; Information; Technology adoption; Energy audits

1. Introduction

Interest in energy-efficiency improvements has been reinvigorated by concerns ranging from the environmental effects of fossil fuel combustion—such as climate change due to carbon emissions or environmental damage caused by other pollutants (e.g., SO_x and NO_x)—to energy price volatility and national security. The US National Energy Policy, for example, recommends establishing “a national priority for improving energy efficiency” (White House, 2001), which supports the Bush Administration’s climate policy goal of decreasing the “greenhouse gas intensity” of the economy. As policies that would entail

* Corresponding author. Tel.: +1-202-328-5111; fax: +1-202-939-3460.
E-mail address: newell@rff.org (R.G. Newell).

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significant energy price increases are unlikely to be politically attractive in the near term, the focus has been on the development and diffusion of technology through other means. Thus, policy proposals have tended to emphasize programs that foster research, development, and deployment of technologies, government–industry partnerships, tax credits and other financial incentives, minimum appliance efficiency standards, voluntary agreements, and information programs.

Information programs, which seek to encourage energy efficiency by increasing awareness of conservation opportunities and offering technical assistance with their implementation, are an important element of this energy-efficiency policy portfolio. These programs take a variety of forms, including educational workshops and training programs for professionals, advertising, product labeling, and energy audits of manufacturing plants. In addition to alerting firms to profitable conservation opportunities, access to more accurate performance information can reduce the uncertainty and risk associated with adopting technologies that are new, or that receive differing reviews from equipment vendors, utilities, or consultants. The economic rationale for these programs lies primarily in public good aspects of knowledge and information provision. Although these public information programs are not free, the cumulative benefit of educating many users with similar information can greatly exceed the costs. Such information, however, tends to be under-provided by the private sector. Concerns about environmental externalities associated with energy production and use provide additional justification for these programs.

Despite the role that information programs play in existing and proposed energy-efficiency policy portfolios, surprisingly little is known about how participants respond to such programs. Although a reasonably large literature surveys various market barriers and market failures in energy-efficiency investment,[1] few analyses have focused specifically on information programs. This is in part due to a lack of adequate data for analysis. One exception is Morgenstern and Al-Jurf (1999), who analyze data from the Department of Energy's 1992 Commercial Buildings Energy Consumption Survey. They find that information provided through demand-side-management utility programs appears to make a significant contribution to the diffusion of high-efficiency lighting in commercial buildings. Although not the focus of their examination of energy-saving product innovation, Newell et al. (1999) find that the responsiveness of energy-efficient innovation in home appliances to energy price changes increased substantially during the period after energy-efficiency product labeling was required. DeCanio and Watkins (1998) investigate voluntary participation in the US Environmental Protection Agency's Green Lights Program, which offers companies technical expertise while committing them to a set of energy-efficient lighting improvements. They find that the characteristics of individual firms influence their decision to participate in the program.

We focus here on actions taken by manufacturing plants in response to energy audits offered through the US Department of Energy's Industrial Assessment Centers (IAC) program, which has been providing energy assessments at no financial cost to small and medium-sized manufacturers since 1976. This program is of interest for several reasons. First, significant opportunities to conserve energy may exist in the industrial sector, which represents 37% of total national energy consumption. Second, the opportunity to focus on the behavior of

[1] See, for example, Ruderman et al. (1987), Sutherland (1991), Jaffe and Stavins (1994), and Metcalf (1994).

small and medium-sized firms is rare due to data constraints, even though these firms represent over 98% of all manufacturing firms and more than 42% of total manufacturing energy consumption. This focus is particularly appropriate given that smaller firms are more likely to benefit from access to information and expertise, which tend to be more readily available to larger firms. Finally, the IAC program has generated an unusually extensive set of data on the characteristics of conservation opportunities identified and actions taken under the program (US Department of Energy, 2001). One attractive aspect of these data is that there are multiple observations available for each firm, allowing us to employ a fixed effects model to control for unobserved differences in firms' propensities to adopt technology.

Because of their detail, these data provide a unique opportunity to quantify the factors that encourage small and medium-sized industrial firms to invest in energy-conserving technologies. After summarizing the general character of projects adopted under the IAC program, we explore the influence of technology costs, expected energy savings, and individual firm characteristics on the likelihood of adopting projects. We employ models of varying flexibility to examine and compare the degree of response to differences in capital costs and operating cost savings, as well as the energy price and quantity differences that underlie savings. The results strengthen our understanding of how certain factors influence technology adoption decisions, and whether this behavior is consistent with economic expectations. In addition, the results offer evidence on the likely relative effectiveness of policies aimed at increasing energy efficiency, such as energy or carbon price increases, technology subsidies, and policies that directly alter the energy use of technologies.

Another important aspect of this type of investment decision-making is the "payback cutoff," "hurdle rate," or other discounting factor that firms employ when measuring current costs against future benefits. There is a substantial literature that suggests that "implicit discount rates," which one can calculate based on the capital cost versus operating cost savings of various implemented and unimplemented projects, can in practice be quite high relative to market interest rates (Hausman, 1979; Train, 1985). A related literature further contends that these high implicit discount rates are attributable to various market barriers and market failures—including information problems—and that these problems can be ameliorated by appropriate policies (Ruderman et al., 1987; Jaffe and Stavins, 1994).

Accordingly, several analyses of carbon mitigation costs have modeled the effect of information programs and other policies by significantly lowering the discount rate used for energy-conservation decisions. The clean energy futures study (Brown et al., 2001; Interlaboratory Working Group, 2000), for example, lowered investment hurdle rates to 15% in the industrial sector (and 7% in the residential sector) to capture the effect of information programs and other energy-conservation policies. Such lowering of hurdle rates has the intended effect of decreasing estimated energy use in the model, but modeling the effect of information programs in this way also leads to a number of side effects. Lower hurdle rates also increase the rate at which energy use declines in response to energy price increases resulting, for example, from a carbon permit system or carbon tax. This implies a reduction in the cost of carbon mitigation efforts through carbon price policies.

By expanding the perceived range of investment opportunities available to firms, information programs may indeed lead to the adoption of profitable but previously unimplemented technologies, associated energy use reduction, and lower observed *implied* hurdle rates. But this does not imply an across-the-board reduction in the *actual* investment hurdle rate, which is unobserved and could remain at pre-policy levels. In other words, it is entirely possible that managers continue to apply hurdle rates well above market interest rates to the new set of possibilities brought forth by an information program. On the other hand, it is possible that information programs actually do significantly alter the way in which firms trade off the current costs and future benefits of all energy-conservation opportunities, for example, by educating managers to focus more on the operating cost savings of projects.

We explore these issues by examining the rates of return for potential projects faced by firms that participated in the IAC program to determine whether the level of implicit discounting used by plants that received information assistance may have decreased to levels that some studies suggest. Finally, we analyze the reasons given by firms for not adopting recommended projects in order to determine whether this decision is due to the economic undesirability of the projects, or to some remaining type of market barrier or failure.

We find that about half of the projects recommended by energy assessment teams are actually adopted by the plants receiving these recommendations, although we cannot say how many of these projects might have been adopted in the absence of the energy audit. We find that that firms respond as expected to marginal changes in the financial characteristics of projects (i.e., technology costs, energy prices, the quantity of energy saved, energy operating cost savings, and the payback period). Firms are about 40% more responsive to investment costs than to energy savings, suggesting that policies to reduce implementation costs may be somewhat more effective than various mechanisms that raise energy prices. Although the financial characteristics of projects are clearly important, there also appear to be other, unmeasured project-specific factors (e.g., individual project lifetimes, unmeasured costs and benefits, uncertainty regarding costs and benefits, or project complexity and risks) that influence the investment decision. In contrast to previous studies, we find that plant size has no measurable effect on the adoption decision among the small and medium-sized firms in our sample.

We estimate that the investment threshold typically used by the plants in evaluating which energy audit recommendations to adopt was about a one to 2-year payback, which corresponds to an implicit hurdle rate of 50–100% for projects lasting 10 years or more. Although we are unable to determine whether participation in the IAC program actually lowered investment hurdle rates, these payback thresholds are consistent with what many surveys of plant managers suggest that they deliberately use for many types of investments, including those for energy conservation. In any event, these hurdle rates are many times higher than those assumed in many analyses of the effects of various climate policies.

Finally, the reasons given by program participants for not adopting certain project recommendations suggest that most of these disregarded projects may have been economically undesirable. Many of these reasons hint at various unmeasured costs, project risks, and uncertainty that are unlikely to be reflected in estimated implementation costs and projected annual savings. On the other hand, many projects were likely rejected because of institutional or bureaucratic barriers within firms, and most of the reasons are sufficiently vague that we cannot rule them out as indicative of institutional or bureaucratic barriers.

Overall, one can view the glass as either half full or half empty. Although the results suggest that the IAC program has led to the adoption of many financially attractive energy-conservation projects, plants found about half of the projects recommended by assessment teams to be unattractive. This suggests that other, more costly policies targeted at increasing the financial attractiveness of these projects (e.g., energy/carbon taxes, or tax breaks/subsidies for implementation) may be needed to further promote energy efficiency in these sectors. Furthermore, it would seem that policies that could lengthen the short paybacks that firms routinely demand from all types of projects (not just those for energy efficiency) would have implications that extend well beyond the realm of energy and climate policy.

2. Data

2.1. The IAC program and database

The Industrial Assessment Centers program has been providing free industrial assessments to small and medium-sized manufacturers since 1976. The program operates as an extension service through 26 participating universities, whereby teams of engineering students and faculty help manufacturers identify opportunities to conserve energy, reduce waste, and improve productivity (US Department of Energy, 2002). In addition to these direct benefits, the program also generates indirect benefits by educating participating firms and university students (who may become future employees) to the presence of potential future investment opportunities (Tonn and Martin, 2000). Approximately 500 manufacturers and 150 university students participate each year. Out of the program's current federal outlay of about US$ 7 million per year, each school receives about US$ 180,000 annually, or about US$ 7000 per assessment.

Since 1981, a record of each assessment has been stored in the IAC database.[2] With entries for over 10,000 assessments (recommending over 70,000 individual projects), the database covers virtually every US geographic region and manufacturing industry. Nearly half of these assessments have been conducted in the foods, rubber and plastics, fabricated metals, and commercial machinery industries.

Assessments provided by the IAC program typically follow a standard protocol. Manufacturers that express interest in the program must first meet several eligibility requirements.[3] IAC teams then perform a preliminary assessment (e.g., by reviewing the plant's energy bills) followed by a visit to the plant site, which includes an interview with management, a thorough tour of the plant, and time to gather technical data (e.g., measure lighting levels or check for air leaks). Following the site visit, IAC teams provide plant management with an assessment report that highlights specific opportunities to increase energy efficiency, reduce waste, and improve productivity. Finally, after an appropriate interval (usually 6–9 months), IAC teams contact plant management by phone to determine which projects were

[2] The database is compiled and maintained by the Center for Advanced Energy Studies at Rutgers University, http://caes.rutgers.edu.

[3] Plants must have a standard industrial classification (SIC) code of 20–30 (i.e., manufacturing) and be within 150 miles of an IAC host campus. In addition, plants must have gross annual sales of less than US$ 100 million, fewer than 500 employees at the plant site, annual energy bills between US$ 100,000 and 2 million, and no professional in-house staff to perform the assessment.

actually implemented—or will definitely be implemented within 12 months of the call.[4] For projects that were not adopted, IAC teams try to determine the reason or reasons why (US Department of Energy, 2000, 2002).

The information garnered during the assessment process provides the substance of the IAC database. The database contains information for each recommended project, including the project type, estimated implementation cost, quantity of energy conserved, annual operating cost savings, and confirmation of whether or not the recommended project was implemented. The database also contains other useful information, including the date of the assessment and plant-specific variables such as manufacturing sector (SIC code), annual sales, annual energy costs, and number of employees. Finally, the database contains information indicating why many projects were not implemented (US Department of Energy, 2000, 2002). A rare aspect of these data is that they include multiple project investment decisions for each plant, allowing us to control for plant-level fixed effects that may affect the adoption decision.

2.2. Data procedures

Our data come from the IAC database for the years 1981–2000.[5] We focus exclusively on energy management projects, which are present in 97% of all assessments and represent 83% of all recommended projects during this period.[6] We adjust all monetary figures for inflation, scaling to year 2000 US dollars using the producer price index (finished goods, series WPUSOP3000) from the US Bureau of Labor Statistics (2001). We omit approximately 35% of energy-related projects for various reasons, as explained below, resulting in a sample of 39,920 projects from assessments at 9034 plants. Our results are robust to the inclusion or exclusion of these observations.

In our econometric estimation of the project adoption decision, we employ a discrete dependent variable indicating whether or not a plant adopted a recommended project.[7] Each project is classified by a four-digit assessment recommendation code (ARC), and we include dummy variables for eight two-digit ARC classifications: combustion systems, thermal systems, electrical power, motor systems, industrial design, operations, buildings and grounds, and ancillary costs.[8] These variables are intended to capture heterogeneity across different types of projects (e.g., project lifetimes).

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[4] Implementation must occur within 24 months of the assessment date for projects to be considered implemented. This interval accounts for the fact that some projects are not implemented immediately due to annual capital investment cycles.

[5] Although the database covered 1981–2001, the data were incomplete for many assessments conducted during 2001, presumably because many plants had not yet received their callback interviews at the time the data were downloaded.

[6] The sample includes 9827 assessments and 59,961 recommended energy management projects before cleaning.

[7] The IAC database codes most projects as I (implemented), N (not implemented), P (pending), or K (data excluded or unavailable); some projects are missing this code. Our dependent variable equals 1 for projects coded as I, and 0 for projects coded as N. We omit projects with P, K, or missing implementation codes.

[8] There are a total of nine two-digit ARC classifications for energy management. We omit three observations classified as "alternative energy usage" due to a lack of degrees of freedom for the corresponding dummy variable.

In addition to implementation codes and project type classifications, IAC data contain information regarding the estimated implementation cost and annual operating cost savings of each project. Using these figures, we generate the simple payback for each project, which is defined as cost divided by annual savings. This figure can be interpreted as the number of years before the cost of a project is recovered through annual savings. We focus only on projects with paybacks between 0.025 and 9 years, because careful inspection of the data revealed that data outside this range were of dubious quality.[9]

The data for most projects also include information regarding the estimated quantity of energy that would be conserved annually (e.g., kWh or Btu). We compute the average energy price associated with each project by dividing annual savings by the corresponding quantity of energy conserved.[10,11] In order to make these prices comparable, in percentage terms, across different energy types (e.g., electricity versus natural gas), we normalize the prices within each energy type to have a mean of one. That is, for example, we divide each natural gas price by the mean natural gas price in our sample, and we divide each electricity price by the mean electricity price. We call these new prices our *energy price index*. Finally, we divide annual savings by our new energy price index to generate quantity figures that are also comparable in percentage terms across different energy types.[12] We call these new quantities our *energy saved quantity index*. To ease interpretation of parameter estimates, continuous variables are normalized so their means equal unity, or zero after taking natural logarithms.

2.3. Descriptive statistics

As shown in Table 1, the 9034 manufacturing plants in our sample average about US$ 30 million in annual sales. The 38,920 energy management projects recommended to these plants have an average estimated implementation cost of US$ 7400 and estimated savings of US$ 5600 per year. The average estimated payback period for these projects is only 1.29 years. In spite of these seemingly quick payback periods, however, firms adopted just 53% of these projects. We explore the reasons in depth below. The IAC audit teams estimate that over the 20-year period 1981–2000 the adopted projects in our sample represented about US$ 103 million in energy-conservation investment, resulting in aggregate per year savings

[9] Overall, we observe that adoption rates fall from approximately 65 to 40% as payback increases from 0.025 years to 9 years. Adoption rates for projects outside this range do not follow the same pattern, however. In fact, adoption rates for these projects regress toward the mean for all projects, suggesting that the information supposedly conferred by these payback values is of negligible value.

[10] We focus only on projects whose prices and quantities have a clear and interpretable meaning (e.g., “other gas” or “other energy” would not qualify). In some cases, net savings are associated with more than one energy type (e.g., switching from electric to natural gas heating), making it impossible to identify individual energy prices and quantities. Thus, we focus only on projects with positive annual savings for a single energy type. After generating prices, we drop projects whose prices are clear outliers. The average annual energy prices derived from the data are consistent with historical energy prices.

[11] Electricity-related dollar savings is often the result of reductions in electricity usage (i.e., kWh $\times$ \$/kWh) plus reductions in demand charges (i.e., max kW $\times$ \$/kW). We treat all electricity-related dollar savings as having come directly from reductions in usage.

[12] Equivalently, the quantity index can be calculated by weighting the original quantities within each energy type by the mean price for that energy type.

Table 1
Descriptive statistics

Variable	Mean	S.D.	Minimum	Maximum
Adopted	0.53	0.50	0.00	1.00
Payback (years)	1.29	1.29	0.03	9.00
Implementation cost (US$)	7400	82714	3.47	10100000
Annual savings (US$)	5574	27881	8.45	2661508
Energy price index	1.00	0.38	0.12	4.56
Energy saved quantity index	6091	42853	6.96	4650939
Annual sales (US$)	29156398	37715612	41503	684192832
Employees	170	147	1	4000
Floor area (square feet)	253887	3208579	300	150000000
Annual energy costs (US$)	486969	702126	2502	11951324

Statistics are based on the sample of 38,920 observations for energy-related project recommendations, representing 9034 plant assessments. Monetary figures are in 2000 US dollars.

of about US$ 100 million, as shown in Table 2. This represents an estimated aggregate payback period of about 1 year for adopted projects. By contrast, projects that were not adopted would have cost an estimated US$ 186 million for an aggregate estimated per year savings of only US$ 117 million. These numbers imply that firms tend to adopt the most profitable projects, an issue we explore in our econometric analysis below. Overall, adoption of projects recommended by the IAC program led to an estimated 20 trillion Btu of aggregate per year energy conservation, or about 45% of total recommended energy conservation.[13]

Breaking these numbers down by project type, Table 2 shows that 90% of the projects in our sample affect *building and grounds* (e.g., lighting), *motor systems*, and *thermal systems*, while a smaller but significant number of projects affect *combustion systems* and *operations*, and just a handful of projects affect *electrical power*, *industrial design*, and *ancillary costs*. We also see significant variation in terms of cost, annual savings, payback, and adoption rates. *Thermal systems*, *electrical power*, and *industrial design* projects have high costs and low adoption rates. *Building and grounds* and *ancillary costs* projects have average costs, close to average annual savings, and longer than average payback periods; firms adopt these projects about 50% of the time. *Combustion systems* and *motor systems* projects have lower than average costs, average or less than average paybacks, and relatively high adoption rates. Overall, it appears that project types with high annual savings relative to cost (as reflected by low payback periods) are correlated with high rates of adoption, as long as costs are not too high.[14] This is consistent with survey findings (e.g., US Department of Energy, 1996)

[13] There is evidence, based on comment fields within the IAC database, that some projects are only partially implemented (e.g., plant installed 50% of recommended energy-efficient lighting), so the above estimates may overstate actual aggregate costs and per year savings. The data also suggest that partial implementations can be more profitable than the original recommendation (e.g., plant installed 50% of lighting for 75% of predicted savings).

[14] The exception is *operations* projects, which have low implementation costs and short payback periods, yet are only adopted 50% of the time. *Operations* projects may be associated with significant unmeasured opportunity costs, however (e.g., temporary plant shutdowns).

Table 2
Adoption rates, payback, cost, and annual savings by project type

Project type	Number of projects	Adoption rate	Mean payback (years)	Mean cost (US$)	Mean annual savings (US$)	Aggregate cost of adopted projects (US$)	Aggregate annual savings of adopted projects (US$)
Building and grounds (e.g., lighting, ventilation, building envelope)	14208	0.51	1.47	6217	4347	39995506	31349388
Motor systems (e.g., motors, air compressors, other equipment)	13783	0.60	1.22	5297	4123	36891259	32818958
Thermal systems (e.g., steam, heat recovery and containment, cooling)	6790	0.44	1.23	9021	8273	16670472	20203020
Combustion systems (e.g., ovens, furnaces, boilers, fuel switching)	2358	0.56	0.99	5131	7442	4611227	9570203
Operations (e.g., use reduction, maintenance, scheduling, automation)	1471	0.50	0.93	2617	4267	1716740	3483098
Electrical power (e.g., demand management, generation, transmission)	155	0.30	1.82	287100	94215	953399	602745
Industrial design (e.g., modify thermal, mechanical systems)	145	0.38	1.44	34013	25537	1634788	1487817
Ancillary costs (e.g., administrative, shipping, distribution)	10	0.50	1.76	7160	4715	43788	15363
All projects	38920	0.53	1.29	7401	5574	102517178	99530592

Statistics are based on sample of 38,920 project recommendations, broken down by project type. Aggregate cost and aggregate annual savings are for the years 1981–2000. Monetary figures are in 2000 US dollars.

that suggest projects above a certain cost may not get adopted, regardless of their benefits, due to budgeting constraints or differing management control depending on project cost.

Most energy savings have come from the adoption of projects affecting *building and grounds*, *motor systems*, and *thermal systems*. This is not surprising, given that these projects represent the bulk of all recommended and adopted projects. In terms of return on investment, however, it is clear that *combustion systems* and *operations* projects have been the most profitable. The aggregate annual savings for adopted projects in these categories are roughly double their aggregate cost. *Thermal systems* projects have also proven profitable overall, with aggregate per year savings exceeding aggregate cost by 21%. Overall, these numbers suggest that the IAC program has alerted manufacturers to a large number of new energy-conservation investment opportunities that appear profitable based on the IAC estimates of costs and benefits. Anecdotal evidence from general comments in the IAC database also suggests that the program has helped participating plant managers demonstrate the profitability of known investment opportunities to upper-level management.

Finally, there is evidence based on project-specific comments that a relatively small number of projects would have been implemented within a short time frame without IAC involvement (e.g., due to routine maintenance schedules). There is also evidence that a gradual move toward energy efficiency would have occurred over time without IAC involvement (e.g., due to retirement of aging equipment and replacement with more energy-efficient models). In general, however, it appears that the IAC program has either been the primary impetus for the adoption of most recommended projects, or has at least accelerated the progress of energy-efficiency improvement.

In order to gain a more systematic understanding of firm behavior in response to the IAC program, we develop an econometric model that formally relates the energy-conservation investment decision to the economic incentives of recommended projects, including payback, cost, annual savings, energy prices, and quantities of energy conserved. We discuss the econometric model and results below.

3. Modeling and estimation approach

Given a set of potential energy-conserving projects recommended by IAC auditors, we posit that a firm will adopt a particular project if the perceived expected net benefits of the project are positive given the project's characteristics and relevant investment hurdle rate.[15] We begin by defining π^*_{ij}, the expected net benefits resulting from the adoption of project i at plant j

$$\pi^*_{ij} = \varphi(C_{ij}, B_{ij}, Z_{ij}) + \varepsilon$$

[15] Note that program participants' perceptions of net benefits may not be consistent with IAC estimates due to real or perceived bias in these estimates. If estimated project returns differ from actual or perceived returns, then projects that appear profitable based on IAC estimates may be systematically rejected. We also note that various institutional or bureaucratic issues within the firm (e.g., capital budgeting constraints or principal-agent problems) could lead to the systematic rejection of projects that may be profitable, though this issue is not unique to energy-efficiency projects. Therefore, the relevant investment hurdle rate does not necessarily equal the market interest rate. We return to these issues below in Sections 4.2 and 4.3.

where C is the expected cost of a project, B the expected annual benefits of the project, Z a vector of individual plant and project characteristics (e.g., investment hurdle rates and project lifetimes), φ a function relating C, B, and Z to π^*, and ε a mean-zero independent, identically distributed error term.[16] The error term reflects uncertainty regarding the perceived net benefits of projects, leading to the possible rejection of projects that have positive net benefits, and vice versa.

We do not observe expected net benefits, π^*. Rather, we only observe whether a project is implemented or not. We therefore define a dichotomous variable, π, which indicates whether or not a project is adopted:

$$\pi_{ij} = 1 \quad \text{if } \pi^*_{ij} > 0$$

and

$$\pi_{ij} = 0 \quad \text{if } \pi^*_{ij} \leq 0$$

It follows that

$$\Pr[\pi^*_{ij} > 0] = \Pr[\pi_{ij} = 1], \qquad \Pr[\pi^*_{ij} > 0] = F(\varphi(C_{ij}, B_{ij}, Z_{ij}))$$

where F is a cumulative probability distribution function for ε. Assuming F is logistic leads to the familiar logit model, whereas assuming F is standard normal leads to the probit model (Maddala, 1983). As discussed further below, because we have observations for multiple potential projects at each plant, we can estimate a logit model with plant-level fixed effects (Chamberlain, 1980; Hamerle and Ronning, 1995), thereby controlling for unobserved plant differences in the propensity to adopt.

Our most basic econometric specification, the *payback* model, is given by

$$\varphi = \beta_1 \ln \mathrm{PB}_{ij} + \beta_2 \ln \mathrm{PB}^2_{ij} + \gamma A_i + \alpha_j + \varepsilon \tag{1}$$

where PB is the expected simple payback period for the project (cost divided by annual savings, $\mathrm{PB} = C/B$), A a vector of dummy variables indicating the project type, and α a firm-specific fixed effect. Although it is well known that using a payback threshold is inferior to the net present value criterion (Lefley, 1996), the two criteria lead to the same investment threshold in the case of constant annual cash flows and for a given investment hurdle rate and project lifetime.[17] More importantly, simple payback analysis is the most common technique for project appraisal in general (Lefley, 1996) and, in particular, for firms that receive IAC audits (Muller et al., 1995; US Department of Energy, 1996).

We found that entering PB and the other continuous variables described below in their logged form improved the model's fit of the data and eased interpretation of the results since changes in the probability of adoption correspond to percent changes in the logged variables. Further, PB has been normalized to equal one at its mean so that the marginal probability of adoption at the mean payback is given directly by the coefficient on the linear

[16] Note that we suppress i, j subscripting in the text where this does not lead to confusion.

[17] The three most serious flaws associated with using a constant payback criterion to rank projects are (i) that it does not consider differences across projects in the time profile of the flows of cost and benefits; (ii) that it ignores differences in project lifetimes; and (iii) that it does not consider differences in the total net benefits from implementation (i.e., it uses the ratio).

term.[18] The plant fixed effects control for unobserved individual plant differences in the propensity to adopt, as well as other assessment-related factors, such as the assessment date and IAC school conducting the assessment.

Because payback is equal to cost divided by annual savings, Eq. (1) implies that percent changes in cost and savings have the same effect on the probability of adoption. Theory suggests that they *should* have the same effect. Nonetheless, previous empirical studies have found that implementation cost has a stronger effect on energy-conservation investments than energy savings (Jaffe and Stavins, 1995; Hassett and Metcalf, 1995). In order to test whether this is also the case for IAC program participants, we explore less restrictive specifications. The *cost–savings* model is given by

$$\varphi = \beta_3 \ln C_{ij} + \beta_4 \ln C_{ij}^2 + \beta_5 \ln B_{ij} + \beta_6 \ln B_{ij}^2 + \gamma A_i + \alpha_j + \varepsilon \tag{2}$$

where C is the expected implementation cost of a project, B the expected annual savings in energy costs, and the other variables are as above. Like PB in Eq. (1), both C and B have been normalized and enter in their logged forms. Note that although it is discounted energy savings that matter for the investment decision (rather than simply the annual flow of savings, B), the discount factor multiplying B becomes additive after taking logarithms. As the discount factor depends on the firm's investment hurdle rate and the project lifetime, its effect will be captured in the plant and project-type fixed effects, α and A.

The *cost–benefit* model can also be made less restrictive. Because annual savings equals the quantity of energy conserved multiplied by the energy price, Eq. (2) implies that percent changes in energy prices and quantities have the same effect on the probability of adoption. But one might conjecture, for instance, that energy prices are perceived as being less permanent than the quantity of energy saved, or that plant managers with engineering backgrounds are more sensitive to physical energy savings than to differences in the dollar value of these savings. For this reason we explore the possibility that energy prices and quantities have different effects on the probability of adoption. Our *price–quantity* model is given by

$$\begin{aligned}\varphi &= \beta_7 \ln C_{ij} + \beta_8 \ln C_{ij}^2 + \beta_9 \ln P_{ij} + \beta_{10} \ln P_{ij}^2 + \beta_{11} \ln Q_{ij} \\ &\quad + \beta_{12} \ln Q_{ij}^2 + \gamma A_i + \alpha_j + \varepsilon\end{aligned} \tag{3}$$

where P and Q are the price and quantity indexes described in Section 2.2, with Q also normalized to equal one at its mean, and the other variables are as above.

We estimate the *payback*, *cost–benefit*, and *price–quantity* models using a maximum likelihood, conditional fixed effects logit estimator, with plant-level fixed effects (Chamberlain, 1980; Hamerle and Ronning, 1995). First note that assessments with either all positive or all negative outcomes do not contribute to the log-likelihood and are therefore dropped from the estimation. About 52% of these dropped assessments correspond to plants that adopted *all* recommendations, whereas 48% correspond to plants that adopted *none*. If the responsiveness of omitted plants to financial costs and benefits was systematically different from plants that were included in the analysis, then the omission of these observations could potentially

[18] The percent effect of payback is found by differentiating φ with respect to ln PB, which yields $\beta_1 + 2\beta_2 \ln \text{PB}$. Evaluated for the mean payback, however, this simplifies to β_1, since we have normalized payback to equal one at its mean and $\ln(1) = 0$. The corresponding change in predicted probability is proportional to β_1 (see footnote 19).

lead to misleading coefficient estimates. As we discuss below, however, our results are robust to alternative models that include these observations. Although these observations are not included in our formal econometric estimation, they are included in our earlier calculations of overall adoption rates, mean costs and benefits, and other important summary statistics.

Second, note that because firms only participate in one assessment at a single point in time, variables such as annual sales, number of employees, and year of assessment are perfectly collinear with the plant-level fixed effects and cannot therefore be included in the estimation. We also estimated logit, random-effects logit, probit, random-effects probit, linear, linear fixed effects, and linear random-effects models, adding plant size and dummy variables for year, SIC code, and IAC school to models without plant-level fixed or random-effects. Our overall results (i.e., the effect of payback, cost, annual savings, prices and quantities) are robust to these alternatives. In addition, unlike other studies, we do not find a significant effect for plant size in models where it was included, whether measured by annual sales, annual energy costs, floor area, or employees. We note, however, that the IAC database only includes small and medium-sized firms, and that the effect of plant size on technology adoption may only be evident relative to larger firms. The results of the fixed effects logit estimations are presented below.

4. Results

4.1. Estimation results

Table 3 presents the results of our three econometric models of increasing flexibility. We transformed the coefficient estimates and standard errors so that they are presented as marginal effects at the means of the continuous variables.[19] Note also that we have transformed the variables so that the marginal effects for continuous variables are given directly by the coefficients on the linear terms, as discussed in Section 3. Effects for the project type dummy variables have also been transformed so that they reflect the full change in predicted probability associated with each project type, relative to building and grounds projects (the omitted dummy variable).[20]

[19] Given the form of the logistic distribution, $\Lambda(\boldsymbol{\beta}'\boldsymbol{x}) = \exp(\boldsymbol{\beta}'\boldsymbol{x})/(1+\exp(\boldsymbol{\beta}'\boldsymbol{x}))$, marginal effects in a logit model are equal to $\partial E[\pi]/\partial \boldsymbol{x} = \boldsymbol{\beta}\Lambda(\boldsymbol{\beta}'\boldsymbol{x})(1-\Lambda(\boldsymbol{\beta}'\boldsymbol{x}))$ for continuous variables. With all continuous variables normalized to one at the mean, or zero after taking logs, and setting all fixed effects to zero, the marginal effects simplify dramatically to $\partial E[\pi]/\partial \boldsymbol{x} = \boldsymbol{\beta}/4$ at the mean (Anderson and Newell, 2003). The assumption of setting the fixed effects to zero is both convenient and necessary because the conditional logit estimator does not produce individual parameter estimates for the fixed effects. Standard logit estimates of the same specification yielded a constant term estimate of -0.07, suggesting that the "average" fixed effect is indeed close to zero. Including a fixed effect of this magnitude in the calculation of marginal effects would reduce the factor multiplying $\boldsymbol{\beta}$ only negligibly from 0.2500 to 0.2497. Standard errors are estimated using the delta method and, like the marginal effects, simplify dramatically to $\boldsymbol{\sigma}/4$, where $\boldsymbol{\sigma}$ is the estimated standard error of $\boldsymbol{\beta}$.

[20] The effect of a categorical variable, such as our project-type fixed effects, is found by taking the difference in the predicted probability with and without the categorical variable set to one. Given our normalizations described above, this results in the following simple relationship for the effect of categorical variable x_i: $E[\pi|x_i = 1] - E[\pi|x_i = 0] = \exp(\beta_i)/(1+\exp(\beta_i)) - (1/2)$. Again, standard errors are estimated using the delta method and, given a number of simplifications, equal $\sigma_i/4$, where σ_i is the estimated standard error of β_i.

Table 3
Fixed effect logit estimates of project adoption

	Payback model	Cost–benefit model	Price–quantity model
ln(payback = savings/cost)	−0.083** (0.005)		
ln(payback = savings/cost)^2	−0.009** (0.002)		
ln(project cost)		−0.087** (0.005)	−0.085** (0.005)
ln(project cost)^2		−0.005** (0.001)	−0.005** (0.001)
ln(annual savings)		0.061** (0.006)	
ln(annual savings)^2		0.000 (0.002)	
ln(price of energy)			0.043** (0.016)
ln(price of energy)^2			−0.030 (0.018)
ln(quantity of energy saved)			0.058** (0.006)
ln(quantity of energy saved)^2			−0.001 (0.001)
Motor systems	0.092** (0.008)	0.090** (0.008)	0.090** (0.008)
Thermal systems	−0.167** (0.011)	−0.165** (0.011)	−0.165** (0.011)
Combustion systems	0.002 (0.016)	−0.002 (0.016)	−0.003 (0.016)
Operations	−0.094** (0.019)	−0.095** (0.019)	−0.095** (0.019)
Electrical power	−0.273** (0.060)	−0.253** (0.061)	−0.250** (0.062)
Industrial design	−0.214** (0.060)	−0.198** (0.061)	−0.197** (0.061)
Ancillary costs	−0.038 (0.211)	−0.048 (0.213)	−0.049 (0.213)
log-likelihood	−10133	−10118	−10116
Likelihood ratio	1278**	1308**	1312**

Asterisks denote statistical significance at various levels: (**) = 99%. Data are observations of energy-conserving project recommendations made under IAC program from 1981 to 2000. Dependent variable equals 1 if project is adopted and 0 otherwise. Estimation method is ML conditional fixed effects logit with plant-specific fixed effects. Each model is estimated on an effective sample of 5263 plant visits representing 26,068 recommended projects. 3771 plants (12,852 projects) in the full sample were dropped due to their having no variation in whether projects were adopted or not. Marginal effects at variable means are given directly by linear terms, setting fixed effects and project type dummies at zero. Marginal effects for dummy variables give change in predicted probability associated with changing dummy variable from 0 to 1 (see Sections 2 and 3 for further detail).

Our overall results are consistent with economic expectations. To provide a sense of how our model fits the pattern of the data, Fig. 1 plots the observed fraction of projects actually adopted at various payback levels, along with the estimated probability of adoption based on the *payback* model given by Eq. (1). As expected, projects with a longer payback period (i.e., greater ratio of costs to annual benefits) are less likely to be adopted. Further, the predicted probability corresponds quite well to the actual adoption rates of projects with various paybacks. Specifically, the results indicate that a 10% increase in payback leads to about a 0.8% decrease in the probability of adoption. The negative coefficient on the squared term for payback indicates that percentage increases in the payback period have an increasingly negative effect on adoption rates. This result manifests itself in Fig. 1 as downward curvature in the adoption function.

The *cost–benefit* model relaxes the implicit restriction that costs and benefits have the same magnitude effect. According to the results of this model, a 10% increase in cost decreases the probability of adoption by 0.8%. The negative coefficient on the squared term

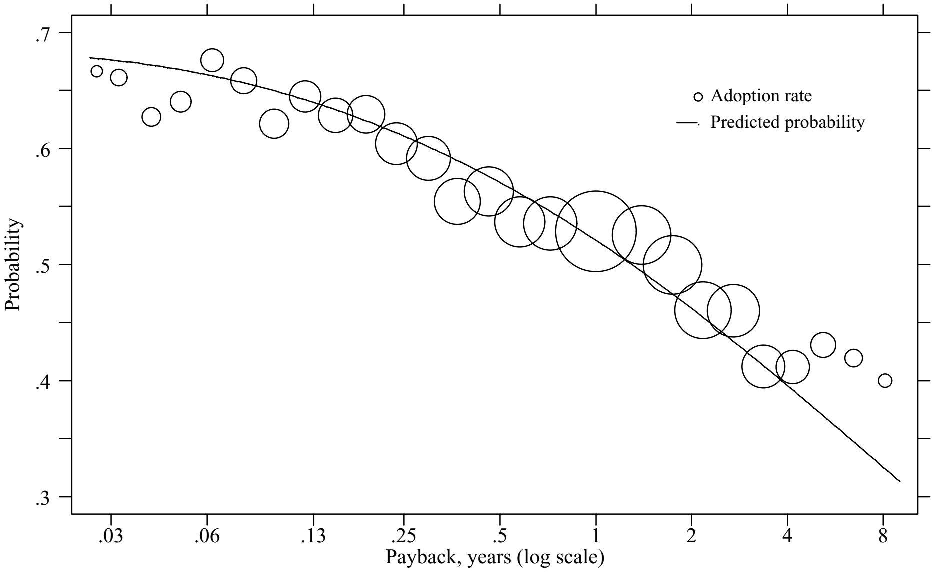

Fig. 1. Probability of adoption vs. payback. Circles represent the observed adoption rates for fixed intervals of payback in log scale. The areas of the circles are proportional to the number of observations in each interval. The solid line is the predicted probability of adoption for the *payback* model (see Table 3). All fixed effects are set to zero for the figure.

for costs indicates that the effect of costs is increasingly negative, suggesting that very costly projects are especially unlikely to be adopted. This result is consistent with survey findings that show that most firms consider an investment of US$ 5000 or more to be large, regardless of the benefits, and higher cost projects (e.g., US$ 10,000 or more) are subject to greater scrutiny since they often must be approved on a capital budgeting basis rather than out of production and maintenance budgets (Muller et al., 1995; US Department of Energy, 1996). This result is suggestive of potential market imperfections—namely, problems in institutions efficiently allocating funds to profitable investment opportunities.

On the other hand, a 10% increase in annual savings increases the probability of adoption by only 0.6%. The magnitudes of the cost versus savings effects are statistically different at the 99% level.[21] These results are consistent with previous literature, which finds that up-front implementation costs have a larger effect on energy-conservation decisions than future annual savings. The magnitude of the difference, however, is much less pronounced in our results. We find that costs have a 40% greater percentage effect relative to future energy savings at the mean of the data, whereas Jaffe and Stavins (1995) found that costs had about three times the effect, and Hassett and Metcalf (1995) found that costs had about eight times the effect of energy savings. One difference between our study and these, however, is that we have data that directly measure the estimated dollar value of energy savings, which includes both price and quantity information, whereas these other studies only used

[21] Using Wald tests, we reject the hypotheses that $\beta_3 = -\beta_5(\chi^2(1) = 37.22)$ and that $\beta_4 = \beta_6(\chi^2(1) = 5.16)$.

variation in energy prices to identify the effect of future energy dollar savings. It has also been suggested that IAC estimates of energy savings may be more accurate than estimates of implementation cost, perhaps leading to an "errors in variables" bias of the implementation cost coefficient toward zero relative to annual savings.[22] We discuss this issue further below in the context of the *price–quantity* model.

The *price–quantity* model relaxes the implicit restriction that changes in energy prices have the same percentage effect as changes in the quantity of energy conserved. The results indicate that a 10% increase in energy prices increases the probability of adoption by 0.4%, but that a 10% increase in the quantity of energy conserved increases the probability of adoption by 0.6%. Although the parameter estimates indicate that energy-conservation *quantities* have about a 30% greater effect on adoption likelihood than energy *prices* (i.e., the per unit value of conservation) at the mean of the data, these estimated effects are not statistically different at any reasonable confidence level.[23] Still, they suggest that plant managers may be more responsive to differences in the quantity of energy conserved for alternative projects than to differences in energy prices. Perhaps plant managers with engineering backgrounds are inherently more responsive to technical energy savings than to their dollar value. Alternatively, energy quantity changes may be perceived as less uncertain or subject to change than energy price changes.

The *price–quantity* model also permits a more direct comparison to the studies cited above regarding the relative effects of up-front costs versus energy prices. Our results indicate that costs have a little more than double the effect of energy prices, which is more dramatic than the difference between cost and savings in our *cost–savings* model above, but still not as large as the three or eight times larger effect cited in previous studies.[24] These results imply that a policy of subsidizing energy-conserving technologies may be more effective in spurring the adoption of these technologies than a policy of taxing resource use.[25]

Jaffe et al. (2003) suggest several possible explanations for this divergence. One possibility is a behavioral bias that leads plant managers to focus on implementation costs more than on lifetime operating costs and benefits.[26] An alternative view is that plant managers focus equally on both, but that uncertainty about future energy prices or whether they will face such costs (e.g., due to a location change) makes them place less weight on energy prices than on implementation cost, which is known. Finally, plant managers may have fairly accurate expectations regarding future energy prices, and make investment decisions

[22] According to IAC contacts (Heffington, 2003), most engineering programs provide student IAC team members with solid training for calculating energy and cost savings early in their curriculum, whereas training for calculating implementation costs comes later, if at all. Moreover, data regarding implementation costs may be harder for students to obtain. By contrast, plant personnel are typically better equipped to accurately estimate implementation costs due to their more frequent interaction with vendors and installers.

[23] Using Wald tests, we cannot reject the hypotheses that $\beta_9 = \beta_{11}(\chi^2(1) = 0.87)$ or the joint hypothesis that $\beta_9 = \beta_{11}$ and $\beta_{10} = \beta_{12}(\chi^2(2) = 2.69)$.

[24] Using Wald tests, we reject the hypotheses that $\beta_7 = \beta_9(\chi^2(1) = 56.10)$ and the joint hypothesis that $\beta_7 = \beta_9$ and $\beta_8 = \beta_{10}(\chi^2(2) = 88.55)$. We also reject the hypothesis that $\beta_7 = \beta_{11}(\chi^2(1) = 225.74)$ and the joint hypothesis that $\beta_7 = \beta_{11}$ and $\beta_8 = \beta_{12}(\chi^2(2) = 391.36)$.

[25] Note, however, that unlike taxes on resource use, policies that reduce technology costs do not provide the continued incentive to reduce energy consumption.

[26] This is consistent with the observation that plant managers are often better equipped to estimate implementation costs (e.g., through interactions with equipment vendors) than future energy savings (Heffington, 2003).

accordingly, but researchers (or, in this case, IAC teams) may use imperfect or flawed proxies of these expectations, causing their measured effect to be smaller than their true effect.[27]

Although our results demonstrate that firms generally respond as predicted by economic theory to the incentives of payback, cost, savings, energy prices, and conservation quantities, these variables do not fully explain the technology adoption decision. Indeed, holding these variables constant, certain types of projects are more likely to be adopted than others, as measured by the project type dummy variables. *Motor systems* projects are the most attractive type of project, with a 9% greater probability of being adopted than *building and grounds* projects, the omitted group. *Combustion systems* and *ancillary costs* projects are about as likely to be adopted as *building and grounds*. Projects affecting *operations, thermal systems, industrial design* and *electric power* have, respectively, a 10, 17, 20, and 25% lower probability of being adopted than *building and grounds* projects. Interestingly, we also find that as paybacks approach zero, adoption rates increase only to about 70%; similarly, as paybacks approach our sample maximum of 9 years, adoption rates decrease only to about 30%.

These results are consistent with the descriptive statistics on relative adoption rates for the various project types listed in Table 2. Further, they suggest that the IAC program's measures of financial costs and benefits do not fully capture the relative desirability of alternative projects. There may be many missing factors—such as individual project lifetimes, unmeasured costs and benefits, uncertainty regarding costs and benefits, project complexity and risks—that are crucial to understanding the adoption decision. Errors in measuring the true costs and benefits of projects could also be leading to an "errors in variables" bias of the coefficients toward zero, resulting in estimated effects that are smaller in magnitude than their true values.

4.2. Payback thresholds and implicit discount rates

Previous literature has posited that information programs and other policies may lower the sometimes seemingly high implicit discount rates observed for firms with respect to their energy-efficient investment decisions. Undoubtedly, one source of high implicit discount rates may be that firms are unaware of particular energy-efficient investment opportunities, or at least the relative costs and benefits of such opportunities. By conveying information regarding such opportunities, information programs may lower observed implicit discount rates. The observation that the IAC program has led to the adoption of many previously unimplemented projects attests to this possibility.

We address this issue by looking at the observed level of implicit discounting for firms that participated in the IAC program. We focus on the 5264 firms in our final sample that adopted some, but not all of the energy-related projects recommended through IAC energy audits. This group is equivalent to the estimation sample from our econometric analysis. By sorting the payback periods of each plant from shortest to longest, one can in principle locate a "payback threshold" for that plant, below which all projects are adopted and above which

[27] For example, studies often use current realized energy prices as a proxy for expected future energy prices. Current prices fluctuate more than expected future prices, however, leading to a downward bias in the coefficient on the energy price proxy relative to the true relationship with expected prices.

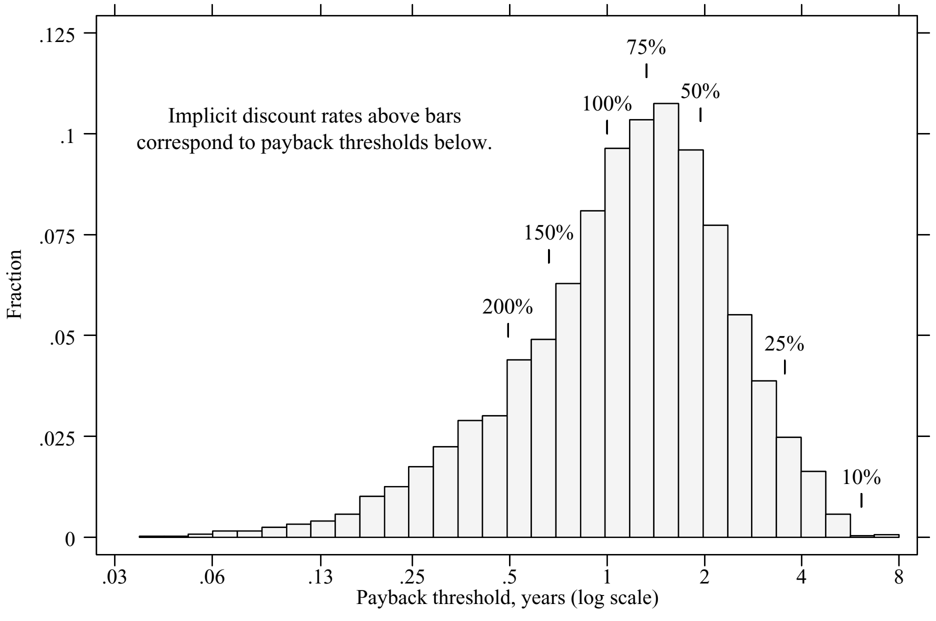

Fig. 2. Histogram of payback threshold values. Figure shows fraction of plants having a payback threshold within fixed intervals of payback in log scale. Based on sample of 5263 plants that adopted some (but not all) projects. Payback threshold values are given by midpoint between maximum payback for adopted projects and minimum payback for projects that are not adopted within each assessment. Mean payback threshold is 1.4 years; median is 1.2 years. Implicit discount rates above bars correspond to payback thresholds assuming a 10-year project life; if project lives are shorter than 10 years, implicit discount rates are lower (e.g., about 5% lower for a project life of 5 years and a 1.5-year payback) (see Section 4.2 for further detail).

all projects are rejected. The payback threshold is an analogue to an investment hurdle rate. In reality, however, we observe that most firms exhibit some overlap in the paybacks of projects that are adopted and those that are rejected (i.e., some adopted projects have longer paybacks than rejected projects). For each plant, we therefore find the shortest payback amongst the projects that are rejected and the longest payback amongst the projects that are adopted, and we take the average of these two paybacks as an estimate of the plant's payback threshold. After conducting the same analysis for plants that do not exhibit any overlap in the paybacks of adopted and rejected projects, we obtain very similar results.

Fig. 2 shows the distribution of payback thresholds. Over 98% of firms have estimated payback thresholds less than 5 years, and about 79% have payback thresholds less than 2 years. The mean payback threshold is 1.4 years, and the median is 1.2 years. These payback cutoffs correspond to implicit discount rates of about 70 and 80% for a 10-year project, respectively, as indicated in the figure.[28]

[28] Implicit discount rates are calculated by solving $\mathrm{PB} = (1/r) - 1/(r(1+r)^{\mathrm{T}})$ for r, where PB is the payback cutoff value, T the project lifetime, and r the investment hurdle rate to be calculated. We assume a project lifetime of 10 years. Assuming a shorter project lifetime of 5 years would lower our estimates of the mean and median implicit discount rate by only about 5%, and would alter higher implicit rates by an even smaller amount.

Although these payback periods may seem quick, and the corresponding hurdle rates high, they are consistent with the investment thresholds that small and medium-sized manufacturers report that they routinely employ for all types of projects, including energy-efficiency projects. For example, a series of industry roundtables conducted by the alliance to save energy found that acceptable projects were typically limited to a 2-year payback or shorter, although larger companies sometimes considered 3-year paybacks to be acceptable (US Department of Energy, 1996). This is consistent with other broad surveys of the use of the payback criterion, not just for energy-conservation projects, but much more widely (Lefley, 1996). Likewise, in a follow-up survey of plants that had received an IAC audit, Muller et al. (1995) found that 85% of firms reported that they considered paybacks of greater than 2 years financially unattractive. The median threshold in that survey was a 1–1.5 year payback, which again is consistent with our findings.

Of course, our analysis of paybacks is predicated on the assumption that IAC estimates of project costs and benefits are reasonably accurate, or at least not systematically biased. Evidence from previous studies, however, suggests that analysts have substantially overestimated energy savings due to optimism or due to reliance on highly controlled studies. For example, previous studies have found that actual savings from utility-sponsored programs typically achieve 50–80% of predicted savings (Sebold and Fox, 1985; Hirst, 1986). Based on an analysis of residential energy consumption data, Metcalf and Hassett (1999) find that the realized return on conservation investments in insulation was about 10%, well below typical engineering estimates that returns were 50% or more.

If IAC estimates are similarly biased, and if program participants have a relatively accurate perception of likely project returns, then it may be that implicit discount rates based on IAC estimates appear higher than they really are. Alternatively, program participants may not know actual project returns, but may have formed prior notions regarding the likely magnitude and direction of such bias and compensate by "padding" their investment hurdle rate accordingly. Of course, it is also possible that program participants perceive bias that does not exist, in which case program participants are likely missing profitable investment opportunities. Once again, however, the fact that our estimates of payback thresholds (and implicit hurdle rates) are consistent with the investment criteria these types of firms have repeatedly said (in other surveys) they deliberately use suggests that our estimates are not far off.

Comment fields within the IAC database contain some information regarding actual costs and benefits obtained during post-assessment interviews with plant management, but unfortunately, such information is not recorded systematically. After searching through these fields, we were only able to identify 210 (out of nearly 40,000) recommended projects that contained useful, quantitative information regarding actual project costs and benefits.[29] Not surprisingly, analysis of this information yields only inconclusive and speculative results. The limited evidence we have suggests that IAC auditors sometimes overestimate and sometimes underestimate actual costs and benefits of projects. We attempted to find a

[29] These include both actual cost and benefit figures for adopted projects, as well as client firm estimates of what actual costs and benefits would have been for non-adopted projects based, for example, on actual price quotes or further analysis. A smaller number of projects also provided qualitative information regarding actual costs and benefits. Including both quantitative and qualitative data, actual savings were higher than predicted in 121 cases and lower than predicted in 83 cases; actual costs were higher than predicted in 34 cases and lower than predicted in 24 cases.

pattern in these differences, but estimates of a relationship between actual and predicted costs and benefits were imprecise.[30]

Although we are unable to determine whether the IAC program actually lowers investment hurdle rates, implicit discount rates based on the revealed behavior of program participants remain above 50% for most firms after program participation. Since these discount rates are based on projects and technologies that firms *knew about*, it is unlikely that they can be explained by informational market failures of the type the IAC program is designed to alleviate, although other market failures may play a role, as we discuss in Section 4.3. Alternatively, if IAC estimates of project returns are biased upward, but firms know actual returns, then actual hurdle rates may be lower than they appear based on IAC estimates. Another possibility is that program participants apply high hurdle rates relative to market interest rates to compensate for real or suspected bias in estimates of project returns. In any event, the widespread use of short payback thresholds remains a puzzle, the possible answers to which lie beyond the scope of this paper.

4.3. Reasons given for not adopting projects

In order to explore the extent to which high implicit discount rates may be the result of remaining market failures or imperfections, we examine the reasons given by firms for not adopting projects. Since about 1991, these reasons have been coded and recorded in the IAC database. For the purposes of our analysis, we focus on the 93% of rejected projects between 1991 and 2000 that provide at least one reason for not adopting the project. We classify these reasons as possibly having an *economic*, *institutional*, or *financing* rationale, as shown in Table 4. Note that some reasons given for not adopting projects correspond to multiple categories, as we discuss in below.

As can be seen from Table 4, as much as 93% of projects were not adopted for what we classify as *economic* reasons. Many such reasons suggest an unattractive balance between the financial costs and benefits of a project (e.g., “unsuitable return on investment”), which should be reflected in IAC estimates of implementation cost and annual savings. But some reasons hint at opportunity costs (e.g., “lack staff for analysis/implementation”) and various project risks (e.g., “risk or inconvenience to personnel” or “suspected risk of problem with equipment”) that are not typically reflected in the IAC cost estimates. Firms report that the risk of technologies not working properly, which can lead to production halts or changes in product quality and cost is, in fact, a strong deterrent to adopting certain projects (US Department of Energy, 1996). The implication of this result is that simple financial measures alone do not determine the decision to invest in energy-efficient technologies. Analysts or policymakers that look at these measures, see that measured financial benefits outweigh financial costs, and then assume that projects that are not adopted reflect market barriers or market failures may be overlooking many unmeasured costs and benefits.[31]

[30] We also experimented with various sample selection models, since information for actual costs and benefits is more likely to appear for adopted projects (which may not exhibit significant bias), but the results of this experimentation were not robust.

[31] In our econometric model, many of these differences should be captured with our project type dummy variables and plant fixed effects.

Table 4
Reasons given for not adopting projects

Reason for not adopting	Number	Percent	Percent by category		
			Economic reasons	Institutional reasons	Financing reasons
Still considering	3295	27.1	×	×	×
Other	1169	9.6	×	×	×
Too expensive initially	858	7.1	×		×
Lack staff for analysis/implementation	820	6.8	×	×	
Cash flow prevents implementation	810	6.7		×	×
Not worthwhile	688	5.7	×		
To be implemented later	643	5.3	×	×	×
Unsuitable return on investment	616	5.1	×		
Impractical	591	4.9	×	×	
Facility change	582	4.8	×	×	
Process/equipment changes	513	4.2	×	×	
Unknown	472	3.9	×	×	×
Unacceptable operating changes	423	3.5	×	×	
Personnel changes	368	3.0	×	×	
Disagree	295	2.4	×	×	
Bureaucratic restrictions	246	2.0		×	
Risk of problem with product/equipment	219	1.8	×		
Risk/inconvenience to personnel	124	1.0	×	×	
Rejected after implementation failed	73	0.6	×		
Production schedule changes	71	0.6	×	×	
Material restrictions	33	0.3	×		
Could not contact plant	5	0.0	×	×	×
Total projects that provided reason	12147	100.0	93.0	82.0	58.2

Table summarizes reasons for non-adoption of projects between 1991 and 2000. Table excludes projects that did not provide a reason for non-adoption. Some projects list more than one reason for why the plant did not adopt, so numbers sum to more than 12,147 and percentages sum to more than 100% percents by category also add to more than 100% reflecting the fact that some reasons for not adopting correspond to multiple categories (see Section 4.3 for further detail).

On the other hand, many of these reasons are sufficiently vague that it is not altogether clear that they should be categorized solely as economic factors. For example, program participants may be averse to "process or equipment changes" or "facility changes" for personal or other non-economic reasons. Thus, we also classify many of these reasons as possible *institutional* factors, totaling as much as 82% of projects that were not adopted. One clear institutional reason for non-adoption was "bureaucratic restrictions" within the firm (e.g., plant managers may need CFO approval before undertaking energy-conservation projects), perhaps indicating certain principal-agent market failures.

Finally, according to the IAC data, as much as 58% of the projects were not adopted possibly for *financing* reasons (e.g., limited cash flow), perhaps indicating a failure of capital markets to efficiently allocate financial resources. Again, many such reasons overlap with the economic and institutional reasons, though some (e.g., "too expensive initially" or "cash flow prevents implementation") more clearly suggest some type of financing issue. It is possible that loans directed at energy conservation could be effective in ameliorating this problem if that was desired.

5. Conclusion

The US Department of Energy's Industrial Assessment Center program provides a unique opportunity to quantify the effects of an information program for energy-efficient technology adoption. We find that 53% of the projects recommended through the IAC program were adopted, representing 45% of total recommended energy savings and 46% of total recommended dollar savings. Overall, our results indicate that firms respond as expected to the economic incentives of different energy-conserving investment opportunities. Rates of adoption are higher for projects with shorter payback periods, lower implementation cost, greater annual energy savings, higher energy prices, and greater quantities of energy conserved. These simple financial measures do not explain everything, however. Indeed, holding these factors constant, we find that certain project types are more likely to be adopted than others, suggesting that there may be many economic costs, benefits, risks, and other factors that the IAC program's simple financial measures do not capture.

We find evidence that firms are more responsive to implementation costs than to annual energy savings, although this difference is not as pronounced as in previous studies. Similarly, firms seem to be more responsive to energy savings based on the quantity of energy conserved than to energy prices, though these effects are not statistically different. These results suggest that policy mechanisms to reduce costs (e.g., tax breaks or subsidies for implementation) and directly promote technical efficiency improvements may be somewhat more effective in the short term than price mechanisms (e.g., energy or carbon taxes). Only energy price increases, however, also provide the continuing incentive to reduce energy use.

As in previous studies, the firms in our sample demand quick paybacks of 1–2 years (implicit hurdle rates of 50–100%) for project adoption, as revealed through their technology adoption decisions. These results are consistent with the investment criteria that small and medium-size firms typically state that they *intend* to use. Our assessment of the reasons given for not adopting projects reveals that most may have been rejected for economic reasons, though some of these reasons may be difficult to quantify financially. On the other hand, many other projects appear to have been rejected for institutional reasons or lack of financing, and many of the "economic" reasons could also be indicative of institutional factors.

Overall, one can view the glass as either half full or half empty. The data suggest that during 1981–2000 the IAC program led to the adoption of many financially attractive energy-conservation projects. For an estimated aggregate financial outlay of about US$ 103 million by firms, the projects in our sample have yielded an estimated US$ 100 million and 20 trillion Btu in aggregate per year energy savings. Cumulative savings are likely many times as high. Note that these figures do not include Department of Energy spending on the program nor do they include various indirect program benefits (e.g., training of students and firm participants).

Still, nearly half of the projects recommended by the program are not adopted, and implicit discount rates remain seemingly high relative to market interest rates, despite the provision of free information. Nonetheless, these implicit discount rates are in the same range as what firms have stated in other surveys that they intend to use. Analysis of the reasons given for not adopting projects does little to explain why so many projects are not adopted—though we do find evidence that there are likely many unmeasured costs and risks not captured in the IAC program's simple financial estimates, so that *estimated* rates of return likely differ from *realized* rates of return.

To the extent that the routine use of short payback cutoffs (i.e., high hurdle rates) is a symptom of remaining market imperfections in corporate management, such as problems of agency, moral hazard, imperfect or asymmetrical information, and incentive design (DeCanio, 1993), there may be opportunities for increased energy efficiency through policies that can correct such imperfections. To the extent that such policies are costly or impractical, our results suggest that policies targeted at increasing the financial attractiveness of energy-efficiency projects (e.g., subsidies for implementation or taxes on energy use) could be used to further promote energy-efficient technology adoption.

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Barriers within firms to energy-efficient investments

Stephen J. DeCanio

Many investments in energy efficiency fail to be made despite their apparent profitability. Internal hurdle rates are often set at levels higher than the cost of capital to the firm. Reasons for these practices include bounded rationality, principal–agent problems, and moral hazard. The policy implication is that government can simultaneously improve overall energy efficiency and increase private sector productivity by providing informational and organizational services that go beyond the traditional regulatory framework.

Keywords: Energy efficiency; Principal–agent problem; Bounded rationality

A considerable body of evidence suggests that the US economy could become much more energy efficient than it presently is. Opportunities to improve energy efficiency can be found in residential and commercial buildings and industrial processes.[1] A study by the Office of Technology Assessment of the US Congress (OTA) recently found that the government could save at least 25% of the energy used in federal buildings, with no sacrifice of comfort or productivity.[2] Of perhaps greater significance from the economic point of view, many of these potential energy saving investments appear to have very high rates of return in comparison to the economy-wide average cost of capital. Residential consumers resist energy saving investments that have rates of return of 30% to 40% or more, while detailed, on-site surveys of selected industrial corporations have uncovered energy conservation projects with rates of return frequently in excess of 30%.[3]

The author is with the Department of Economics, University of California, Santa Barbara, CA 93106, USA and The Fielding Institute, Santa Barbara, USA.

The existence of such sizable unrealized profits poses both theoretical and policy problems. On the theoretical side, how can we account for such a deviation from the standard economic presumption of cost minimization or profit maximization? What characteristics of the markets, agents, or of the observations themselves account for the discrepancy? On the policy side, it is natural to ask how government might intervene to improve the situation. The difference between what is and what could be realized suggests that well designed policies to improve energy efficiency might achieve one of the most sought after objectives of economic policy – Pareto improvement with gains for all concerned. Before ambitious policy goals can be set, however, it is necessary to examine the *causes* for the apparent gap between actual and theoretical performance.[4]

Barriers to profitable investments

Firms do not behave like individuals

In thinking about why firms may not always behave optimally, it is important to remember that a firm is a *collection* of individuals, brought together under a complex set of contracts both written and unwritten, but that the firm itself is not an entity acting with a single mind. Economists often talk about 'the firm' as though it had its own consciousness, but this is either an (often very useful) theoretical simplification or an example of sloppy thinking. The behaviour of the firm is the outcome of the interplay of the motivations of the individuals comprising it, the rules and conventions governing their interaction, and the environment within which the firm operates. The firm makes choices and decisions, but these are generated through its rules of procedure, rather than being the products of an individuated volition. The top decision makers of the firm exercise a considerable degree of control, but that is not sufficient to

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transform it into a conscious entity with a unitary will. Other hierarchical organizations (eg government bureaucracies, armies, university administrations) can experience divergence between goals and actions.

Recognizing this possibility has important consequences. The individuals making up a business firm may all be rational seekers after their own interest, but the outcome of their collective action may be suboptimal. The logic of collective action is such that, in general, '*rational, self-interested individuals will not act to achieve their common or group interests*.'[5] This principle applies to private sector corporations as well as to government bureaucracies or political collectives. The presence of public goods, externalities, and the clash between individuals' private incentives and the good of the whole all combine to produce outcomes that fall short of what could be obtained if all the resources of the group were deployed by a single guiding intelligence.

Some of the specific ways in which a corporation's internal operating rules may thwart optimization of its activities will be discussed below. Before beginning that discussion, however, it is important to note that the inefficiency of a corporation will not be easy to detect. Whatever flow of profits is being generated by the corporation's management, the capital market (ie the market for the stocks, bonds and other securities of the firm) will value the assets of the corporation at a level such that the rate of return on those assets is equal to what could be earned by investing in another activity of comparable risk. If profits are not as large as they might be, the total value of the corporation's assets will be lower than it could be, but this deficiency will not show up in a lower rate of return to the company's stock. So long as the profits of the corporation are positive, a constant level of management inefficiency will not be discernible from data on stock or bond prices. Only a takeover or replacement of the management team can reveal that the old management was not earning as much from the firm's assets as might have been possible.

The possibility of a hostile takeover or shareholder revolt exerts pressure on management to maximize shareholder wealth, but there is no automatic guarantee that this maximization will be achieved in practice. It is costly and risky to attempt to change the management of a major corporation, as many would be takeover groups have learned to their regret. Even if the management team is entirely committed to maximizing the wealth of the corporation's owners, the complexities of directing a large, multifaceted organization will cause management to fall short. Indeed, if there were no difficult challenges to be overcome in obtaining the largest possible return from a given corporate organization, top management jobs would not be so highly paid and attract such high-powered talent.

Failures of complete maximization are to be expected

It follows from these considerations that deviations from full profit maximization should not be surprising. Indeed, a long standing and respected tradition in economic thought holds that business organizations can only approach or approximate profit maximizing behaviour, because of the complexity of the environment they face and limitations on the decision making resources they command. The most famous proponent of this view is Herbert Simon, the Nobel laureate who pioneered the notion that 'satisficing' rather than 'maximizing' is descriptive of how firms actually operate.

According to this paradigm, economic agents resort to satisficing when 'approximation must replace exactness in reaching a decision'.[6] Instead of the profit maximizing first order conditions of the standard economic model, firms employ a variety of expedients in carrying out their activities:

> Several procedures of rather general application and wide use have been discovered that transform intractable decision problems into tractable ones. One procedure . . . is to look for satisfactory choices instead of optimal ones. Another is to replace abstract, global goals with tangible subgoals, whose achievement can be observed and measured. A third is to divide up the decision-making task among many specialists, coordinating their work by means of a structure of communications and authority relations. All of these, and others, fit the general rubric of 'bounded rationality,' and it is now clear that the elaborate organizations that human beings have constructed in the modern world to carry out the work of production and government can only be understood as machinery for coping with the limits of man's abilities to comprehend and compute in the face of complexity and uncertainty.[7]

Under this view of the operation of the firm, an understanding of the forces that lead to any particular pattern of behaviour (regarding, say, energy management) could only be obtained by a careful, microlevel examination of the actual decision making processes of the firms themselves. It would be necessary to see, in specific instances, exactly what sort of informational, computational and organizational constraints were faced by particular firms in order to understand why they did or did not make particular investments.[8]

Asymmetric information and divergent incentives

The conflict between individual rationality and the optimality of the firm's aggregate behaviour can manifest itself in other, quite distinct, ways. Even without limitations on the ability of individuals to 'comprehend and compute' the complex reality they face, institutional or other restrictions on information availability and real differences in the underlying interests of the parties can lead to suboptimal results. Within the framework of decentralized corporations, multidivisional structures or government bureaucracies, individual maximization can produce results contrary to the formal goals of the organization. A wide variety of circumstances can lead to a failure of the organization to maximize profits or minimize costs, even though the individual agents are fully rational wealth maximizers.

It has been known (or strongly suspected) since the time of Berle and Means or even earlier that the interests of shareholders and managers may not coincide.[9] Indeed, a major task of organizational design is to induce the managers of a stockholder owned corporation to act in a manner as consistent as possible with the interests of the owners. This manifestation of the principal–agent problem leads to a variety of reasons why profitable investments might not be undertaken.

One frequently cited factor causing underinvestment in energy saving technologies is the alleged shortsightedness of management. This myopia is usually thought of as being manifested in very short payback periods required for energy (and other) investments, or unduly high internal hurdle rates that must be met for investments to be undertaken. Recently compiled data testify to the existence of both kinds of foreshortening of the time horizons of US managers. In a survey of 228 US manufacturing firms, Poterba and Summers found that the average after-tax real hurdle rate was 12%.[10] This compares to the historical (since the 1920s) real rate of return on equities in the USA of 7%.[11] A 12% hurdle rate is much higher than the historical cost of capital for comparably risky investments. Similarly, a survey of 48 firms conducted by the EPA revealed that the median payback required for one class of energy investment was two years.[12] A payback of two years for a project with a 10-year lifetime is equivalent to a post-tax real rate of return of 56%.[13]

Yet deeper consideration of the situation facing the owners and management of a large, multidivisional corporation uncovers several factors that might lead to adoption of such overly stringent investment criteria, despite the fact that the cost of capital faced by the firms is considerably lower than the hurdle rates that projects are required to meet in order to be accepted.

Managerial compensation is often tied to recent performance, and in many corporations, managers are rotated through different jobs every few years. This sort of rotation policy may be important in maintaining managerial motivation, preventing ossification, and ensuring that managers have a perspective on the full range of the company's activities. However, this sort of frequent job turnover may lead managers to prefer projects with short payback periods even if those projects are inferior, in some global profit maximizing sense, to others of longer duration.[14] A manager who only expected to be in a particular job for two or three years would have no personal incentive to promote a project having a more distant payoff.[15]

Tying management compensation to short-term performance has the same effect. Statman and Sepe refer to a body of research indicating that 'managerial decisions are quite sensitive to compensation plans',[16] with the particular finding that capital investment in long-term projects 'increased with adoption of long-term compensation plans'.[17] Yet one observer noted that

> there is growing concern that the evaluation, reward/punishment, and executive incentive systems presently employed often emphasize short run accounting-based returns instead of maximization of the long-run value of the firm. Thus, short run earnings, earnings per share, or sales growth are often rewarded. This emphasis on short-run results may encourage management to forego investment in capital equipment or research and development which would benefit the corporation several years hence even more than the improved earnings next year would.[18]

Other features of the executive compensation system can skew decisions away from beneficial energy investments. Managers will be deterred from initiating risky projects if the personal consequences of failure seem to be much larger than the payoff to success, and if managers are risk averse while shareholders are risk neutral because the latter hold diversified portfolios of assets.[19] Human capital investment in energy conservation expertise will be low if the compensation and prestige of the managers responsible for energy use (eg facilities personnel) are less than the rewards for other positions.

Hurdle rates can be set with an eye towards the problems of control of a large organization, not just to correspond to the firm's cost of capital. Models in the managerial and accounting literature embodying this theme usually stress the asymmetry of information between stockholders or central headquarters and the divisional managers who are more familiar with local conditions, in addition to the divergence of preferences between owners and managers or between different layers of management.[20] In an important paper by Antle and Eppen, the owners set the hurdle rate substantially above the cost of capital to ensure that only highly profitable investments are undertaken.[21] The reason is that the shareholders cannot easily observe the true profitability of projects, so they may not be able to prevent dissipation of some profits into managerial slack (defined as the excess of resources allocated over the minimum necessary to accomplish the tasks assigned) if a lower hurdle rate closer to the cost of capital were applied. Imposition of a too high hurdle rate means that some profitable projects are forgone, but it still constitutes a second-best solution to the owners' monitoring and control problem.

In a related model, Narayanan shows that managers might prefer investments with rapid paybacks, because the quick return on such projects enhances the managers' reputations with the owners.[22] If a manager's true ability is not observable by the shareholders, then

> the manager hopes that if he selects the quick-return project, the stockholders may attribute the extra dollars to his ability and pay him higher wages not only in that period but also in subsequent periods, since his pay is based on current and past performances.[23]

This effect is reinforced if the market cannot observe the manager's choices of projects (which is possible because many managerial choices are small and outside the public domain). In this case, shareholders cannot know whether poor returns are

> a result of the manager's (in)ability or due to the fact that he has chosen a project with later cash flows . . . This is the primary reason why managers scramble to show quick results.[24]

Michael T. Jacobs, former Director of the US Treasury Department's Office of Corporate Finance, has recently published a book arguing that agency problems associated with a weakening of equity ownership rights and misdirected regulatory policies have led to a spread of corporate myopia and a loss of competitiveness.[25] Jacobs faults the proliferation of antitakeover laws (40 states have adopted or strengthened such statutes in recent years) and the demise of 'relationship banking' for the rise of short-term thinking on the part of top management. According to Jacobs, without effective oversight by providers of capital or the discipline of possible removal through a hostile takeover, managers often fail to make the most of the corporate assets they deploy.

Lambert has shown how, in a principal–agent framework, executives may underinvest in relatively risky projects if they perceive those projects to have a potentially negative impact on their own welfare.[26] In Lambert's representation of the situation, a conflict of interest exists because even if the principal can observe which projects are selected, the principal cannot know *why* they were selected. The effort that must be expended by the manager to discover information about projects is inextricably bound up with project selection, so the preferred contracts between owner and manager are second best. Interestingly, there are gains to both the manager and the owner from improvement of communication between them. Transmission of information about the profitability of projects may be costly, executives may not be able to articulate the information, or the principal may not be able to understand it.[27] These features may well characterize certain energy saving investments.

A similar rationale for a bias in favour of projects with rapid paybacks arises when moral hazard is present in the agency relationship. Suppose the cash flows of investment projects depend on a combination of the effort expended by management and a random state of nature unknown at the time the level of effort is selected. Moral hazard is present if the principal (the owner) cannot observe either the manager's effort or the random state of nature *ex post*, and the manager has disutility for effort.[28] In this case, projects with more rapid paybacks may enable the owner to set contract terms for the manager that control the moral hazard at lower cost:

> Usually, the manager's second-period compensation is optimally a function of both first- and second-period cash flow realizations; i.e., intertemporal linkages are optimal. The first-period compensation is always a function of the first-period cash flow. Hence, the second-period compensation is riskier in an ex-ante sense. So, an owner who wants to motivate a manager strongly in the second period to fully extract the project's economic value must impose more risk on the manager than if the owner had little value to extract in the second period. In this case, a faster payback project helps because its dominant value source is the first-period cash flow. Consequently, the faster payback project may optimally impose less contracting risk on the manager and result in lower contracting costs for the owner.[29]

The specific results of this model require risk aversion on the part of the manager (to rule out a pure rental contract under which the principal gets a fixed payment and the manager absorbs all risk) and the feature that the manager's effort affects the probability of the project's success rather than the cash flow from the project if it is successful. These details aside, the underlying idea that is common to these models is that the owner's general problem of acquiring information and exercising control leads to second-best expedients that may maximize profits subject to the organizational constraints, but which are not first-best solutions that would optimize the allocation of resources given full information and complete coincidence of interests between the owner and management.

Problems of focus and attention

Another hypothesis frequently offered to explain the failure of firms to exploit fully the cost saving energy investments available to them is that top management gives low priority to relatively small cost cutting projects (including energy saving ones). In reviewing the Alliance to Save Energy's detailed survey of energy investment practices in 15 industrial firms, Ross reports that

> [t]op corporate management is preoccupied with many other responsibilities and assigns low priority to cost cutting. Also top management feels unable to decentralize or delegate open-ended responsibility for investment in smaller projects, especially since information and decision costs for smaller projects are relatively high.[30]

The same problem of focus and priority applies to the oversight of federal government managers, and is referred to frequently in the literature on energy conservation.[31]

This problem is related to the obstacles that arise under the 'satisficing' paradigm, in the sense that management attention and resources are scarce and must be concentrated on those areas deemed crucial to the survival of the firm – expansion or preservation of market share in its main product lines, strategic development of new products and markets, and compliance with legally mandated environmental or workplace safety controls. Given limits to the amount of work that can be accomplished by those responsible for the firm's investment decisions, it is not surprising that some classes of investments (ie small projects seen as peripheral to the main thrust of the firm) get short shrift.

There are also difficulties in monitoring the savings achieved by energy management investments. A large part of corporate energy usage is tied to factors that vary unevenly over time, such as the weather or state of the economy. It is often not simple to separate the effects of changes in energy management policy from changes in these external factors. If energy management has not been a priority in the past, then the historical data needed for comparisons will be lacking.

Firms may not be able costlessly to expand or contract their management team in such a way that all the managers are optimally occupied at all times. Too much instability in the make up of management can have adverse effects on morale and, indirectly, on a firm's reputation in the market for management services. Because of training costs and the value of firm-specific human capital, employment is not perfectly correlated with output over the course of the business cycle, and similar considerations preclude a perfect match between tasks and management resources.

Statistical or selection bias in estimating investment returns

Information problems can affect the setting of investment criteria by management in another way. If the estimated returns to most types of prospective investment projects are biased systematically upward, then management may impose a hurdle rate greater than the firm's cost of capital to ensure that the returns actually realized on projects undertaken are high enough to be profitable. Such a policy could inhibit energy-efficiency investments whose returns are forecast accurately, if management fails to distinguish them from the projects whose forecast returns are upwardly biased.

Even if cost and revenue estimates for proposed projects are unbiased, it is natural to suppose that projects with higher anticipated rates of return will be the ones that tend to be selected. As a result, the selection of projects from the universe of proposals is not an unbiased sample. Some projects will be selected because they actually do have higher returns, but others will be selected because their actual returns have been overestimated. As a result, the returns on the projects selected will be lower, on average, than their projected returns.[32] Selection bias can lead to cost overruns even if the cost estimates themselves are unbiased and decision makers utilize all available information optimally.[33] This possibility could lead management to screen out some profitable low risk energy investments in the course of compensating for the general selection bias.

In addition, it is not necessarily the case that cost and revenue estimates of projects will be unbiased. Both experimental and survey evidence suggest the opposite. Statman and Tyebjee report that decision makers with prior work experience believe that investment project proposals embody an optimistic bias.[34] They find that their results are consistent with Miller's hypothesis 'that decision makers have information, gained from experience, about prior probabilities, and that this experience is not available to forecasters.'[35] These experimental results were confirmed in a survey of 121 Fortune 500 companies.[36] The survey found that nearly 80% of the respondents believed that revenue forecasts of capital budgeting proposals are typically overstated. One group of respondents

> suggested that the optimistic bias resulted primarily from 'myopic euphoria' in which the individuals responsible for preparation of the forecasts were simply too involved with the projects to be totally objective,

while another group 'felt that the optimistic bias resulted from erroneous initial information provided to forecasting staff members by *upper-level* managerial personnel' – the 'pet project' phenomenon.[37] Worries about either type of informational bias might lead managers to set overly strict criteria for new investments, thereby blocking some profitable energy saving projects.

Policy implications

None of the explanations for the existence of barriers to energy saving investments discussed in the previous section relies on irrationality or managerial irresponsibility to account for the missed profit opportunities. Yet paradoxically, the prevalence of incentive, information and organizational control problems suggests a number of areas in which government policy can make a difference. What may be required is to step away from the traditional regulatory approach and to seek precedents in some other kinds of government action not always thought of as closely related to environmental protection goals.

Government as a clearing house for information

Because of its central position and data gathering mandates, government is ideally situated to serve as a repository and distribution point for information on energy technologies. Private-sector firms often find it difficult to acquire knowledge about the set of technological options open to them, and to evaluate the characteristics of the technologies that do exist. Government agencies such as the EPA and the Department of Energy can efficiently collect, maintain, and disseminate information about energy saving possibilities. Libraries, archives, and electronic databases are universally recognized as having strong public goods features, and as such are likely to be provided best by government.

The information gathering and distribution function can directly work to lower the intrafirm barriers to efficient energy management. Providing information can help diminish the adverse effects of the principal–agent problem within firms. Many inefficiencies stem from the principal's problems in distinguishing between the effects of management decisions and the state of the world. For example, owners (or top management) may require a high hurdle rate as a second-best strategy to cope with incentive and control problems, even if this means forgoing some projects with rates of return closer to (but still above) the firm's cost of capital. (See the discussion above.) By providing good information about the economic performance of energy saving investments, government can enable both owners and management to make decisions based on realistic assessments of what those investments are likely to yield. In a similar vein, by publicizing the results of typical or representative energy saving investments, government can actually reduce the perceived risk of similar investments by firms slow to adopt the new technologies.

Management consulting

Government has large amounts of information, experience and talent at its disposal, and there is no reason why this concentrated expertise cannot be made useful to business firms. Even given a policy agenda that is distinct from the profit making objective of the private firms, government's knowhow and knowledge base can be an extremely valuable resource for the private sector.

An interesting historical example of the gains available through this channel is the case of the agricultural experiment stations. Established in each state in 1887 and supported with federal funds, the stations provided local farmers with information about plant and animal varieties, feeds and fertilizers, and best agricultural practices as they were known at the time. The agricultural experiment stations were able to balance the tension between centralized administration and the need to adapt to local variations:

> So long as communication among stations was good, and a sophisticated awareness of the limited transferability of results from one state to another was present, the system of state stations could rest like a centipede on American ground, with many feet and one body, moving as a unit, but adapting at each point to local conditions.[38]

The agricultural experiment stations were highly successful in disseminating practical technological information to a diverse and geographically dispersed population – the millions of farmers who were their targeted clientele. The productivity gains resulting from the stations' efforts were large and sustained.[39] It is not difficult to visualize a network of industrial experiment stations, demonstrating (among other things) energy-efficient technologies, serving the same sort of function in the present day economy.

The EPA has already launched a project that fits this conceptual framework – the Green Lights Program. Begun in 1991, Green Lights is a voluntary programme designed to encourage major corporations to undertake energy saving lighting upgrades that:

- maintain or improve lighting quality;
- embody the latest energy saving technology; and
- meet a profitability criterion consistent with the goal of shareholder wealth maximization.

In return for a corporate commitment to survey facilities and make the indicated lighting investments over a five-year period, the EPA provides technical information, current data on utility rebate programmes nationwide, and advertising and public relations support. In addition, EPA has developed a sophisticated and powerful expert system that can assist participating companies in analysing their lighting needs and performing economic analyses of the upgrade possibilities. Green Lights has been highly successful to date, with over 140 major corporations joining in the first year of the programme's operation.[40]

Another way in which the government can contribute to improvement of energy management practices is to suggest methods of overcoming the incentive barriers within firms. For example, the problems of focus, small scale, and lack of connection to central business objectives of the firm could be overcome if firms were to set up internal energy management profit centres. Such organizational units could consolidate projects, lend funds internally, monitor energy use, and raise energy management to the strategic priority level by acting as independent profit centres within decentralized corporations. It is within the mandate of the EPA to encourage firms to experiment with establishment of such divisions, and to share the experiences obtained from such experiments throughout the economy.

Serving as a rallying point

In any modern society, the central government is uniquely positioned as the focal point of general societal preoccupations. Simply to have the government pay attention to an issue is often sufficient to make that issue salient. The environmental concerns that are linked to generation of energy by fossil fuel combustion can be channelled by the government's giving those concerns visibility and standing.

Changes in corporate policy usually require an individual or group to champion the change. It is a fact of bureaucratic politics that efforts by such a group stand a much better chance of success if the group can point to similar efforts being made by other firms, and if the group can link its proposals to values widely shared within the corporation. The government can advance initiatives for change both by communicating directly with top management (because top management will be attentive to signals coming from the government) and by providing a frame of reference for the discussion of new initiatives. Environmental protection is broadly supported at all levels of the management of most firms, and government attention can help overcome some of the organizational inertia that slows down adoption of corporate policies to benefit the environment. Also, firms realize that because of the diffuse nature of many of the most important environmental externalities, joint action across geographical, sectoral, and even national boundaries is required for effective action. Knowing that the government is giving priority to a particular externality (such as that associated with energy production from fossil fuels) makes it more rational for a firm to adopt environmental protection measures than if it were acting alone.

Conclusion

We have seen that because of problems of information and control, a well managed corporation may still have available to it profitable opportunities that it finds difficult to realize. One task of management is to ferret out such opportunities and overcome the barriers to them. Even so, a large number of potentially profitable projects, including some that would capture substantial energy savings, fail to be undertaken.

Competitive pressure in the immediate product market in the form of potential market entry by other firms, or the possibility of changes in management through the market for corporate control, exert some pressure for efficiency. At the same time, however, the firm is shaped by internal informational and incentive factors having little to do with the neoclassical optimization paradigm. The profitability performance of the firm is influenced as much by its structure, governance, and organization as by its adherence to any set of mechanically applicable procedures for maximization of profit with a given technology.

In this context, a societal drive for greater energy efficiency can be seen as a opportunity for innovation. As shown above, non-regulatory governmental programmes to improve corporate decision making can provide benefits regardless of the specific purpose of the government's initiatives. In the case of energy efficiency, there is an added benefit. Current fossil fuel energy production technologies increase the kinds of pollution that contribute to global warming, acid precipitation and urban smog. Increasing corporate profits by improving energy efficiency can thus raise the level of society's wealth while simultaneously helping to ensure that the standard of living we now enjoy can be sustained for future generations.

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[1]See, for example, E. Tasdemiroglu, S. Chandra and S. Moalla, 'Savings from energy-efficient industrialized housing for the US', *Energy World*, Vol 16, No 8, August 1991, pp 1119–1123; Jagjit Kaur, S.P. Singh, R.L. Sawhney and M.S. Sodha, 'Optimum layered distribution of masonry and insulation of a building component', *International Journal of Energy Research*, Vol 15, 1991, pp 11–18; Frank M. Stewart, 'Energy efficiency programs for existing buildings', *Applied Energy*, Vol 36, Nos 1 & 2, 1990, pp 21–27; Marvin J. Horowitz, 'Energy efficiency improvements and investment behavior in small commercial buildings', *Energy*, Vol 14, No 11, November 1989, pp 697–707; S. Zubair, V. Bahel and M. Arshad, 'Capacity control of air-conditioning systems by power inverters', *Energy*, Vol 15, No 3, March 1989, pp 141–151; Scott A. Moses, Wayne C. Turner, Jorge B. Wong and Mark R. Duffer, 'Profit improvement with variable frequency drives', *Energy Engineering*, Vol 86, No 3, 1989, pp 6–23; Roger Burger, 'Lowering cooling tower water temperature saves energy for chillers and process systems', *Energy Engineering*, Vol 85, No 3, 1988, pp 17–28; Kenneth A. Fonstad, 'Energy savings through control of cooling tower air flow', *Energy Engineering*, Vol 85, No 3, 1988, pp 4–16; Arthur H. Rosenfeld and David Hafemeister, 'Energy-efficient buildings', *Scientific American*, Vol 258, No 4, April 1988, pp 78–85; Clark W. Gellings, Ahmad Faruqui and Ken Seiden, 'Potential energy savings from efficient electric technologies', *Energy Policy*, Vol 19, No 3, April 1991, pp 217–230; Jayant R. Patel, 'Case study: energy conservation – a continual process at defense contractor's manufacturing facility', *Energy Engineering*, Vol 88, No 4, 1991, pp 50–60; A. Kaya, 'Automatic control of continuous drying processes', *Energy Engineering*, Vol 88, No 5, 1991, pp 55–72; Preston Lowrey and Jeff Harasha, 'A preliminary assessment of the feasibility of using riblets in internal flows to conserve energy', *Energy*, Vol 16, No 3, March 1991, pp 631–642; Bruce C. Hiatt, 'Energy efficiency in electric motors', *Energy Engineering*, Vol 87, No 4, 1990, pp 36–42; Martin Timm, 'Cool storage for industrial applications', *Energy Engineering*, Vol 87, No 6, 1990, pp 23–33; Marc Ross, 'Improving the efficiency of electricity use in manufacturing', *Science*, Vol 244, No 4902, April 1989, pp 311–317; H. Kadete, 'Energy conservation in tobacco curing', *Energy*, Vol 14, No 7, July 1989, pp 415–420; *op cit*, Ref 1, Moses *et al*; Hanagudu Harish, 'Electric motor replacements for mechanical steam turbine drives', *Energy Engineering*, Vol 86, No 5, 1989, pp 49–57; Thomas W. Mix, 'Advanced separation techniques for petrochemicals', *Energy*, Vol 12, Nos 10/11, October/November 1987, pp 1121–1133; E.P. Velikhov, V.M. Maslennikov, A.E. Sheindlin, E.E. Shpilrain and V. Ya. Shterenberg, 'Integrated energy generation and industrial processing as a method of energy conservation', *Energy*, Vol 12, Nos 10/11, October/November 1987, pp 1083–1093; J. Nelson, V. Tinnis and O. Vartiainen, 'Energy conservation and energy management in the metals industry', *Metals Technology*, Vol 11, Part 8, August 1984, pp 341–345; Stanley F. Sobezynski, 'Conserving energy in the paper industry', *Chemical Engineering Progress*, Vol 80, No 6, June 1984, pp 51–56; Daniel H. Johnnie Jr and H.J. Klooster, 'Upgrading refineries for energy conservation', *Chemical Engineering Process*, Vol 80, No 6, June 1984, pp 42–46; Alfred C.C. Tseung, Jeanette A. Antonian and D. Brynn Hibbert, 'Energy conservation in the chlor-alkali industry', *Chemistry and Industry*, Vol 16, No 2, January 1984, pp 55–59; J.A. Pardoe, 'CONFORM continuous extrusion process: its contribution to energy conservation', *Metals Technology*, Vol 11, Part 8, August 1984, pp 358–365; and A.M. Robinson, 'Energy management for multicomplex plants', *Chemical Engineering Progress*, Vol 80, No 6, June 1984, pp 39–41.

[2]US Congress, Office of Technology Assessment, *Energy Efficiency in the Federal Government: Government by Good Example?*, OTA-E-492, Washington, DC, US Government Printing Office, 1991.

[3]For resistance by residential consumers see Fereidoon P. Sioshansi, 'The myths and facts of energy efficiency', *Energy Policy*, Vol 19, No 3, April 1991, pp 231–243; *op cit*, Ref 1, Rosenfeld and Hafemeister. Hausman found an average population annual discount rate of 26.4% for the purchase of room air conditioners, with discount rates for low income family groups ranging from 39% to 89%: see Jerry A. Hausman, 'Individual discount rates and the purchase and utilization of energy-using durables', *The Bell Journal of Economics*, Vol 10, No 1, 1979, pp 33–54. Hartman and Doane found an implicit average discount rate of 31.6% for household weatherization investments, with low-income households exhibiting rates greater than 70%: Raymond S. Hartman and Michael J. Doane, 'Household discount rates revisited', *The Energy Journal*, Vol 7, No 1, January 1986, pp 139–148. For industrial corporations see James L. Wolf, Michael Reid, Robin M. Miller and Ellen Jo Fleming, *Industrial Investment in Energy Efficiency: Opportunities, Management Practices, and Tax Incentives*, Alliance to Save Energy, Washington, DC, 1983.

[4]For a valuable survey stressing explanations based on market imperfections and failures of individual rationality, see John B. Robinson, 'The proof of the pudding: making energy efficiency work', *Energy Policy*, Vol 19, No 7, September 1991, pp 631–645. My focus will be on the corporate sector rather than on households, and on the reasons business firms fail to realize their profitable energy saving opportunities even though the members of the firms are rational agents.

[5]The quotation is from Mancur Olson's path-breaking monograph, *The Logic of Collective Action: Public Goods and the Theory of Groups*, Cambridge, MA, Harvard University Press, 1965, 1971 (italics in the original). The notion that collective action will in general be suboptimal is well understood in the literature of public choice. See, for example, William H. Riker and Peter C. Ordeshook, *Positive Political Theory*, Prentice-Hall, Englewood Cliffs, NJ, 1973.

[6]Herbert A. Simon, 'Theories of bounded rationality', in C.B. McGuire and R. Radner, eds, *Decision and Organization*, North-Holland, Amsterdam, 1972, pp 161–176.

[7]Herbert A. Simon, 'Rational decision making in business organizations', *The American Economic Review*, Vol 69, No 4, September 1979, pp 493–513.

[8]It has been argued by Jensen and Meckling that satisficing

behaviour is really only maximizing behaviour in the presence of search, transactions and computation costs: Michael C. Jensen and William H. Meckling, 'Theory of the firm: managerial behavior, agency costs and ownership structure', *Journal of Financial Economics*, Vol 3, No 4, October 1976, pp 305–360. If 'costs' are defined to include those that are not measurable, this statement is tautological. For purposes of policy analysis or for direction of the operations of firms, it makes no substantive analytical difference whether the effects of such intangible or non-measurable costs are treated as deviations from profit maximization. A satisficing firm does the best it can under its unique circumstances.

[9]Adolf A. Berle and Gardiner C. Means, *The Modern Corporation and Private Property*, New York, The MacMillan Company, 1932. Jensen and Meckling *op cit*, Ref 8, cite the pertinent passage in Adam Smith:

The directors of such [joint-stock] companies, however, being the managers rather of other people's money than of their own, it cannot well be expected, that they should watch over it with the same anxious vigilance with which the partners in a private copartnery frequently watch over their own. Like the stewards of a rich man, they are apt to consider attention to small matters as not for their master's honour, and very easily give themselves a dispensation from having it. Negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such a company.

Adam Smith, *The Wealth of Nations*, Cannan Edition, New York, Modern Library, 1937, p 700 (originally published 1776). And thinking of this particular economic problem even predates Adam Smith, as in the Parables of the Silver Pieces [Matthew 25:14–30], the Wily Manager [Luke 16:1–8] and the Good Shepherd [John 10:6–13]: Catholic Biblical Association of America, *The New American Bible: Translated from the Original Languages with Critical Use of All the Ancient Sources*, New York, P.J. Kenedy and Sons, 1970. For a useful survey of antecedents, see Oliver Williamson, *The Economics of Discretionary Behavior: Managerial Objectives in a Theory of the Firm*, Prentice-Hall, Englewood Cliffs, NJ, 1964.

[10]James Poterba and Lawrence Summers, 'Time horizons of American firms: new evidence from a survey of CEOs', unpublished manuscript, Massachusetts Institute of Technology and Harvard University, 1991.

[11]These rates are expressed in real terms, that is, after removing the expected inflation component present in the nominal interest rates observed in the market.

[12]Environmental Protection Agency, *Green Lights Partner Questionnaire*, survey responses of 48 firms, xeroxed, Washington, DC, 1991.

[13]Assuming a marginal tax rate of 34% and full straight-line depreciation over the 10 year lifetime of the project.

[14]Alfred Rappaport, 'Executive incentives vs. corporate growth', *Harvard Business Review*, Vol 56, No 4, July–August, 1978, pp 81–88.

[15]Assuming that the manager's actions have no observable effect on the net worth of the corporation, as measured by the stock price, for example. For projects that are individually small, this condition is likely to hold.

[16]Meir Statman and James F. Sepe, 'Managerial incentive plans and the use of the payback method', *Journal of Business Finance & Accounting*, Vol 11, No 1, Spring 1984, pp 61–65.

[17]*Ibid*, citing D.F. Larcker, *The Association between Performance Plan Adoption and Corporate Capital Investment*, Working paper, Northwestern University, 1980.

[18]George E. Pinches, 'Myopia, capital budgeting, and decision making', *Financial Management*, Autumn 1982, pp 6–19. The quotation is from page 13.

[19]*Op cit*, Ref 14.

[20]M. Harris, C.H. Kriebel and A. Raviv, 'Asymmetric information, incentives and intrafirm resource allocations', *Management Science*, Vol 28, No 6, June 1982, pp 604–620.

[21]Rick Antle and Gary D. Eppen, 'Capital rationing and organizational slack in capital budgeting', *Management Science*, Vol 31, No 2, February 1985, pp 163–174.

[21]M.P. Narayanan, 'Observability and the payback criterion', *Journal of Business*, Vol 28, No 3, July 1985, pp 309–323.

[23]*Ibid*, p 310.

[24]*Ibid*, p 319.

[25]Michael T. Jacobs, *Short-Term America: The Causes and Cures of Our Business Myopia*, Boston, Harvard Business School Press, 1991.

[26]Richard A. Lambert, 'Executive effort and selection of risky projects', *Rand Journal of Economics*, Vol 17, No 1, Spring 1986, pp 77–88.

[27]*Ibid*, p 85.

[28]This definition, and the remainder of this paragraph, is drawn from Paul K. Chaney, 'Moral hazard and capital budgeting', *The Journal of Financial Research*, Vol 12, No 2, Summer 1989, pp 113–128.

[29]*Ibid*, p 119.

[30]Marc Ross, 'Perspectives on capital budgeting', *Financial Management*, Vol 15, No 4, Winter 1986, p 20.

[31]*Op cit*, Ref 2. Peter G. Sassone and Michael V. Martucci, 'Industrial energy conservation: the reasons behind the decisions', *Energy*, Vol 9, No 5, May 1984, pp 427–437; *op cit*, Ref 3, Wolf. Low priority for energy investments is also a prevalent situation in other countries, both developed and developing. See Mark D. Levine, Stephen P. Meyers and Thomas Wilbanks, 'Energy efficiency and developing countries', *Environmental Science and Technology*, Vol 25, No 4, April 1991, pp 584–589; R. Aburas, 'Energy conservation policies in Jordan', *Energy Policy*, Vol 17, No 6, December 1989, pp 591–598; and Jane Carter, 'Energy conservation in the United Kingdom: a major industrial opportunity', *The Energy Journal*, Vol 5, No 1, 1984, pp 149–158.

[32]Keith C. Brown, 'A note on the apparent bias of new revenue estimates for capital investment projects', *The Journal of Finance*, Vol 29, No 4, September 1985, pp 1215–1216; and 'The rate of return of selected investment projects', *The Journal of Finance*, Vol 33, No 4, September 1978, pp 1250–1253.

[33]James Quirk and Katsuaki Terasawa, 'Sample selection and cost underestimation bias in pioneer projects', *Land Economics*, Vol 62, No 2, May 1986, pp 192–200; Martin B. Zimmerman, 'Learning effects and the commercialization of new energy technologies: the case of nuclear power', *Bell Journal of Economics*, Vol 13, No 2, Autumn 1982, pp 297–310.

[34]Meir Statman and Tyzoon T. Tyebjee, 'Optimistic capital budgeting forecasts: an experiment', *Financial Management*, Vol 14, No 3, Autumn 1985, pp 27–33.

[35]E.M. Miller, 'Uncertainty induced bias in capital budgeting', *Financial Management*, Autumn 1978, pp 12–18; *op cit*, Ref 34, p 32.

[36]Stephen W. Pruitt and Lawrence J. Gitman, 'Capital budgeting forecast biases: evidence from the Fortune 500', *Financial Management*, Vol 16, No 1, Spring 1987, pp 46–51.

[37]*Ibid*, pp 47–49.

[38]William N. Parker and Stephen J. DeCanio, 'Two hidden sources of productivity growth in American agriculture, 1860–1930', *Agricultural History*, Vol 56, No 4, October 1982, p 651.

[39]*Ibid*. See also Zvi Griliches, 'Hybrid corn and the economics of innovation', *Science*, Vol 132, 29 July 1960, pp 275–280, for discussion of the agricultural experiment stations' role in the diffusion of hybrid corn.

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Toronto Hydro-Electric System Limited
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Exhibit J
Tab 6
Schedule 5
Appendix C
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DISCUSSION PAPER

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Energy Efficiency Economics and Policy

Kenneth Gillingham, Richard G. Newell, and Karen Palmer

1616 P St. NW
Washington, DC 20036
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RESOURCES FOR THE FUTURE

Energy Efficiency Economics and Policy

Kenneth Gillingham, Richard G. Newell, and Karen Palmer

Abstract

Energy efficiency and conservation are considered key means for reducing greenhouse gas emissions and achieving other energy policy goals, but associated market behavior and policy responses have engendered debates in the economic literature. We review economic concepts underlying consumer decisionmaking in energy efficiency and conservation and examine related empirical literature. In particular, we provide an economic perspective on the range of market barriers, market failures, and behavioral failures that have been cited in the energy efficiency context. We assess the extent to which these conditions provide a motivation for policy intervention in energy-using product markets, including an examination of the evidence on policy effectiveness and cost. While theory and empirical evidence suggest there is potential for welfare-enhancing energy efficiency policies, many open questions remain, particularly relating to the extent of some of the key market and behavioral failures.

Key Words: energy efficiency, appliance standards, energy policy, market failures, behavioral failures

JEL Classification Numbers: Q38, Q41

Contents

Energy Efficiency Economics and Policy

Kenneth Gillingham, Richard G. Newell, and Karen Palmer *

1. Introduction

Energy efficiency and conservation have long been critical elements in the energy policy dialogue and have taken on a renewed importance as concerns about global climate change and energy security have intensified. Many advocates and policymakers hold that reducing the demand for energy is essential to meeting these challenges, and analyses tend to find that demand reductions can be a cost-effective means of addressing these concerns. With such great policy interest, a significant literature has developed over the past 30 years that provides an economic framework for addressing energy efficiency and conservation as well as empirical estimates of how consumers respond to policies to reduce the demand for energy.

We begin by defining a few terms to put the literature in context. First, it is important to conceptualize energy as an input into the production of desired energy services (e.g., heating, lighting, motion), rather than as an end in itself. In this framework, energy efficiency is typically defined as the energy services provided per unit of energy input. For example, the energy efficiency of an air conditioner is the amount of heat removed from air per kilowatt-hour of electricity input. At the individual product level, energy efficiency can be thought of as one of a bundle of product characteristics, alongside product cost and other attributes (Newell et al. 1999). At a more aggregate level, the energy efficiency of a sector or of the economy as a whole can be measured as the level of Gross Domestic Product per unit of energy consumed in its

* Kenneth Gillingham, Stanford University, Precourt Energy Efficiency Center, P.O. Box 16336, Stanford, California 94309; e-mail: kgilling@stanford.edu. Richard G. Newell, corresponding author; Duke University, Nicholas School of the Environment, Box 90227, Durham, North Carolina 27708; e-mail: richard.newell@duke.edu. Also, Resources for the Future, 1616 P Street, NW, Washington, DC 20036; and National Bureau of Economic Research, 1050 Massachusetts Avenue, Cambridge, MA 02138. Karen Palmer, Resources for the Future; e-mail: palmer@rff.org. The authors appreciate the very helpful research assistance of Maura Allaire, as well as useful comments from James Sweeney, Timothy Brennan, Maximilian Auffhammer, Richard Howarth, Danny Cullenward, and Sebastien Houde. This research was funded in part by the Resources for the Future Electricity and Environment Program, a special gift from Exelon for work on Energy Efficiency, and the U.S. Environmental Protection Agency STAR Fellowship program.

production (see, e.g., Metcalf [2008] and Sue Wing [2008] for analyses of the determinants of energy intensity at the state and national levels).

In contrast, energy conservation is typically defined as a reduction in the total amount of energy consumed. Thus, energy conservation may or may not be associated with an increase in energy efficiency, depending on how energy services change. That is, energy consumption may be reduced with or without an increase in energy efficiency, and energy consumption may increase alongside an increase in energy efficiency. These distinctions are important when considering issues such as the "rebound effect," whereby the demand for energy services may increase in response to energy efficiency–induced declines in the marginal cost of energy services. The distinction is also important in understanding the short- versus long-run price elasticity of energy demand, whereby short-run changes may depend principally on changes in consumption of energy services, while longer-run changes include greater changes in the energy efficiency of the equipment stock.

One must also distinguish between energy efficiency and economic efficiency. Maximizing economic efficiency—typically operationalized as maximizing net benefits to society—is generally not going to imply maximizing energy efficiency, which is a physical concept and comes at a cost. An important issue arises, however, regarding whether private economic decisions about the level of energy efficiency chosen for products are economically efficient. This will depend on both the economic efficiency of the market conditions the consumer faces (e.g., energy prices, information availability) as well as the economic behavior of the individual decisionmaker (e.g., cost-minimization).

Market conditions may depart from efficiency if there are market failures, such as environmental externalities or imperfect information. Aside from such market failures, most economic analysis of energy efficiency has taken cost-minimizing (or utility/profit maximizing) behavior by households and firms as a point of departure in analysis. Some literature, however, has focused more closely on the decisionmaking behavior of economic actors, identifying potential "behavioral failures" that lead to deviations from cost-minimization; this literature is motivated at least partly by results from the field of behavioral economics. Much of the economic literature on energy efficiency therefore seeks to conceptualize energy efficiency decisionmaking, identify the degree to which market or behavioral failures may present an opportunity for net-beneficial policy interventions, and evaluate the realized effectiveness and cost of actual policies.

This line of research has important implications both for assessing the cost of correcting market failures—such as environmental externalities—as well as clarifying the role of policies that are oriented to correcting behavioral failures. For example, if behavioral failures lead to underinvestment in energy efficiency, then a degree of reductions in energy-related emissions could be available at low or even negative cost. At the same time, policies that provide an efficient means of correcting environmental externalities—such as an emissions price—may not be well-suited to inducing these relatively low-cost energy and emission reductions. In principle, a set of policies addressing both market and behavioral failures could therefore potentially provide a more efficient overall response. In practice, the value of individual policy components will depend on the extent of existing market problems and the ability of specific policies to correct these problems in a net beneficial manner.

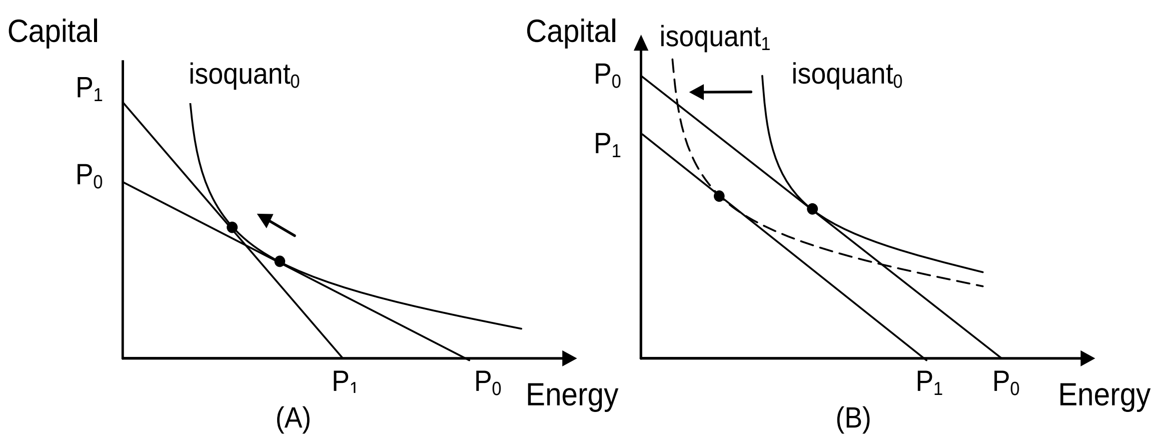
This article views the literature through this perspective, and begins by introducing the notion of energy efficiency as an investment in producing energy services. After presenting evidence of energy market influences on energy efficiency, we turn to identifying and examining empirical evidence on a range of market and behavioral failures that have been discussed in the energy efficiency literature. We then address the implications of this evidence for policy interventions and briefly review the empirical evidence on the effectiveness and cost of policy, including price policies and information policies. Finally, we provide overall conclusions. We limit the scope of this study primarily to energy efficiency and conservation in buildings and appliances and do not address transportation in detail. Nonetheless, most of the same conceptual and empirical issues carry over to transportation as well.

2. Energy Efficiency as an Investment in Producing Energy Services

From an economic perspective, energy efficiency choices fundamentally involve investment decisions that trade off higher initial capital costs and uncertain lower future energy operating costs. In the simplest case, the initial cost is the difference between the purchase and installation cost of a relatively energy-efficient product and the cost of an otherwise equivalent product that provides the same energy services but uses more energy. The decision of whether to make the energy-efficient investment requires weighing this initial capital cost against the expected future savings. Assessing the future savings requires forming expectations of future energy prices, changes in other operating costs related to the energy use (e.g., pollution charges), intensity of use of the product, and equipment lifetime. Comparing these expected future cash flows to the initial cost requires discounting the future cash flows to present values. Holding consumption of energy services constant, a privately optimal decision would entail choosing the level of energy efficiency to minimize the present value of private costs, while economic efficiency at a societal level would entail minimizing social costs. This makes energy efficiency different in character from many other product attributes for which there may not be a well-defined notion of what constitutes optimal or "rational" behavior on the part of the individual.

This conceptualization of the problem maps directly into a production function framework in which capital and energy are viewed as inputs into the production of energy services. Along an isoquant describing a given level of energy services, the cost-minimizing level of energy use (and thus energy efficiency) is found at the point of tangency where the marginal increase in capital cost with respect to energy reduction is equal to their relative price (in present value terms) (Figure 1). As described above, the relative price will depend on the capital cost of efficiency improvements, the discount rate, expected energy prices, equipment utilization, and decision time horizon. This framework applies at the household level as well as at a broad sectoral or multisectoral level where energy and capital are used to produce energy services.[1]

Figure 1. (A) Energy Efficiency Improving Substitution versus (B) Energy Saving Technological Change



[1] Understanding the economic forces governing the rate and direction of energy-related technological change at the product, sectoral, and aggregate levels has been an important area of research, particularly in the context of climate change modeling. For a review of the literature devoted to this topic, which is beyond the scope of this paper, see Gillingham et al. (2008).

Focusing on the household level as an example, greater energy efficiency can be driven by market forces in two ways within this production function framework. First, households may move along the energy services isoquant by substituting capital for energy in response to a change in relative prices (Figure 1A, with relative prices changing from P_0 to P_1). Or, second, technological change that shifts the isoquant in a way favoring (i.e., biased toward) greater energy efficiency (Figure 1B, with isoquant_0 shifting to isoquant_1) could change the production possibilities available to households. In contrast, energy conservation not driven by energy efficiency improvements would be associated with a lower level of energy services (i.e., a lesser isoquant).

Market failures can be represented within this framework as a divergence of the relative prices used for private decisions from the economically efficient prices. For example, unpriced environmental externalities and missing information on the energy intensity of product use would both tend to lower the relative price of energy, leading to choices of inefficiently low energy efficiency (e.g., P_0 compared to P_1 in Figure 1A). Note that this framework presupposes optimizing behavior by the consumer, given available information—an assumption subject to debate within the behavioral economics literature, as discussed in other sections.

The next section further explores the role of energy markets in governing energy efficiency decisions, while the subsequent section identifies potential market and behavioral failures that may lead to suboptimal decisions.

3. Energy Market Influences on Energy Efficiency

Energy markets and market prices influence consumer decisions regarding how much energy to consume and whether to invest in more energy-efficient products and equipment. An increase in energy prices will result in some energy conservation in the short run; however, short-run changes in energy efficiency tend to be limited due to the long lifetimes and slow turnover of energy-using appliances and capital equipment. However, if an energy price increase is persistent, it also is more likely to significantly affect energy efficiency adoption, as consumers replace older capital equipment and firms have time to develop new products and processes.

The extent of demand responsiveness to changes in price is captured in the price elasticity of energy demand. Table 1 presents the ranges of energy own-price elasticity estimates in the literature. Long-run price elasticities are larger than short-run, corresponding to more energy efficiency improvements as capital turns over. On average, natural gas price elasticities are greater than electricity or fuel oil elasticities. Note that, because they are based on actual consumer behavior, these price elasticity estimates include any increase in consumption of energy services that might occur in response to a lower unit cost of energy services resulting from increased energy efficiency (i.e., the rebound effect).

Table 1. Ranges of Estimates of Energy Own-Price Elasticities (absolute values shown; all values are negative)

	Short-run		Long-run	
	Range	Sources	Range	Sources
Residential				
Electricity	0.14–0.44	Dahl (1993)	0.32–1.89	Bernstein & Griffin (2005), Hsing (1994)
Natural gas	0.03–0.76	Bohi & Zimmerman (1984), Dahl (1993)	0.26–1.47[a]	Bohi & Zimmerman (1984), Dahl(1993)
Fuel oil	0.15–0.34	Wade (2003)	0.53–0.75	Dahl (1993), Wade (2003)
Commercial				
Electricity	0–0.46	Dahl (1993)	0.24–1.36	Wade (2003), Dahl (1993)
Natural gas	0.14–0.29	Dahl (1993), Wade (2003)	0.40–1.38	Wade (2003), Bohi & Zimmerman (1984)
Fuel oil	0.13–0.49	Dahl (1993), Wade (2003)	0.39–3.5	Wade (2003), Newell & Pizer (2008)
Industrial				
Electricity	0.11–0.28	Bohi & Zimmerman (1984), Dahl (1993)	0.22–3.26	Bohi & Zimmerman (1984), Dahl (1993)
Natural gas[a]	0.51–0.62	Bohi & Zimmerman (1984)	0.89–2.92	Dahl (1993), Bohi & Zimmerman (1984)
Fuel oil	0.11	Dahl (1993)	0.5–1.57[b]	Bohi & Zimmerman (1984)

[a] Estimates drawn largely from regional studies.
[b] Estimates for 19 states

Other studies that have focused specifically on factors influencing technology adoption find that higher energy prices are associated with significantly greater adoption of energy-efficient equipment (Anderson and Newell 2004, Hassett and Metcalf 1995, Jaffe et al. 1995). Further upstream in the technology development process, Newell et al. (1999) and Popp (2002) find energy-efficient innovation is also significantly determined by energy prices (see Popp et al. [2009] for a review). Empirical estimates therefore demonstrate a substantial degree of responsiveness of energy utilization and energy-efficient technology adoption and innovation to changes in energy price.

4. Potential Market and Behavioral Failures

Much of the literature on energy efficiency focuses on elucidating the potential rationales for policy intervention and evaluating the effectiveness and cost of such interventions in practice. Within this literature there is a long-standing debate surrounding the commonly cited “energy efficiency gap.” There are several ways to view this gap. At its core, the gap refers to a significant difference between observed levels of energy efficiency and some notion of optimal energy use (Jaffe et al. 2004). That notion of optimal energy use has at times focused on maximizing physical energy efficiency, which will not generally coincide with maximal economic efficiency because energy efficiency comes at a cost. Within the investment framework described above, the energy efficiency gap takes the form of underinvestment in energy efficiency relative to a description of the socially optimal level of energy efficiency. Such underinvestment is also sometimes described as an observed rate or probability of adoption of energy-efficient technologies that is “too slow.”

Often the efficiency gap is illustrated by a comparison of the market discount rate and relatively high “implicit discount rates” that are implied by consumer choices over appliances with different costs and energy efficiencies (Hausman 1979). The empirical evidence is relatively well-established; in a number of studies published primarily in the late 1970s and early 1980s, analysts using a variety of methodologies found implicit discount rates ranging from 25 percent to over 100 percent (Sanstad et al. 2006, Train 1985).

Economists have posited a number of explanations to account for part or all of the apparent gap: hidden costs not accounted for by the analyst, including search costs as well as reductions in other product attributes (e.g., lighting quality) (Jaffe et al. 2004); lower energy savings than assumed by the analyst, due in part to heterogeneity of consumers (Hausman and Joskow 1982); uncertain future energy savings, implying rational consumers should put more weight on the initial cost (Sutherland 1991); the irreversibility of energy efficiency investments and the associated option value of waiting to invest later (Hassett and Metcalf 1993, Hassett and Metcalf 1995, van Soest and Bulte 2000); and the possibility that consumers are appropriately forming expectations about future energy prices but energy analysts are using incorrect proxies for these expectations (Jaffe et al. 2004). For example, studies have found that actual savings from past utility-sponsored programs achieved 50 percent to 80 percent of predicted savings (Hirst 1986, Sebold and Fox 1985), although a more recent study by Auffhammer et al. (2008) suggests that utilities have improved their ability to predict savings. Similarly, Metcalf and Hassett (1999) find that once all costs are accounted for, the realized return to attic insulation is much below the returns promised by engineers and manufacturers, and at 9.7 percent is consistent with the interest rate suggested by standard investment theory. Others have argued that the energy efficiency gap must not exist because rational optimizing consumers would not be willing to ignore large benefits—the proverbial $20 bill on the sidewalk (Sutherland 1996).

Some authors examine these explanations for why there may not be a gap and find some of them lacking. Metcalf (1994) finds that the uncertainty of future energy savings described in Sutherland (1991) should actually lead a rational investor to require a rate-of-return that is lower than the market discount rate, since energy efficiency investments will tend to serve as a hedge against other risks. Sanstad et al. (1995) show that the option value analysis of Hassett and Metcalf (1993, 1995) implies an implicit discount rate much lower than observed implicit discount rates, even when taking irreversibility into account. Howarth and Sanstad (1995) discuss heterogeneity and hidden costs as a possible concern, but suggest that analysts are cognizant of these issues and are careful to take them into account. For example, Koomey and Sanstad (1994) pay close attention to confounding factors such as heterogeneity and hidden costs and still find high implicit discount rates for efficient ballasts for commercial lighting and consumer purchases of refrigerators.

Other papers focus on distinguishing "market barriers" to the adoption of energy-efficient technologies from market failures. Market barriers can be defined as any disincentives to the adoption or use of a good (Jaffe et al. 2004). Market barriers may or may not be market failures in the traditional welfare economic sense. Potential market barriers described in the broader energy efficiency literature occasionally include such factors as low energy prices, fluctuating energy prices, or high technology costs, which are clearly not market failures on their own. Systematic biases in consumer decisionmaking that lead to underinvestment in energy efficiency relative to the cost-minimizing level are also often included among market barriers. Following the Shogren and Taylor (2008) review of behavioral economics, however, we classify these biases as "behavioral failures." In the present context, we consider behavioral failures to represent consumer behavior that is inconsistent with utility maximization, or in the current context, energy service cost-minimization. In contrast, market failure analysis is distinct in presupposing individual rationality and focusing on the conditions surrounding interactions among economic agents and society.

There is an economic rationale for policies to correct market barriers if they represent market or behavioral failures (Shogren and Taylor 2008). Table 2 provides a summary of potential market and behavioral failures relating to energy efficiency and conservation along with policy responses that have been implemented, or could be implemented, to address these problems in cases where they are found to be significant. We focus on the most commonly raised market and behavioral failures, but do not prejudge whether they are empirically significant problems for energy efficiency and conservation.[2] The remainder of this section discusses each of these potential concerns in turn, while the subsequent section reviews experience with policies that have been proposed and implemented, in part, as a response to these concerns.

Table 2. Commonly Cited Market and Behavioral Failures Relevant to Energy Efficiency Along with Potential Policy Responses

Potential Market Failures	**Potential Policy Options**
Energy market failures	
Environmental externalities	Emissions pricing (tax, cap-and-trade)
Average-cost electricity pricing	Real-time pricing; market pricing
Energy security	Energy taxation; strategic reserves
Capital market failures	
Liquidity constraints	Financing/loan programs
Innovation market failures	
Research and development (R&D) spillovers	R&D tax credits; public funding
Learning-by-doing spillovers	Incentives for early market adoption
Information problems	
Lack of information; asymmetric information	Information programs
Principal–agent problems	Information programs
Learning-by-using	Information programs
Potential Behavioral Failures	
Prospect theory	Education; information; product standards
Bounded rationality	Education; information; product standards
Heuristic decisionmaking	Education; information; product standards

4.1 Energy Market Failures

The common theme in energy market failures is that energy prices do not reflect the true marginal social cost of energy consumption, either through environmental externalities, average-cost pricing, or national security.

[2] In addition to the issues discussed below, Fischer (2005) develops an economic theory supporting a role of price discrimination in imperfectly competitive markets in diminishing producers' incentives to improve energy efficiency of low-end products. The effects of inseparability of product features on markets for energy efficiency is discussed by Ruderman et al. (1987), although in competitive markets associated inefficiencies should be minimal.

Environmental externalities associated with the production and consumption of many sources of energy lead to emissions of greenhouse gases and other air pollutants resulting in costs that are borne by others—that is, they are not internalized by the energy consumer. Absent policy, an environmental externality leads to an overuse of energy relative to the social optimum, and hence, underinvestment in energy efficiency and conservation. Although there is no debate over the existence of environmental externalities, the magnitude of such externalities and their degree of internalization is uncertain and hard to measure. Gillingham et al. (2006) review the literature on environmental externalities from the production of electricity and find that past policies to reduce electricity use provided monetized benefits from the reduction in CO_2, nitrous oxides (NO_x), sulfur dioxide (SO_2), and fine particulate matter (PM_{10}) that were about 10 percent of the direct value of the electricity savings. Environmental externalities, largely in the form of air emissions, also exist with other fossil fuels, such as home heating oil or propane. To the extent that energy prices do not currently internalize these externalities (which varies by pollution type), the market will provide a level of energy efficiency that is too low from a societal point of view. The economically optimal policy response is to price emissions, which will indirectly stimulate greater energy efficiency.

Prices faced by consumers in electricity markets also may not reflect marginal social costs due to the common use of average-cost pricing under utility regulation. Average-cost pricing could lead to under- or overuse of electricity relative to the economic optimum. On one hand, to the extent that average costs are above marginal costs due to amortized fixed costs, consumers face a price above the economically optimal price, thus encouraging underuse of electricity.

On the other hand, average-cost prices depend on the average cost of the mix of generators used to produce electricity. Market-based pricing produces daily or hourly wholesale prices that reflect the cost of the marginal generator and retail prices that typically reflect the average of these marginal costs over a period of months. Time-of-use (TOU) prices vary in a pre-set manner by time of day or season, while real-time-pricing (RTP) directly conveys information about the current marginal cost of generation and transmission in the price, updated at an hourly or even more frequent basis. If consumers are facing prices that are at times too low (peak times) and at other times too high (off-peak), they will be overusing electricity during the peak and underusing during the off-peak relative to the social optimum (Joskow and Tirole 2007).

RTP, and to a lesser degree, TOU pricing, can partly alleviate this market failure (which could alternatively be described as a policy failure). Of course, the cost of implementing TOU pricing or RTP may exceed the benefits, and there may be other market failures related to the adoption of real-time meters (Brennan 2004). However, recent evidence from the Anaheim Critical Peak pricing experiment suggests that with recent technology advances, a variation of RTP implemented during peak periods has significant potential to improve social welfare, with little effect on use in off-peak periods (Wolak 2006). Whether there would be conservation of total energy use with a comprehensive RTP scheme during all time periods is less clear. Similarly, the effect of TOU pricing or RTP on energy efficiency investments is unclear, and would depend on the pricing existing during the time those investments would be used.

Some authors have suggested that there are national security external costs from the United States' dependence on certain energy sources, particularly oil, from unstable regions of the world, that consumers do not face in energy prices or therefore take into account in their energy use decisions (Bohi and Toman 1996, Bohi and Zimmerman 1984). While these concerns are associated primarily with transportation-related consumption of oil, they are relevant to building-related energy consumption of fuel oil for heating and the association between the natural gas and oil markets. Economic and other analysis of the national security risks of energy consumption is not entirely satisfying, in part due to the lumpiness of the problem. On the margin, reducing oil consumption would not likely change the associated security risks, nor the military and diplomatic expenditures undertaken in response. Nonetheless, a long-term larger reduction may reduce these risks, and to the extent these risks are not fully reflected in the price of relevant energy resources, there will be a resulting underinvestment in energy efficiency.

4.2 Information Problems

Information problems are consistently raised in the energy efficiency literature and, along with behavioral failures, are often given as the primary explanation for the energy efficiency gap (Sanstad et al. 2006). Specific information problems cited include consumers' lack of information about the availability of and savings from energy-efficient products, asymmetric information, principal–agent or split-incentive problems, and externalities associated with learning-by-using. The following descriptions take the consumers' perspective, but several of these same information problems have been studied in the context of decisionmaking by firms (DeCanio 1993, 1994a, 1994b, DeCanio and Watkins 1998, Stein 2003). As discussed in the next section, if such problems are significant and correctable they may warrant labeling and other information programs.

Lack of information and asymmetric information are often given as reasons why consumers systematically underinvest in energy efficiency. The idea is that consumers often lack sufficient information about the difference in future operating costs between more-efficient and less-efficient goods necessary to make proper investment decisions (Howarth and Sanstad 1995). This argument can be consistent with cost-minimizing behavior if we assume that under perfect information consumers would reach a privately optimal outcome. Alternatively, information problems may occur when there are behavioral failures, so that consumers are not appropriately taking future reductions in energy costs into account in making present investments in energy efficiency. We discuss information problems in the context of behavioral failures in the next section.

Asymmetric information, where one party involved in a transaction has more information than another, may lead to adverse selection (Akerlof 1970). In the context of energy efficiency, adverse selection could imply that sellers of energy-efficient technologies that would provide clear *ex post* benefits to consumers are unable to perfectly transfer this information to buyers since the energy efficiency is unobserved (Howarth and Sanstad 1995). The sellers of every product would have an incentive to suggest that the energy efficiency of the product is high, but because the buyers cannot observe the energy efficiency, they may ignore it in their decision. The Howarth and Andersson (1993) model, which incorporates explicit transaction costs of transferring information, formally describes how this circumstance could lead to an underinvestment in energy efficiency. While in this context transaction costs may be a source of market failure, in general transaction costs may be legitimate costs and not a reason for intervening in markets.

The principal–agent or split-incentive problem describes a situation where one party (the agent), such as a builder or landlord, decides the level of energy efficiency in a building, while a second party (the principal), such as the purchaser or tenant, pays the energy bills. When the principal has incomplete information about the energy efficiency of the building, the first party may not be able to recoup the costs of energy efficiency investments in the purchase price or rent charged for the building. The agent will then underinvest in energy efficiency relative to the social optimum, creating a market failure (Jaffe and Stavins 1994). Murtishaw and Sathaye (2006) attempt to quantify the magnitude of the principal–agent problem for four end uses: space heating, refrigerators, water heating, and lighting. They find that the principal–agent problem is potentially relevant to 25 percent of refrigerator energy use, 66 percent of water heating energy use, 48 percent of space heating energy use, and 2 percent of lighting energy use, although they do not quantify the degree to which energy efficiency decisions in these cases have actually been inefficient. Levinson and Niemann (2004) find that tenants whose electric bills are included in their rental contracts consume significantly greater energy than tenants who pay their own electric bills.

Positive externalities associated with learning-by-using can exist where the adopter of a new energy-efficient product creates knowledge about the product through its use, and others freely benefit from the information generated about the existence, characteristics, and performance of the product. This phenomenon is not unique to energy efficiency (Jaffe et al. 2004). In the context of demand-side management programs, some studies have distinguished learning-by-using spillovers into “free-drivers” and program spillovers (Blumstein and Harris 1993, Eto et al. 1996). Free-drivers are nonparticipants who install energy-efficient products due to hearing about them from program participants. Program spillovers occur when the participating household installs additional energy-efficient products, without rebates, due to the information they learned through participation in the program.

4.3 Liquidity Constraints in Capital Markets

Blumstein et al. (1980) first described liquidity constraints that hinder access to financing for energy-efficient investments as a market barrier. Some purchasers of equipment may choose the less energy-efficient product due to lack of access to credit, resulting in underinvestment in energy efficiency and reflected in an implicit discount rate that is above typical market levels. This effect is a variation of a market failure associated with a lack of access to capital that is widely discussed in the development economics literature, and applies to any capital-intensive investment, not just energy-efficient products (Ray 1998). The extent to which liquidity constraints are an issue in energy efficiency has yet to be established empirically. Some evidence indicates that only a small percentage of home improvements are funded by loans, which could imply liquidity constraints are only important for a small fraction of energy efficiency investments or that liquidity constraints effectively force most energy efficiency investments to be self-financed (Berry 1984).

In industry and government, a common financing constraint is the institutional disconnect between capital and operating budgets, but energy services performance contracts have developed to fill this niche. In some cases, such as for industrial customers, energy service providers pay the capital cost and receive a share of the resulting savings. In other cases, such as for government and institutional customers, the customer can borrow at a lower interest rate than the energy service provider, so it makes greater financial sense for the customer to make the investment. In such cases, the energy service providers recommend energy efficiency improvements, guarantee the operating cost savings, and pay the difference if those savings are not realized—often allowing for the repayment of the capital cost to be treated as an operating expense (Zobler and Hatcher 2003). In addition, if liquidity constraints are an issue for energy efficiency investments then they will also constrain other types of investments, and any potential solution would have to reach well beyond energy efficiency policy.

Golove and Eto (1996) describe a case of asymmetric information where consumers are unable to transfer information to their lenders about the relative certainty of operating cost savings from an efficiency investment, and thus likelihood of repayment. Golove and Eto claim the resulting credit constraints imply that consumers should be given a lower interest rate than lenders are willing to offer, and thus consumers faced with the higher interest rate may underinvest in energy efficiency. The extent of this potential problem has not been measured empirically to our knowledge, and this problem of information transfer may apply to other costs as well, possibly altering the result. Energy-efficient mortgages from some lenders address this problem by crediting a home's energy efficiency in determining the interest rate or the size of the mortgage. Warranties may also address this problem privately.

4.4 Innovation Market Failures

R&D spillovers may lead to underinvestment in energy-efficient technology innovation due to the public good nature of knowledge, whereby individual firms are unable to fully capture the benefits from their innovation efforts, which instead accrue partly to other firms and consumers. This is not particular to energy-efficient innovation; rather, it is a general feature of technological innovation, which manifests empirically as an approximately two to four times higher social rate of return to R&D compared to the private rate of return (Griliches 1995, Hall 1996, Nadiri 1993). If energy is underpriced relative to the social optimum this innovation problem will nonetheless be magnified in the context of energy-saving technologies (Goulder and Schneider 1999, Jaffe et al. 2005, Schneider and Goulder 1997).

Learning-by-doing (LBD) refers to the empirical observation that as cumulative production of new technologies increases, the cost of production tends to decline as the firm learns from experience how to reduce its costs (Arrow 1962). LBD may be associated with a market failure if the learning creates knowledge that spills over to other firms in the industry, lowering the costs for others without compensation (Fischer and Newell 2008, van Benthem et al. 2008). In the energy context, LBD processes have been empirically investigated and applied primarily to fledgling low-carbon electricity-generation technologies in the context of energy and climate policy modeling. The empirical evidence on learning in energy-using equipment is very limited, and what there is focuses generally on product cost reductions rather than learning specifically with respect to improving energy efficiency (see, e.g., Bass [1980]). It is also difficult to empirically distinguish learning from other factors that affect product costs and prices. Further research would be needed to more closely examine learning in energy-efficient technologies and ascertain the degree to which the learning spills over to other firms. The potential for positive externalities from LBD is not unique to energy, but may occur with any new technology that displays nonappropriable learning characteristics.

4.5 Behavioral Failures

The behavioral economics literature has drawn attention to several systematic biases in consumer decisionmaking that may be relevant to decisions regarding investment in energy efficiency. Similar insights can be gained from the literature on energy decisionmaking in psychology and sociology (e.g., see Stern [1985], Lutzenhiser [1992, 1993]). Frameworks incorporating such departures from perfect rationality have intuitive psychological appeal as well as an empirical basis from behavioral economic and psychological studies. The crucial question is whether these deviations from perfect rationality lead to significant systematic biases in energy efficiency decisionmaking, and if so, whether these biases lead to under- or overinvestment in energy efficiency. Due to the limited economics literature in this area, in many cases we reference literature from other social sciences that bears directly on energy consumption–related behavior.

The behavioral economics literature draws upon cognitive psychology and other disciplines to inform experimental and theoretical analyses aimed at understanding how consumers make decisions. Behavioral economists tend to relax the classic microeconomic assumption of rational choice and replace it with bounded rationality or other heuristic decisionmaking methods (McFadden 1999). Behavioral economics has been motivated by evidence that consumers are not perfectly rational—even if they are given perfect information—and has developed a positive theory designed to understand how consumers make decisions in practice. In the energy efficiency context, the most relevant and common rationality assumption is that of behavior that minimizes present value costs for a given level of energy service provision.

The evidence that consumer decisions are not always perfectly rational is quite strong, beginning with Tversky and Kahneman’s research indicating that both sophisticated and naïve respondents will consistently violate axioms of rational choice in certain situations (Tversky and Kahneman 1974, Kahneman and Tversky 1979). Since then, an entire literature has developed examining when and how people violate the axioms of rational choice. Surveys of this literature of behavioral decision theory include Camerer (1997), McFadden (1999), Machina (1989), Rabin (1997), and Thaler (1991). Shogren and Taylor (2008) and List and Price (2009) provide reviews specifically in the context of resource and environmental economics. This review follows the primary theme of behavioral economics by focusing on consumer decisions. Firms may also face some of the same issues, although competitive forces serve to moderate the significance of behavioral failures for firms (Shogren and Taylor 2008).

The three primary themes that emerge from behavioral economics and have been applied in the context of energy efficiency are prospect theory, bounded rationality, and heuristic decisionmaking. The prospect theory of decisionmaking under uncertainty posits that the welfare change from gains and losses is evaluated with respect to a reference point, usually the status quo. In addition, consumers are risk averse with respect to gains and risk seeking with respect to losses, so that the welfare change is much greater from a loss than from an expected gain of the same magnitude (Kahneman and Tversky 1979). This can lead to loss aversion, anchoring, status quo bias, and other anomalous behavior (Shogren and Taylor 2008).

Bounded rationality suggests that consumers are rational, but face cognitive constraints in processing information that lead to deviations from rationality in certain circumstances (Simon 1959, 1986). Heuristic decisionmaking is related closely to bounded rationality and encompasses a variety of decision strategies that differ in some critical way from conventional utility maximization in order to reduce the cognitive burden of decisionmaking. For example, Tversky (1972) develops the theory of "elimination-by-aspects," wherein consumers use a sequential decisionmaking process where they first narrow their full choice set to a smaller set by eliminating products that do not have some desired feature or aspect (e.g., cost above a certain level), and then they optimize among the smaller choice set, possibly after eliminating further products.

Not much economic literature empirically tests these behavioral hypotheses to uncover whether there is a systematic bias, either negative or positive, in decisionmaking related to energy consumption. Hartman et al. (1991) empirically examine whether the status quo effect posited in prospect theory holds in the consumer valuation of reliable electric service (but not directly energy efficiency). They find that the status quo effect is significant, suggesting in this case that consumers are irrationally reluctant to move from the status quo and accept more likely interruptions in electricity service.

Empirically testing bounded rationality is even more difficult for there is no single consensus model of bounded rationality in energy decisionmaking (Sanstad and Howarth 1994). Friedman and Hausker (1988) develop a theoretical model by using a particular structure of bounded rationality where consumers do not have the ability to optimize their energy consumption in response to a tiered-rate structure of electricity prices. The model indicates that consumers will overconsume energy if the rate structure is increasing and underconsume if it is decreasing. Friedman (2002) tests this theoretical model by using electric utility data and exploits the increasing block structure of electricity rates to find that the empirical specification consistent with bounded rationality (and leading consumers to overconsume electricity) has more predictive power than one based on utility maximization.

Heuristic decisionmaking in energy is similarly difficult to test empirically, although several papers in psychology have done so. Kempton and Montgomery (1982) use a survey technique to find that consumers use simple heuristic techniques to determine their energy consumption and that these techniques systematically lead to underinvestment in energy efficiency. For example, for decisions regarding energy-efficient investments consumers tend to use a simple payback measure where the total investment cost is divided by the future savings calculated by using the energy price today, rather than the price at the time of the savings—effectively ignoring future increases in real fuel prices (Kempton and Montgomery 1982). Kempton et al. (1992), using similar methods, find that consumers systematically miscalculate payback for air conditioner investments, again leading to overconsumption of energy.

Yates and Aronson (1983) find that consumers attach disproportionate weight to the most psychologically vivid and observable factors, often called the “salience effect.” The salience effect may influence energy efficiency decisions, potentially contributing to an overemphasis on the initial cost of an energy-efficient purchase, leading to an underinvestment in energy efficiency (Wilson and Dowlatabadi 2007). This may be related to evidence suggesting that decisionmakers are more sensitive to up-front investment costs than energy operating costs, although this evidence may also be the result of inappropriate measures of expectations of future energy use and prices (Anderson and Newell 2004, Hassett and Metcalf 1995, Jaffe et al. 1995).

Loewenstein and Prelec (1993) develop a theoretical model of intertemporal choice that replaces the utility function with a value function that is more elastic for outcomes with large absolute magnitudes than for outcomes with small magnitudes, consistent with evidence in Thaler (1981) and Holcomb and Nelson (1992). Thus, in this value function framework, discounting depends on the magnitude of the outcome. Applying this to the case of energy efficiency investments, flows of electricity savings are typically smaller than the annual returns from other types of investments and thus would be subject to higher rates of discount. Loewenstein and Prelec (1993) posit that their model may capture a behavioral bias that implies a systematic underinvestment in energy efficiency relative to the consumers' cost-minimizing choice. To our knowledge the model has not been empirically tested in the context of energy efficiency.

This review reveals that the empirical literature testing behavioral failures specifically in the context of energy decisionmaking is very limited. The literature in psychology and sociology discusses these biases further and provides some additional evidence of such biases (e.g., see Wilson and Dowlatabadi [2007] for a review of the approaches in the different fields as applied to energy). The available evidence suggests that systematic biases may exist in consumer decisionmaking that could lead to overconsumption of energy and underinvestment in energy efficiency. However, more fully understanding the magnitude of these biases, disentangling them from informational and other market failures, and measuring the ability of practicable policies to address these behavioral failures remains an important area for future research.

5. Energy Efficiency Policy

While the literature has identified a number of potential market and behavioral failures that are relevant to energy efficiency, for policy responses to improve economic efficiency they must successfully reduce these failures and the associated benefits must exceed the cost of implementing the policy.

In the previous section we identified a number of relevant market failures, several of which are, however, not unique to energy efficiency and conservation. For example, R&D spillovers exist throughout the economy and motivate general policies such as patent protection, R&D tax credits, and basic research funding. Policy decisions specific to energy efficiency R&D arise mainly in the context of determining the level and allocation of public research spending among different purposes (see Newell [2008] for a related discussion). LBD spillovers are similar in that any emerging technology may exhibit nonappropriable gains from learning, raising questions over the appropriate bounds on policy.

The environmental externalities avoided by energy efficiency and conservation largely result from emissions associated with burning fossil fuels. Economic theory suggests that if consumers are optimizing and there are no other market imperfections, a first-best policy to address the environmental externalities would ensure that the external cost from emissions is added to the energy price, such as through a Pigouvian tax or cap-and-trade system. The resulting internalization of the externality would lead to reduced energy demand (more conservation) and more energy efficiency investment. To assess the amount of energy savings from such an emissions price policy, one can examine the price elasticity of energy demand discussed earlier, which is typically done in the context of a computable general equilibrium model or other aggregate energy-economic model. In the context of climate policy, such modeling typically finds that a significant portion of cost-effective emissions reductions are achieved through energy efficiency and conservation, alongside renewable energy, nuclear power, and carbon capture and storage applied to coal (Clarke et al. 2006, Weyant et al. 2006). Policies to directly promote energy efficiency are second-best responses to environmental externalities, however, because they do not discriminate among the emissions intensities of different energy sources, do not provide an incentive for reducing consumption of energy services, and tend to apply only to a subset of sources. Instead, policies to promote energy efficiency may be the appropriate response to demonstrated behavioral failures, particularly in contexts where that behavior has broader societal implications (e.g., environmental externalities).

The remaining discussion focuses on the economic rationale, effectiveness, and cost of policies that are specifically targeted to energy efficiency grouped into three broad categories: information programs, incentives, and product standards. Before turning our attention to these issues, we briefly review some generic issues that arise in measuring the effectiveness and cost of energy efficiency policies. For a more detailed review of these issues see Gillingham et al. (2006).

5.1 Issues in Measuring Energy Efficiency Policy Effectiveness and Cost

The literature on energy efficiency and conservation policy evaluation is extensive and has become more sophisticated with time. There are a few critical issues common to energy efficiency policies. First, *ex ante* studies dominate much of energy efficiency policy literature, particularly for evaluating product standards. These studies formed a valuable starting point for understanding future policy, but they do not demonstrate that policies have been effective or net-beneficial in actual implementation. As more energy efficiency and conservation policies have been implemented, the literature is shifting to *ex post* studies that examine the historical effectiveness and cost of energy efficiency and conservation policies in order to improve future policy making.

One of the major criticisms of the energy efficiency and conservation policy evaluation literature is that “free-riders” are not always properly accounted for. Free-riders are consumers who would have invested in energy efficiency or conserved energy absent the policy, but receive additional benefits from the policy (Joskow and Marron 1992). Benefits from free-riders should not be counted in the benefits from the policy, but costs (that are not simply transfers) should be included in the costs of the policy. As discussed above, on the other hand, papers in the broader energy efficiency literature point to an offsetting effect of "free-drivers," where nonparticipants in the program are induced to invest in energy efficiency or conserve energy due to observing program participants (Blumstein and Harris 1993, Eto et al. 1996, Geller and Attali 2005).

Another common criticism of energy efficiency policy evaluations is that they either ignore or inappropriately account for the rebound effect, whereby energy efficiency improvements decrease the marginal cost of energy services, thereby increasing demand and inducing less-than-proportional reductions in energy use. There is an extensive debate in the literature about the importance of the rebound effect in the context of energy efficiency standards (see Gillingham et al. [2006] for a review), but some empirical evidence suggests it may be numerically small in the case of energy efficiency standards (Dumagan and Mount 1993). For example, Davis (2008) examines the case of clothes washers, and finds a relatively small, but not insignificant, rebound effect of –6 percent. For recent evidence in the household transportation context, see Small and Van Dender (2007).

5.2 Information Programs

Information programs typically aim to induce energy efficiency investments by providing information about potential energy savings or examples of energy savings. Some programs attempt to promote energy conservation, particularly for electricity during times when the electricity grid is stressed. Historically, many information programs have been part of utility demand-side management (DSM) programs, and others have been federal programs such as EnergyStar, appliance labels, and Home Energy Ratings for new homes. Information programs also include programs to provide feedback to consumers about their energy consumption.

Information programs are motivated by the informational problems and behavioral failures noted earlier. The intention is that by providing greater and more reliable information, issues of uncertain future returns and asymmetric information may be lessened. Additional information may also lower the cognitive cost of energy decisionmaking or help guide consumers toward better decisions.

Information programs vary greatly, both in their method and implementation, and evidence of their effectiveness is mixed. Weil and McMahon (2003) offer anecdotal evidence that product labeling requirements can be successful in increasing energy-efficient investments, but Levine et al. (1995) find that the EnergyGuide product labeling requirements were fairly ineffective. The EnergyGuide label has been revised in a recent rulemaking to improve its effectiveness. According to some studies, voluntary EnergyStar labels appear to have achieved significant savings by inducing greater energy efficiency (Webber et al. 2000). For example, Howarth et al. (2000) present evidence that the voluntary EPA Green Lights program (now part of EnergyStar) and EnergyStar Office products program have been effective in increasing energy efficiency investments by increasing access to information.

Anderson and Newell (2004) examine industrial energy audits and find that while plants only accept about half of the recommended projects, most plants respond to the costs and benefits presented in the energy audits and, with the additional information, adopt investments that meet hurdle rates consistent with standard investment criteria the audited firms say they use. Newell et al. (1999) find that the responsiveness of energy-efficient product innovation to energy prices increased substantially after product labeling was required. Stern (1985) suggests that many early energy conservation information programs (particularly DSM programs) were not very effective. Fischer (2008) examines the psychological literature on feedback programs (i.e., programs that provide consumers real-time information about their electricity consumption) and finds feedback induces energy conservation with typical savings of 5 percent to 12 percent. Reiss and White (2008) examine data from the 2000–2001 California electricity crisis and find that in times of crisis, conservation appeals and information programs can produce sustained reductions in energy demand. Data indicating the cost-effectiveness of these programs are not readily available.

5.3 Financial Incentives

Incentive programs provide financial motivation for energy efficiency investments through direct subsidies, tax credits, tax deductions, rebates, or loan subsides. Financial incentives have also been used to promote energy conservation in the electricity market during times of peak load. In addition, financial incentives have been used to encourage the development of new energy technologies, such as through prizes for highly energy-efficient products (Gillingham et al. 2006). Incentive programs have been primarily implemented as part of utility DSM programs. These programs are broadly motivated by the concerns mentioned above, in effect responding to the perceived underinvestment in energy efficiency by subsidizing such investment.

The empirical evidence on the effectiveness of financial incentives is also somewhat mixed. Stern (1985) suggests financial incentives are not very effective in inducing initial interest in energy efficiency improvement programs, but may help induce energy efficiency investments by those already participating in the programs. Carpenter and Chester (1984) use a survey about the conservation tax credits of the early 1980s and find that although 86 percent of those surveyed were aware of the credit, only 35 percent used it, and of those who used it, 94 percent would have invested anyway. Several studies econometrically estimate the effect of state tax incentives on all conservation investments and find mixed results. Hasset and Metcalf (1995) attempt to correct previous methodological errors and estimate that a 10 percentage point change in the tax price for energy investment increases the probability of making an energy efficiency investment by 24 percent. Using data on the 1980s tax credit, Williams and Poyer (1996) also find that despite the free-rider issue, tax credits increased the probability of an energy efficiency investment.

These results suggest that financial incentives may be effective, but further research is needed to determine their cost-effectiveness. There is a fairly extensive literature examining the cost-effectiveness of utility DSM programs, which typically contain financial incentives along with information programs. Common values in the literature of the "negawatt cost" or the full life cycle cost (i.e., total expense of running the program and installing equipment) per kilowatt-hour saved as a result of a DSM program range from below \$0.01/kWh to above \$0.20/kWh saved (in real 2002 dollars). For comparison, the U.S. average residential electricity price has been in the range of \$0.08–0.09/kWh (in real 2002 dollars) over the past 10 years (EIA 2008). A debate in the literature is still continuing regarding negawatt costs, with recent econometric evidence by Loughran and Kulick (2004) suggesting utilities are overestimating energy savings, leading to costs on the high end. An analysis of the same data by Auffhammer et al. (2008) points out, however, that the savings summary statistic used by Loughran and Kulick (2004) was unweighted, and thus in this case underestimates the national average electricity saved per dollar spent on DSM programs. Auffhammer et al. (2008) find a weighted average negawatt cost in the range of \$0.05–0.13/kWh based on the Loughran and Kulick (2004) model and fail to reject the null hypothesis that the utility-reported savings estimates are correct on average. These figures only include costs to the utilities, however, not to the energy end user; consumer costs may be in the range of 60 percent to 70 percent of utility costs (Nadel and Geller 1996). Taking utility estimates of costs and effectiveness as given, Gillingham et al. (2004) calculate a cost-effectiveness for all DSM programs of \$(2002) 0.034/kWh saved in 2000 by using only utility costs and utility self-reported savings.

5.4 Product Standards

Product standards set a minimum level of energy efficiency that all covered products on the market must meet. In some cases, standards may be differentiated by size and type of the product, such as refrigerator standards that may be different for mini-fridges than full-sized refrigerators. Energy efficiency standards are politically motivated by the full range of concerns noted earlier. From an economic perspective, other policy responses would tend to be more direct, efficient responses to the market failures described. For example, if consumers are making rational decisions and there is heterogeneity in their preferences for energy efficiency, product standards could lead to a loss in economic efficiency by forcing behavior change on those who gain relatively little from energy efficiency (e.g., those who do not use the product often) (Hausman and Joskow 1982). On the other hand, verified behavioral failures could provide an economic rationale for product standards.

The literature on product standards primarily focuses on appliance standards, for which there are primarily *ex ante* estimates of cost and effectiveness based on government regulatory analysis. Using engineering estimates of the energy savings and energy prices, Meyers et al. (2003) find a cumulative net benefit of US$(2003) 17.4 billion over 1987–2000 for the 1987–2000 appliance standards. With projections of future energy savings added, they find a cumulative net benefit of the current standards of US$(2003) 154 billion for 1987–2050. Taking the Meyers et al. (2003) estimates as given, Gillingham et al. (2004) calculate an implied cost-effectiveness of $0.028/kWh saved in 2000.

These net benefit estimates have to our knowledge not been subject to independent verification in the economic literature. Because these analyses do not include a valuation of environmental or security externalities, their net benefits are arising solely from implicit modeling assumptions that are different from the way consumers are behaving in the absence of the standards (i.e., implicitly modeling behavioral failures). The implication is that either consumers are not minimizing costs or that the model is making incorrect assumptions. Further empirical research evaluating the degree to which each of these cases is more correct would be valuable.

6. Conclusion

The literature on the economics of energy efficiency and conservation has embodied significant debate over the past few decades, yet there remain many outstanding issues. The heart of the debate centers on the issue of identifying the economically efficient level of energy efficiency and determining whether policy directed specifically to energy efficiency is necessary to bring us to this level, and if so, determining its net benefits in practice. We identify potential market and behavioral failures that may help to explain this gap, although quantitative evidence on the magnitude of many of these potential failures is limited.

Many of the commonly cited market failures are not unique to energy efficiency, and addressing them tends to call for a much broader policy response, such as an economywide price on greenhouse gases to address climate change, comprehensive innovation policy to increase innovative effort, and electricity market reforms moving toward marginal cost pricing. On the other hand, information and behavioral failures—to the extent they are substantial—tend to motivate more specific energy efficiency policies, provided that the benefits of the policies exceed the costs. Further research in this vein is essential to better clarify the potential for energy efficiency policies to increase economic efficiency.

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- Keith Leslie
- Sun Nov 21 2010

Huge investments to update power system, plus green energy, behind rate hikes

TORONTO Electricity consumers in Ontario were jolted with a shock in the fall economic update, learning rates will jump 46 per cent over five years, although they will get 10 per cent rebates on each hydro bill.

The government says the rate hikes are necessary to pay for badly needed upgrades to the system that previous governments failed to make, and to wean the province off of coal-fired generation.

The Liberals say the new rebates mean electricity bills will rise about 3.6 per cent a year, instead of 7.9 per cent.

“We’ve been saying from Day 1 that the costs of power need to go up to pay for the critical investments we’re making,” said Energy Minister Brad Duguid.

“I think we’re the only party in the province that’s being honest about the fact that building a clean, reliable, modern energy system comes with a cost. There’s no way around it.”

There’s also no way around the huge amounts of money needed to modernize an electricity system in the 21st century. Since coming to office in 2003, the Liberal government’s spending has included:

•$10 billion to add about 8,000 megawatts of cleaner energy supplies to the mix.

•$7 billion to upgrade 5,000 kilometres of transmission and distribution lines.

•A $7-billion deal with Korean giant Samsung to build new manufacturing plants in Ontario for green energy materials.

The number of wind turbines in Ontario has grown from 10 in 2003 to more than 700, and the Sarnia area is now home to the largest solar farm in Canada. The province hopes its Green Energy Act will create 50,000 new jobs.

Ontario also budgeted $26 billion to build two new nuclear reactors and refurbish about 10 older units.

However, that project has been in limbo since AECL submitted a proposal for just the two new reactors at an estimated $26 billion, which the province rejected as “exorbitant.”

The province is also upset the federal government decided to sell AECL in the middle of the procurement process.

Nuclear power is expensive, but will remain the “backbone” of Ontario’s supply mix, generating 50 per cent of our electricity, said Duguid.

The government admits its plans to develop more wind, solar and other renewable forms of energy are responsible for about 56 per cent of the expected increases in electricity rates.

The Progressive Conservatives said the price of electricity has gone up between 75 and 100 per cent since the Liberals took office in 2003, from 4.3 cents per kilowatt hour to 7.5 cents for fixed rates, and up to 9.9 in peak periods for people with smart meters.

Add in the Liberals' green energy policies, and the HST on electricity prices, and people are afraid to open their hydro bills, said the Tories.

"When you buy energy at 80 cents a kilowatt hour and the real price is only four or five cents, we all pay for it and as a province we can't afford that," said Progressive Conservative critic Norm Miller.

"If you treat it as a social program the cost of energy becomes too expensive and businesses can't afford to do business here and people can't afford to live here."

The New Democrats said the Liberal government has made some "wrong-headed" decisions in its efforts to go green, including spending $1 billion to install so-called smart meters in over four million homes and switching people to time of use pricing.

"We see a government that decided on sole-sourcing the Samsung deal for $7 billion at the same time not allowing our own generator of power, OPG, to participate in the green energy regime," said NDP Leader Andrea Horwath.

The worst Liberal offence — in Horwath's eyes — was slapping the HST on electricity bills last summer, immediately adding the eight per cent provincial portion of the tax to energy costs.

"It's a problem for homeowners who will see the 46 per cent increase in their hydro bills, but also though the eight per cent tax on top of that," she said.

The Liberals say phasing out Ontario's coal-fired generating stations — the last are scheduled to be shut in 2014 — not only means cleaner air, but will also saves lives and help keep health care costs down.

The Canadian Press

California Commissioning Collaborative

2007 California Retrocommissioning Market Characterization

Developed by
PECI and Summit Building Engineering

April 2008

2007 California Retrocommissioning Market Characterization

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1. Introduction

In 2007, the CCC Board of Directors required updated information on the market potential for retrocommissioning to support planning and budgeting activities for retrocommissioning programs for the 2009-2011 budget cycle. The following report summarizes the analysis done to meet this need.

As background to this study, in 2000, Pacific Gas and Electric Company (PG&E) hired PECI to characterize current California commissioning practices and provide important information on how to increase quality commissioning services.

A significant portion of that project included analysis to estimate what the commissioning costs and associated energy savings might be for the State of California if commissioning were adopted in both existing buildings and new construction. The analysis also includes estimating the requirements for a commissioning infrastructure to support the effort. This Cost, Savings and Infrastructure section of the 2000 study report was the basis for the updated 2007 study to analyze current market conditions in an effort to estimate of how much retrocommissioning can be done in a typical year going forward.

Since the 2000 study was conducted, several significant drivers have influenced the market for retrocommissioning services:

- Executive Order S-20-04 by the Governor of the State of California set the state's priorities for resource efficiency, and paved the way for laws, standards and policies to enforce California's Green Action Plan, which specifically mandates retrocommissioning in state buildings.
- USGBC's Leadership in Energy and Environmental Design (LEED) Building Rating System for Existing Buildings (EB) has raised the profile and demand for operational improvements in existing buildings. A number of points toward LEED-EB can be earned though retrocommissioning activities.
- Large-scale and sector-based retrocommissioning utility programs kicked off in 2006, increasing access to financial and technical assistance for retrocommissioning services, thereby increasing demand for commissioning services. Information flowing from these large-scale programs will allow for greater access to market intelligence on commissioning costs, savings, etc.

This analysis takes into consideration these market drivers, along with retrocommissioning program estimates on how much retrocommissioning is currently occurring, forecasts for energy cost and usage, and the informed judgment of the project team to characterize the current market for retrocommissioning in California.

2. Assumptions and Estimates

The 2007 analysis is based on a number of key assumptions to determine a reasonable snapshot of the market for retrocommissioning in California. In general, it is assumed that retrocommissioning is currently being done almost exclusively through organized programs that provide financial and technical assistance to building owners, including utility-sponsored incentive programs, partnerships and state-sponsored programs. There is little indication that any significant number of building owners in the private or public sector is undertaking retrocommissioning without program assistance.

The study is limited by the volume and quality of data available from current programs in progress. The lack of available data may be caused by a number of factors; most significantly the ramp-up time required by programs delays implementation to the end of the program cycle. In particular, few projects have been done in the retail, grocery, and healthcare sectors (at the time data was collected), therefore very little data was available on projects in these sectors.

Out of necessity, the study was performed mid-cycle, so only a small number of actual projects have been completed. The lack of a large number of completed projects does affect the confidence in the study's energy savings and implementation cost estimates, but the large number of projects actually in progress did provide reasonable confidence in the estimate of retrocommissioning activity. This analysis used actual data when possible, supplemented with reasonableness checks on estimated data.

Using available sources of information (see section 5) and drawing on PECI's experience and knowledge of the current commissioning market, the following assumptions were made:

- **Annual Estimate.** The analysis used available data from current retrocommissioning programs to estimate retrocommissioning activity in a *typical year going forward*. Data on projects completed and in progress in 2007, projected activity for 2008, and forecasts for programs continuing in the 2009-2011 cycle were all used to develop a typical year, characterized by:
    - Utility partnerships, in-house and third-party programs roll from one program cycle to the next, without requiring a period of program ramp-up. With consistent through-put and a continuous pipeline of projects, the estimated level of retrocommission can be maintained year to year.
    - Mandates for retrocommissioning government and institutional buildings are maintained at current levels.
    - Retrocommissioning programs continue to deliver energy savings at near-current goals, without significant increases from year to year.

- **Area to be Commissioned.** The total square footage to be commissioned is estimated from data reported from current third party programs, partnerships, and utility in-house programs.
    - Accuracy of program reporting is not known, as each program may be reporting the best case scenario for meeting their program square footage goals. Therefore, program estimates may be high, compared to actual results.
    - The amount of retrocommissioning being performed outside of the programs is unknown. Based on anecdotal evidence, it is assumed that most LEED-EB projects are counted within the third-party, partnerships (MBCx), and DGS programs.

- **Cost of Commissioning.** Data used to determine commissioning cost was very limited. Figures for cost of commissioning are the sum of investigation, implementation, and verification, including incentives and estimated owner costs. Administration and management costs of utilities and their contractors managing programs are not included.

- **Energy Savings.** Savings estimates are based on published evaluation reports, engineering estimates of investigated projects in current programs and other program data reported for projects in various stages of completion.
  - Where data on particular market sectors was insufficient, assumptions were made based on other market sectors and project team judgment on reasonable potential.
  - Estimated annual savings represent first-year realized savings. This fraction is determined by applying an estimated realization rate to the projected annual savings.

- **Number of Providers.** It was assumed that a typical individual commissioning provider lead (not firm) will complete an average of 4 projects per year.

- **Annual Carbon Metric Tons Saved.** The source for the carbon savings calculation is the California Climate Action Registry General Reporting Protocol, Ver 2.2, March 2007.

3. Findings

Table 1 summarizes estimated annual market potential for retrocommissioning; Table 2 provides detailed information on the savings fractions used in the assessment. Key findings are discussed below. Results of the study were limited by the volume and quality of data available. Refer to Section 2 for a discussion of the assumptions and estimates used in this analysis.

Table 1. Commissioning Market Assessment – Existing Buildings
Annual Estimate for First Year Savings*

Sector	Elec Energy Savings Fraction (net)	Gas Energy Savings Fraction	Annual Penetration Rate	Area Commis-sioned (millions sf)	Elec. Annual Savings (millions of kWh)	Gas. Annual Savings (millions of therms)	Annual Carbon Metric Tons Saved	Total Cx Cost ($/sf)	Project Payback** (years)	Number of Providers Needed
Office	7.1%	5.1%	8.0%	34.61	43.2	0.54	18,640	$ 0.38	2.2	31
Retail	4.9%	1.7%	1.5%	1.66	1.2	0.00	443	$ 0.38	4.2	1
Grocery	3.4%	1.7%	6.3%	1.76	2.4	0.02	983	$ 0.41	2.3	2
School	5.1%	6.0%	0.0%	0.00	0.0	0.00	-	$ 0.33	0.0	0
College	8.1%	10.5%	2.4%	6.32	6.3	0.17	3,212	$ 0.70	4.7	6
Health	1.7%	0.9%	3.6%	6.34	2.1	0.08	1,206	$ 0.45	8.5	6
Lodging	5.1%	8.5%	17.3%	19.84	12.2	0.42	6,723	$ 0.35	3.6	18
Total			**5.1%**	**70.52**	**67.4**	**1.24**	**31,206**	**$ 0.40**	**3.0**	**64**

* Estimated annual savings represent first-year realized savings, determined by applying an estimated realization rate to the projected annual savings.
** Project payback is determined by whole project cost (includes investigation and implementation costs).

Table 2. Energy Savings Fractions Used in Final Assessment

Sector	Energy Savings Fraction Estimates	Realization Rate	Net Savings Fraction Used in Assessment
Electricity			
Office	8.3%	0.85	7.1%
Retail	5.8%	0.85	4.9%
Grocery	4.0%	0.85	3.4%
School	6.0%	0.85	5.1%
College	8.5%	0.95	8.1%
Health	2.0%	0.85	1.7%
Lodging	6.0%	0.85	5.1%
Gas			
Office	6.0%	0.85	5.1%
Retail	2.0%	0.85	1.7%
Grocery	2.0%	0.85	1.7%
School	7.0%	0.85	6.0%
College	11.0%	0.95	10.5%
Health	1.0%	0.85	0.9%
Lodging	10.0%	0.85	8.5%

Penetration Rate by Sector

- The study results show a total annual penetration rate of 5%, or 70 million square feet annually. This would indicate that the entire stock of commercial buildings over 100,000 square feet can be retrocommissioned every 20 years.
- Notable sector-specific penetration rates:
    - Office: 8%
    - Lodging: 17%

  While these rates appear reasonable, there is some uncertainty associated with the formulation of the base building stock greater than 100,000 sf from the entire building stock population and with the consistency and accuracy of square footage reporting from the retrocommissioning programs. Additional data is needed to develop greater confidence in the sector-specific penetration rate estimates.
- Overlap between sector-based programs may be affecting the actual market potential. Where more than one program is targeting the same building stock, goals for square footage and saving maybe double counted, resulting in inflated penetration rates.

Number of Providers

- The study results estimate that 64 individual lead providers are needed to retrocommission the estimated annual floor space (70 million square feet).
- PECI's programs have qualified 131 individual commissioning providers from 48 firms to work in three programs. At the end of 2008, PECI programs were utilizing 27 individual lead providers, each working on an average of 4 projects.
- From PECI's experience, out of the large number of companies submitting qualifications for working within the retrocommissioning programs, only about 20% may be available when called upon to provide services to the programs. This may be influenced by:
    - Few providers focus exclusively on retrocommissioning. Most providers do a variety of work including major retrofits and design-related projects, and take on program work as a fraction of their total portfolio of work.
    - Retrocommissioning fees may be less attractive than other available work.
    - The inevitable ebb and flow of projects moving through program pipelines may result in periods of high demand, which max out available resources. More consistent throughput would reduce spikes in demand and help alleviate capacity constraints.

Cost of Commissioning

- Costs include both program and owner contributions, though it is not clear if all program reporting consistently included both owner and program costs.
- Summary of Costs:
    - Investigation costs ranged from $0.08 - $0.60 / sf.
    - Implementation + Verification costs ranged from $0.25 - $0.28 /sf.
    - Total costs of commissioning ranged from $0.36 to $0.85 / sf.
    - Based on the total retrocommissioning activity estimated for 2008, the average total commissioning cost was $0.38 / sf for the office sector and $0.40 / sf average for all sectors.

  - Administration and management costs of utilities and their contractors managing programs are not included.
- The wide range in investigation costs was primarily due to the monitoring-based commissioning programs in the higher education sector. In these programs some of the costs to upgrade elements of the building automation system to handle the monitoring were included in the investigation costs.
- The average building size in the programs in 2007-2008 is estimated to be near 280,000 sf. In future years, as the number of non-commissioned buildings of this size become scarce, smaller buildings will make up a larger share of the program mix. This will likely drive up commissioning costs to some extent.

Energy Savings

- Net first-year energy savings estimates (based on projects through investigation) for total electrical use ranged from 1.7% in the hospital sector to 7.1% and 8.1% in the office and college sectors. Reasons for the variations are not clear, other than in the college sector a more rigorous (and costly) commissioning protocol is used (monitoring-based commissioning). These results suggest a correlation between cost of commissioning and savings achieved through the process. It is a logical assumption that performing a more in-depth investigation, though more expensive, will likely result in greater savings. Further research is necessary to validate this assumption.

Cost Effectiveness

- The average project payback was 3.0 years. Non-energy benefits are not included in the analysis.
- Cost per kWh for first-year savings is calculated from annual electric savings and total cost of commissioning as a general indicator of cost effectiveness. The cost for first-year electrical savings for the office sector was $0.30/kWh, $0.70/kWh for college, and $0.42/kWh overall for all sectors. Total costs do not include utility program administration or management costs.

Other Interesting Findings

- Table 3 shows the change in energy intensity by sector, from 2000 to 2007. Though this is based on buildings greater than 30,000 square feet, it is interesting to note that the office section has seen the greatest increase in energy intensity and cost of energy.

Table 3. Energy Use Intensities and Costs Comparison – 2007 vs. 2000*

	Electric Energy Intensity			Total Cost ($/sf/yr)		
	2000	2007	Diff	2000	2007	Diff
Office (>30k sf)	12.84	17.7	38%	1.13	$ 2.42	115%
Restaurant						
Retail	13.84	14.1	2%	1.32	$ 1.81	37%
Grocery (food store)	46.96	41	-13%	3.94	$ 5.39	37%
Schools	6.82	7.5	10%	0.72	$ 1.09	52%
Colleges	10.44	12.3	18%	1.15	$ 1.87	62%
Hospitals (health)	21.2	19.6	-8%	2.37	$ 3.18	34%
Lodging	10.87	12.1	11%	1.09	$ 1.92	76%

*From Table 8-1 of California Commercial End-Use Survey, March 2006; California Energy Commission

4. Research Questions

The 2007 study presents useful and timely estimates on market potential for retrocommissioning in California. It also provides a view into issues requiring further investigation, study and analysis. The following questions highlight several areas for potential follow-on research needed to further explore the opportunities for cost-effective energy savings through retrocommissioning.

- Is there a correlation between cost of commissioning and savings? What commissioning approach and budget will yield the most cost-effective program? What approaches are appropriate for what market sectors and owner types?
- Why is there such a wide range of savings between market sectors? Is there enough data to support these conclusions? Should some markets be eliminated from the programs?
- Persistence Issues
    - How effective are current persistence activities?
    - How long do savings persist for various programmatic approaches?
    - How long do savings persist by measure type?
    - Is there a correlation between persistence of savings and cost of persistence activities?
- Commissioning Provider Issues
    - Are the study results around number of providers needed realistic based on the market factors that affect availability and capacity to do retrocommissioning?
    - How can potential issues with provider capacity be addressed? What strategic actions could be employed to increase the number of available commissioning providers? For example:
        - Develop and deploy training programs that increase the skills of existing retrocommissioning providers.
        - Explore opportunities to foster growth in engineering or related firms who do not currently do retrocommissioning, but could develop the practice with adequate guidance and training.
- How do actual program results compare to the estimates made in this study? In 6 to 12 months, abundant data will be available from programs' implemented projects and may provide a more accurate picture of the actual market potential for retrocommissioning in California. Follow-up study on evaluation results from current programs will allow for another level of analysis on market potential and realization.
- Has the penetration rate for new construction and major renovation changed since the 2000 study? Though out of scope for this study, there may be interest in revisiting the market potential for commissioning new buildings in the future.

5. Data Sources

- Updates to the 2000 study were made for floor stock by market sector, energy use indices and electric and gas rates.
  - Floor Stock Projections. The 2000 study included buildings greater than 30,000 square feet. The current study estimates the square footage of buildings 100,000 square feet and larger, as this is the minimum building size requirement in current retrocommissioning programs. Gross floor stock forecasts from 2007 were obtained from CEC. Gross stock greater than 100,000 square feet was projected based on estimated breakdowns by building size provided by PG&E in 1999 (no other source for building stock by size).
  - California Energy Rate and Cost Forecast (2007-2017) was obtained from CEC. 2008 values were used in the analysis.
  - Energy Intensity values were taken from Table 8-1 of CEC, California Commercial End-Use Survey, March 2006.

- Data from current programs were requested from all of the current retrocommissioning programs, and responses were received from the following:
  - California Department of General Services
  - Ecology Action (LodgingSavers)
  - Enovity (Monitoring-Based Persistence Commissioning Program)
  - LA County Energy Efficiency Partnership
  - PECI (SDG&E, PG&E and SMUD RCx programs)
  - PG&E (PG&E Core program)
  - QuEST (Hospitality Energy Efficiency Program, Hospital Pilot Program, Data Center Cooling Control Program)
  - SCE (SCE Core program)
  - UC/CSU and California Community Colleges MBCx Programs

  Responses from the various program implementers were varied in depth and timeliness of reply. Issues with confidentiality of third-party program information were also a factor. The project team (Kirstin Pinit and Karl Stum) followed this confidentiality agreement:
  Acknowledging the potential sensitivities around the confidentiality of Third Party program designs and intellectual property, PECI agrees to:
  - *Maintain confidentiality of all Third Party program data, limiting access to the information to the immediate project team at PECI; and*
  - *Publish only aggregated data on retrocommissioning programs. Findings will not identify individual program information or project results.*

- The savings fractions used in the 2007 study are based on published evaluation reports, data reported from California programs, and reasonable assumptions made by the project team.

- The cost of commissioning is based on reports from current programs in California. Available data varied, with some programs not reporting costs and some projected costs based on estimated incentives and implementation bids.

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 6
Schedule 5
Appendix F
Filed: 2011 Apr 1
(72 pages)

Introduction to Monitoring and Targeting

WHAT IS M & T?

- Energy Accounting
- Input - Ouput Analysis

HOW DOES M&T SAVE ENERGY?

- Accountability of Energy Use
- Feedback to Management of Energy Savings Due to Energy Investment > Motivation to Invest
- Fast Alert of Energy Waste
- Feedback to Operators of Energy Savings Due to Good Practice > Motivation to Perform

HOW DOES M & T SAVE ENERGY?

Some common doubts:

- **How can installation of meters save energy?**
- **Isn't energy efficiency the responsibility of engineers, not management?**

Barriers to High Efficiency

- Lack of accountability
- Lack of awareness of savings potential
- Lack of knowledge of processes by those paying the energy bills
- Lack of motivation to save

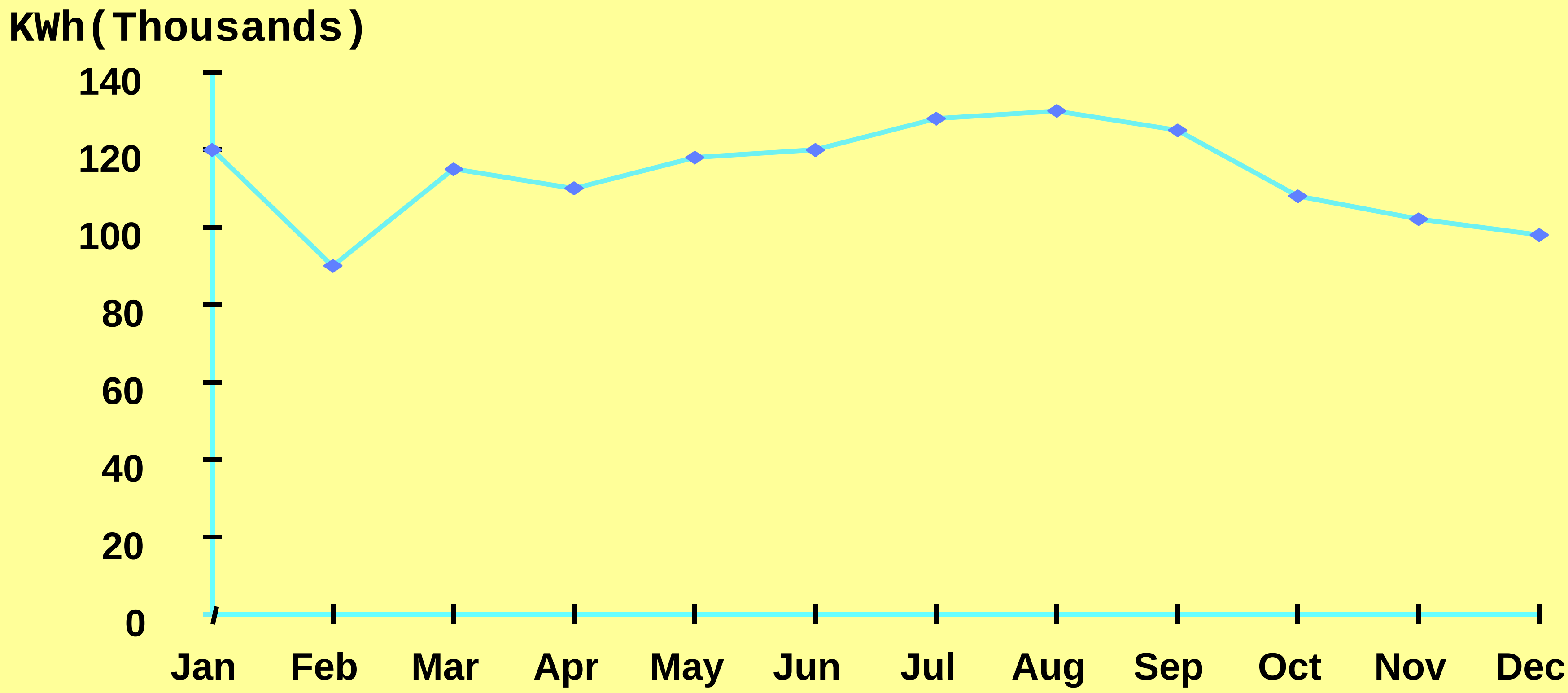
Some questions for any company

- **Who pays the energy bills?**

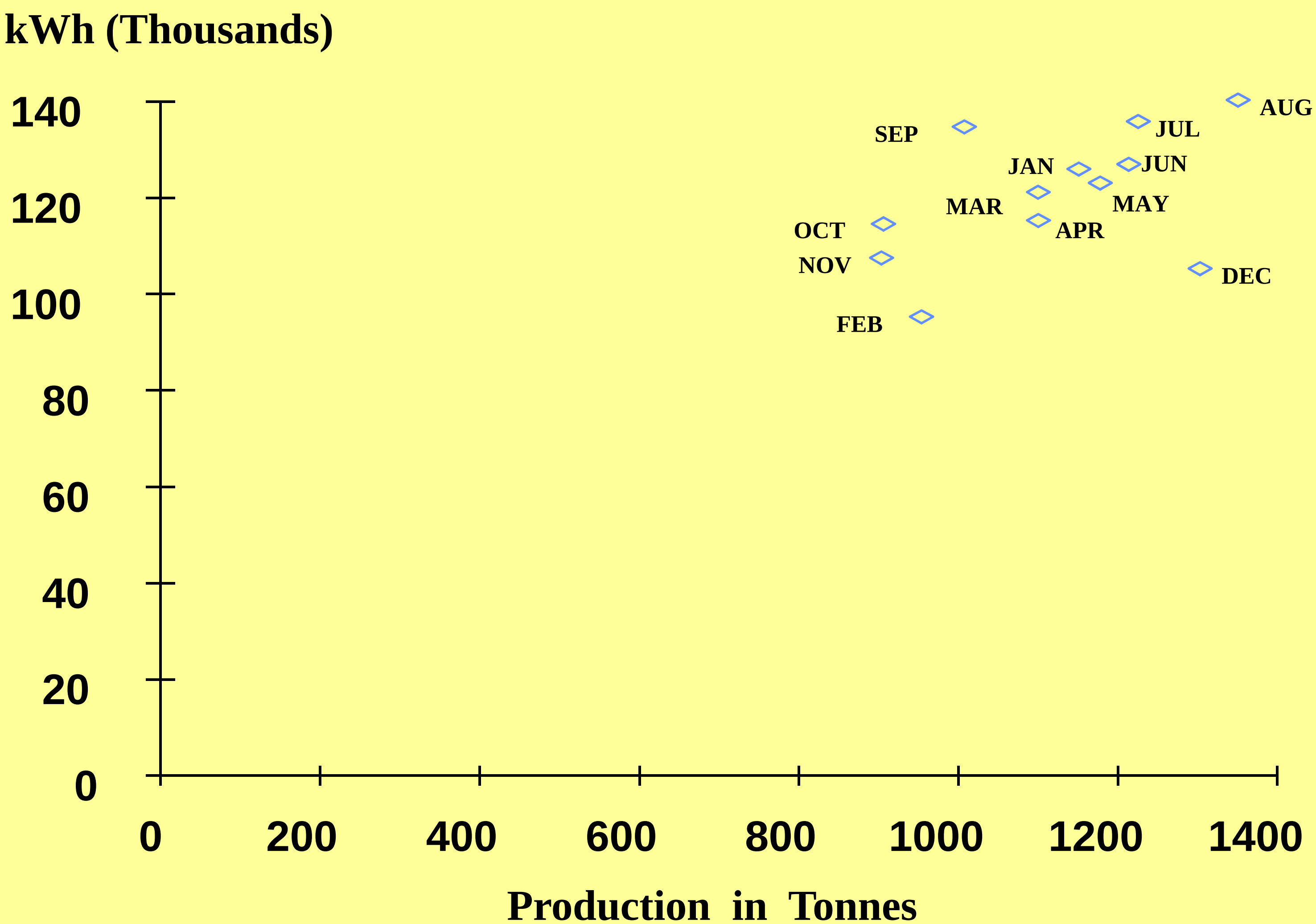
- **Is the company getting value for money?**

- **Who is responsible?**

Simple Analysis



Regression Analysis



Graph Analysis

- Some high months!
- What Happened?
  - Too late to check!
- Who is responsible?
  - Services Department?
- Production people most likely responsible
  - Has anybody told them?

U.K Demonstration Scheme

- Back-up to energy audits
- 25 sectors covered
- 5-15% energy savings achieved
- Other significant benefits
- About 1000 sites practising Monitoring and Targeting

Sector Studies

Relatively Simple -

- Ferrous/Non Ferrous
- Brick & Tile
- Glass
- Paper & Board
- Food & Drink

More Complex -

- Textile
- Cement
- Rubber & Plastics
- Commerce

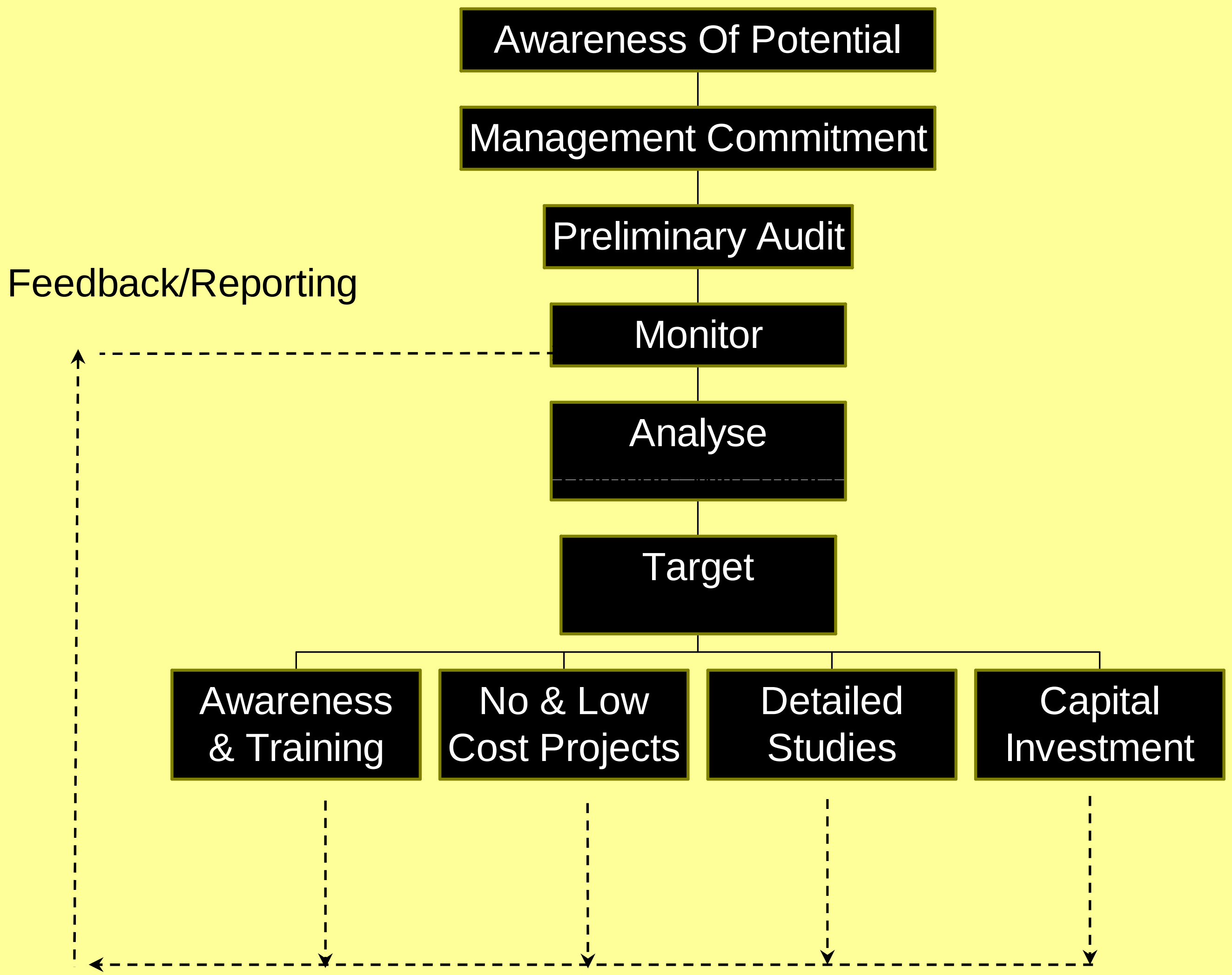
Difficult -

- Chemical
- Engineering

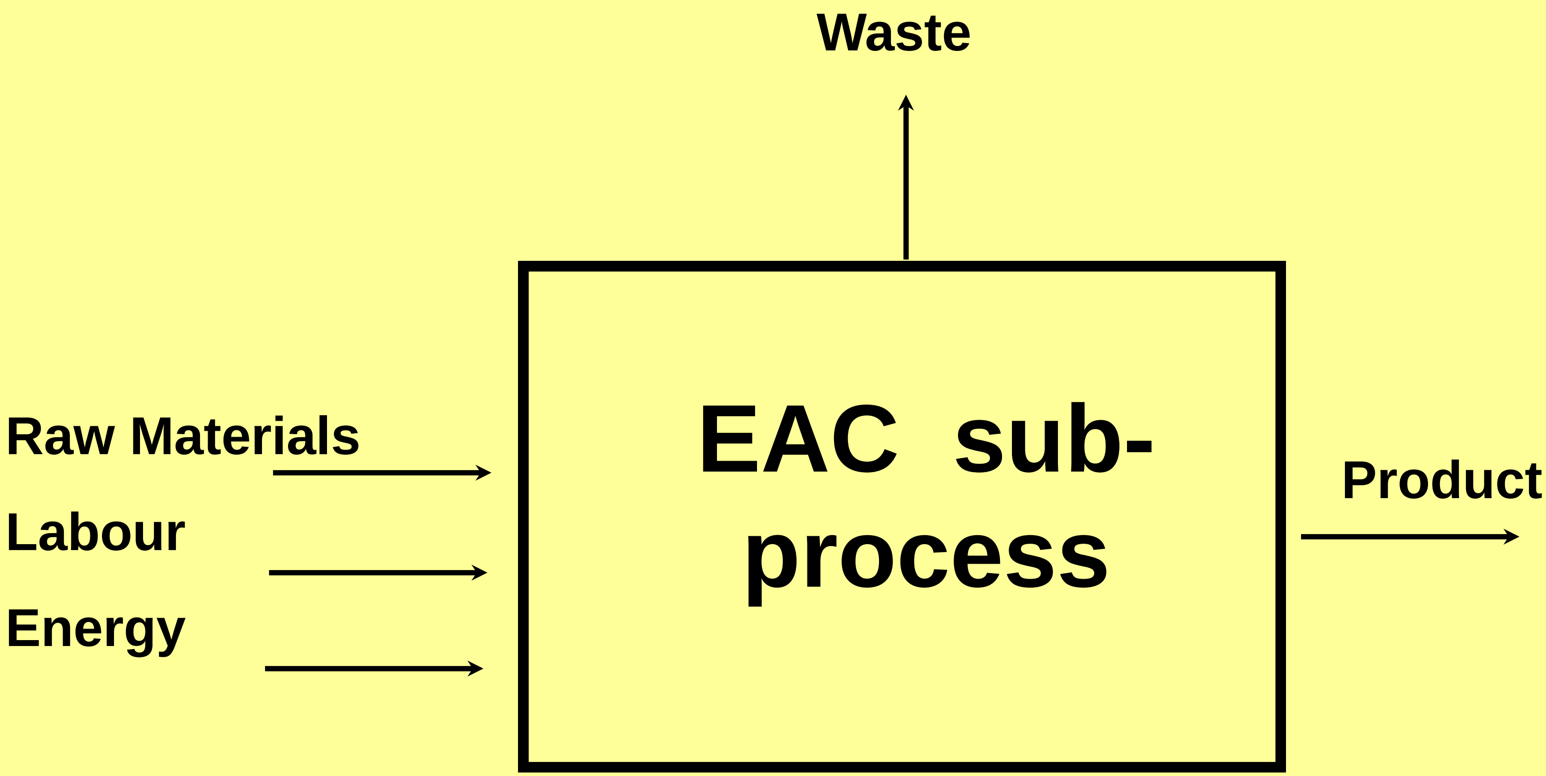
Typical Sector Savings

Sector	% Savings
Bricks	5
Food	13
Iron Foundry	8
Non-Ferrous	12
Paper & Board	9
Pottery	4
Steel	7
Textiles	

M & T Structure



PRELIMINARY AUDIT - ANALYSIS OF PROCESS - DEFINES EACs



OBJECTIVES OF PRELIMINARY AUDIT

- To determine what should be monitored?
- To determine areas of accountability
- To determine costs of further monitoring equipment required
- To estimate other costs and savings

PRELIMINARY AUDIT -DEFINE OUTPUTS

WHAT DOES ENERGY USAGE DEPEND UPON ?

- **Output/Input**

  (Production, Work Content)

- **Plant running time**

- **Temperature**

  (Product, External)

- **Any other? Water content, Constituency, Exothermic Reactions, Endothermic Reactions**

PRELIMINARY AUDIT -
MAIN RESOURCES CAPITAL

- **Additional Metering**

- **Computer Hardware & Software**

- **Test equipment-Demand recorders**

  etc.

PRELIMINARY AUDIT - MAIN RESOURCES REVENUE

- Project Champion
- Clerical assistance, preferably computer literate
- Meter reader

OPERATION OF THE M&T SYSTEM

- **Data Collection and Monitoring**
- **Data Analysis**
- **Target Setting**
- **Reporting and Feedback**
- **Initiating Savings**

MARCH

DATA COLLECTION & MONITORING

DATA

- All Meter readings
- Production Data
- Ambient Temperature Data (degree days)
- Auxilliary Data

METER READINGS FREQUENCY

- Each batch
- Each shift
- Daily
- Weekly
- Monthly

DATA ANALYSIS

Data Input

Operation of Computer

Comparison with Targets

ANALYSIS - WHAT TYPE OF SOFTWARE

1) Spreadsheet

- **Cheap**
- **Most people familiar with it**
- **Often a company standard**

BUT

- **can easily be tampered with**
- **not very flexible when changes are needed**
- **complex if many meters or readings**

2) Database

- **Capable of handling an infinite amount of data**
- **More difficult to tamper with**
- **More flexible**
- **Essential for installations of more than 50 meters**

ANALYSIS - MAIN FUNCTIONS

- Analyse input meter readings
- Calculate actual consumptions
- Analyse correlation between consumptions and targeting variables
  - (Targeting)
- Calculate variances between actual and target consumptions
- Store data over a long period of time for targeting and trend analysis

TARGETING

Selection of 'Production Variable' for Targeting

Performance Evaluation using Targets

Resetting of Targets

Bottle Wash Water Vs Milk Throughput

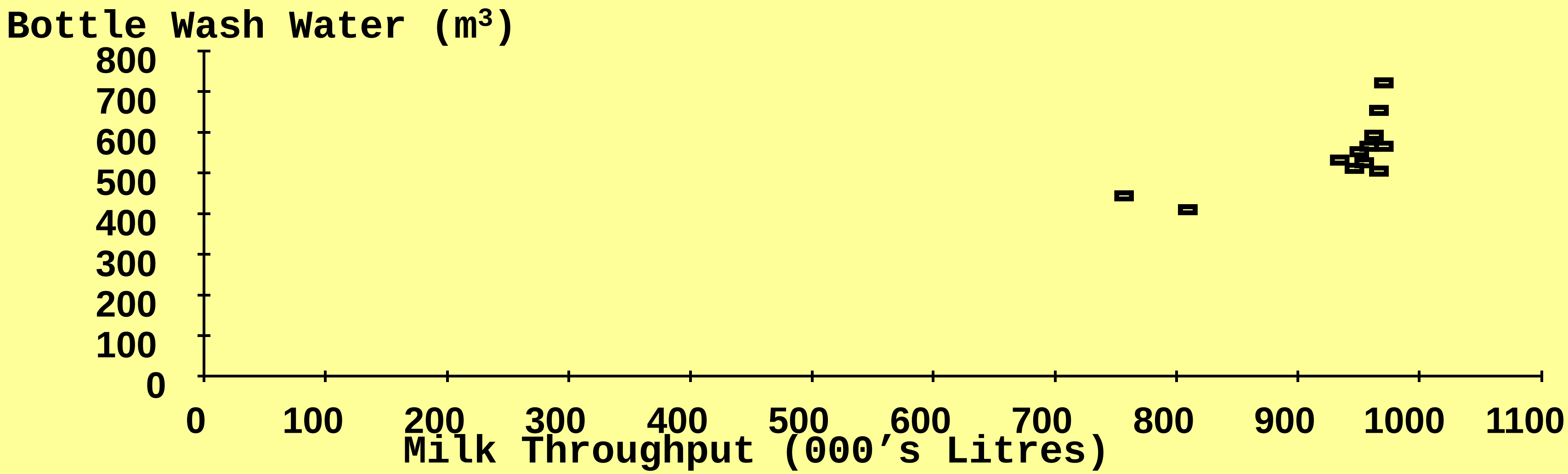
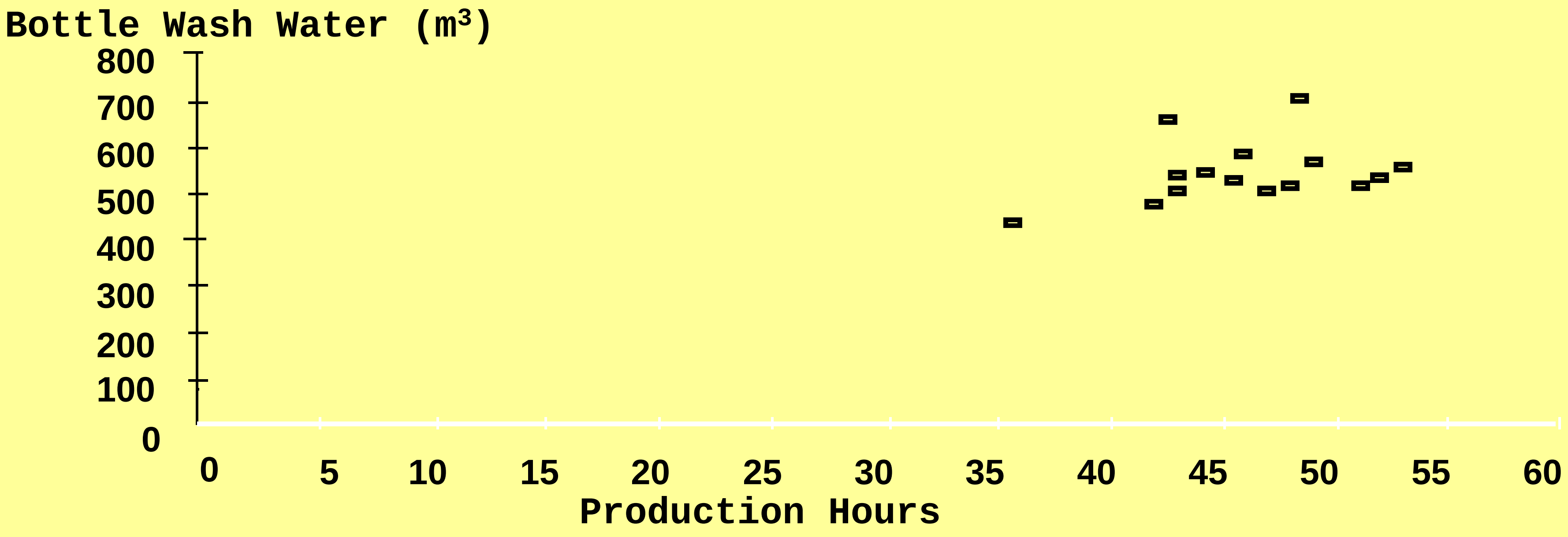
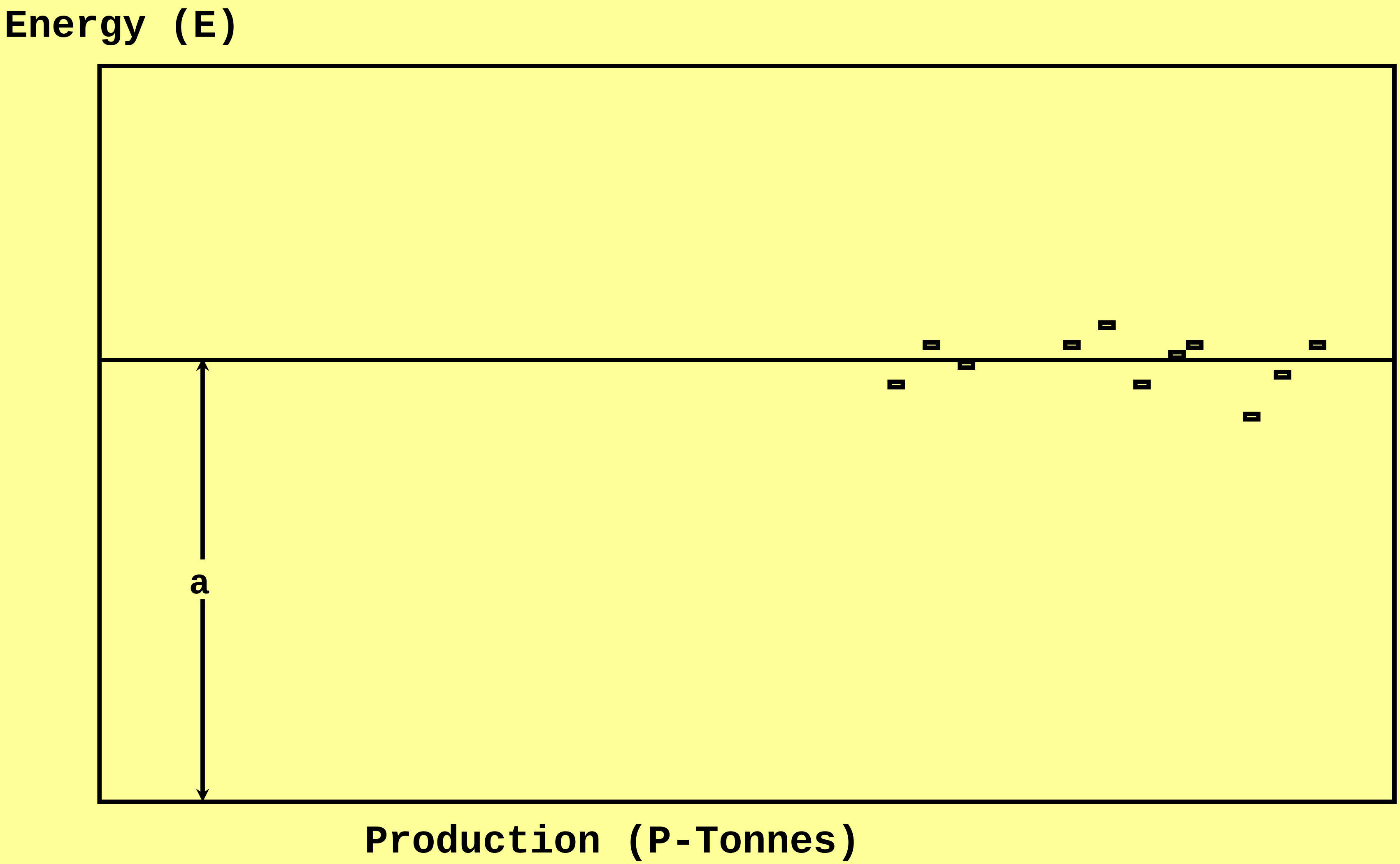


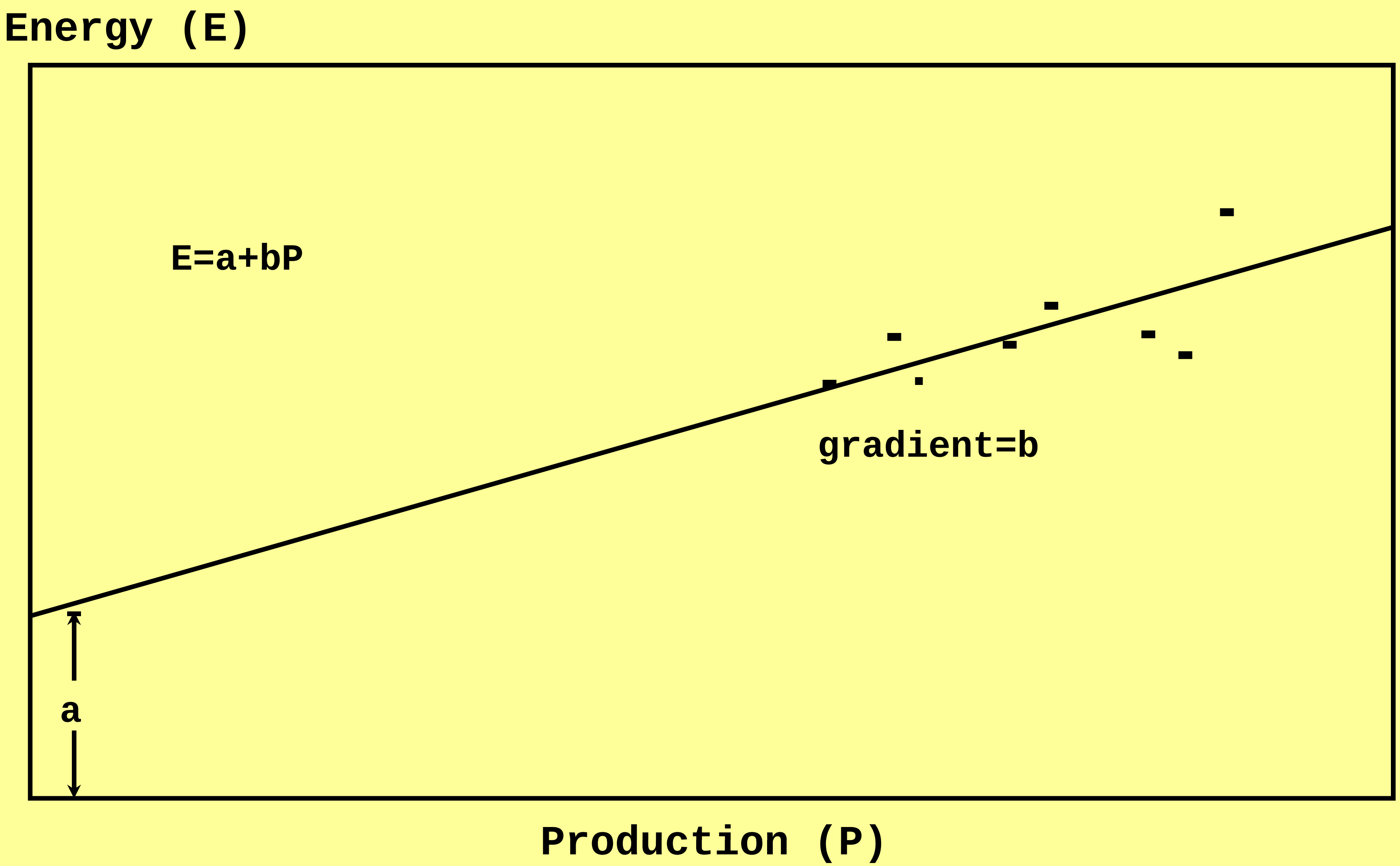
Fig.2 Bottle Wash Water Vs Production Hours



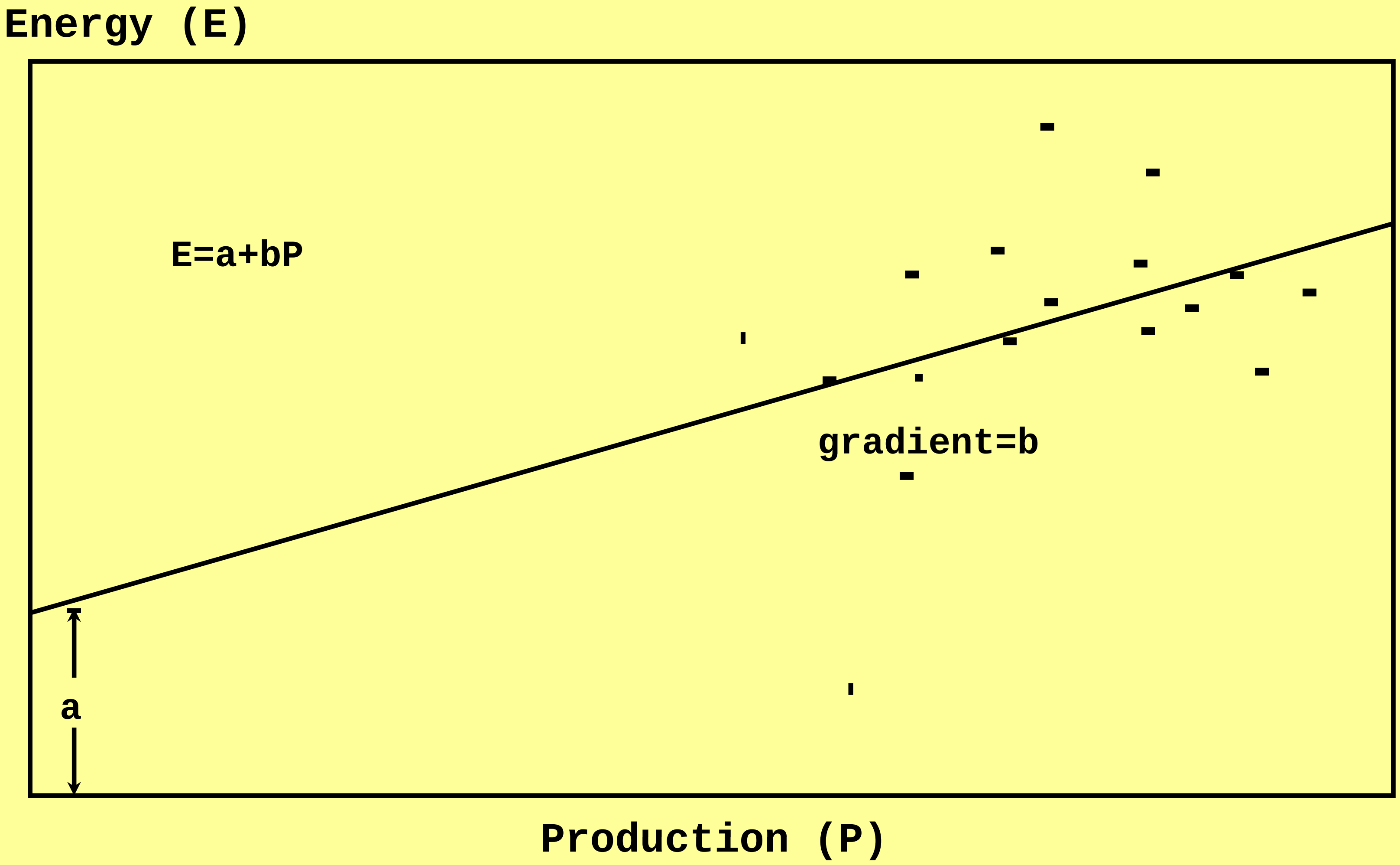
TARGETING - CONSTANT



TARGETING - SINGLE REGRESSION



TARGETING - PERFORMANCE EVALUATION



RE-SETTING TARGETS

- **Analyse subsequent 10 weeks data and re-set target**
- **Allocate a % reduction on target related to new equipment/procedures**
- **Continually up-date target**

REPORTING AND FEEDBACK

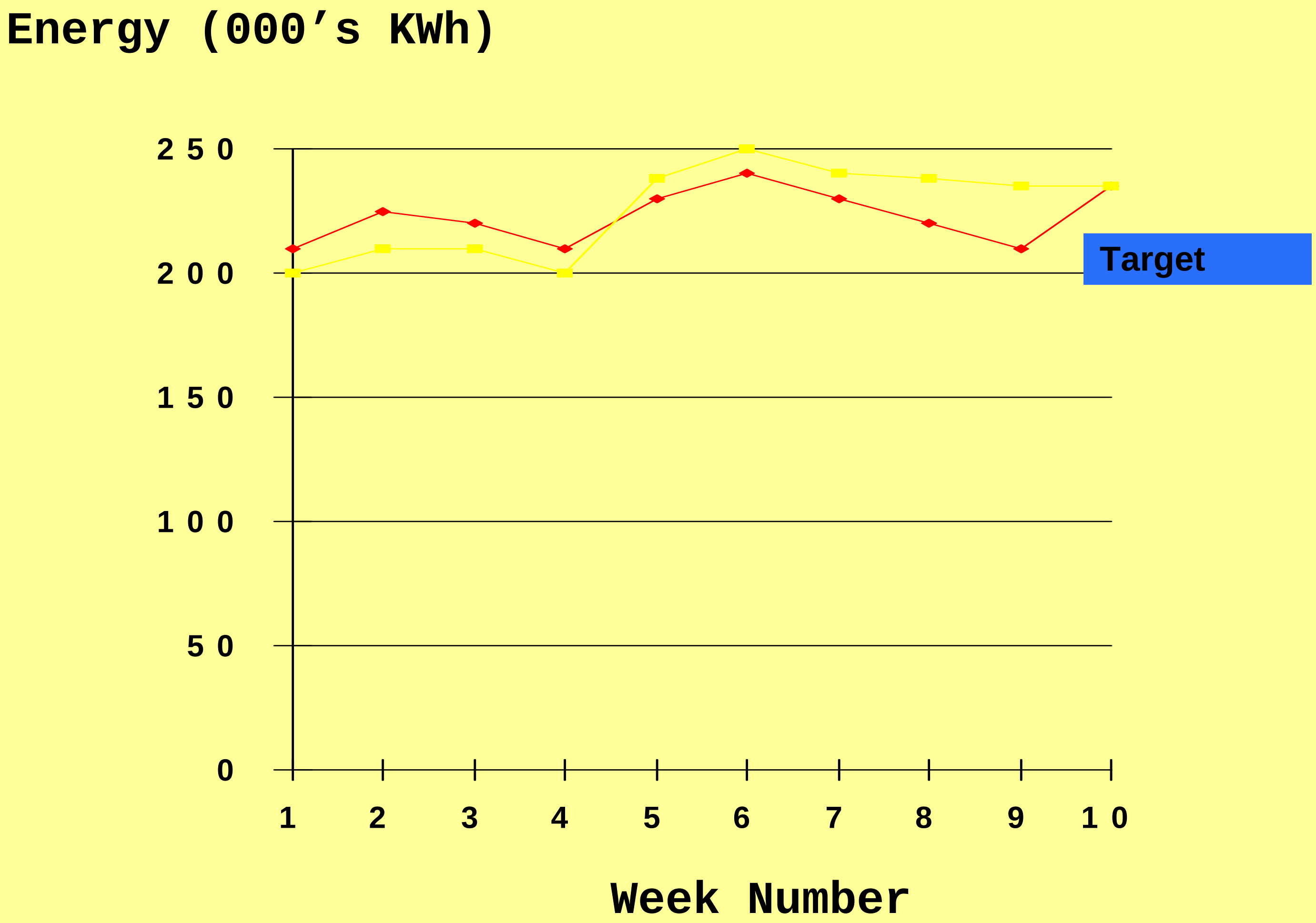
REPORTING PURPOSE

- **To keep people informed of their weekly performance**
- **To monitor long term progress**
- **To create feedback on improvements made**
- **To motivate people to improve**

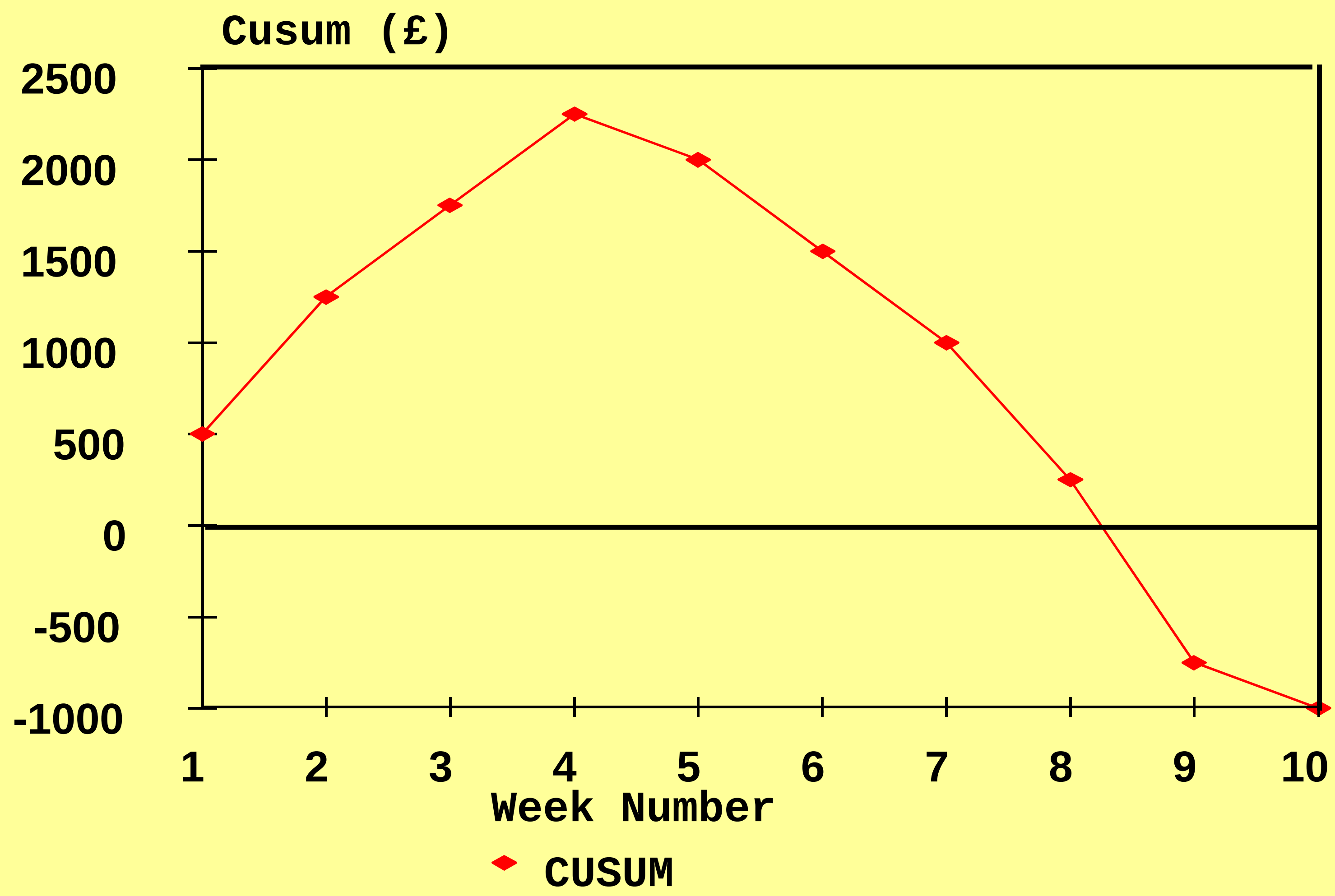
REPORTING DESIGN

- Frequency
- Units
- Cumulative?
- Graphical or Tabular

REPORTING EXAMPLE



REPORTING - CUSUM PLOT



CREATING ACTION

Action is Part of the M&T Process

ENERGY TEAM - WHO?

- Senior Management
- Production Managers
- Engineering Manager
- Project Champion
- Finance/Quality People

ENERGY TEAM - WHY?

- To communicate the aims and implementation plan to the rest of the workforce
- To assist the Energy Manager in carrying out his strategy
- To identify energy saving opportunities
- To ensure actions are implemented

DEPARTMENTAL TEAMS

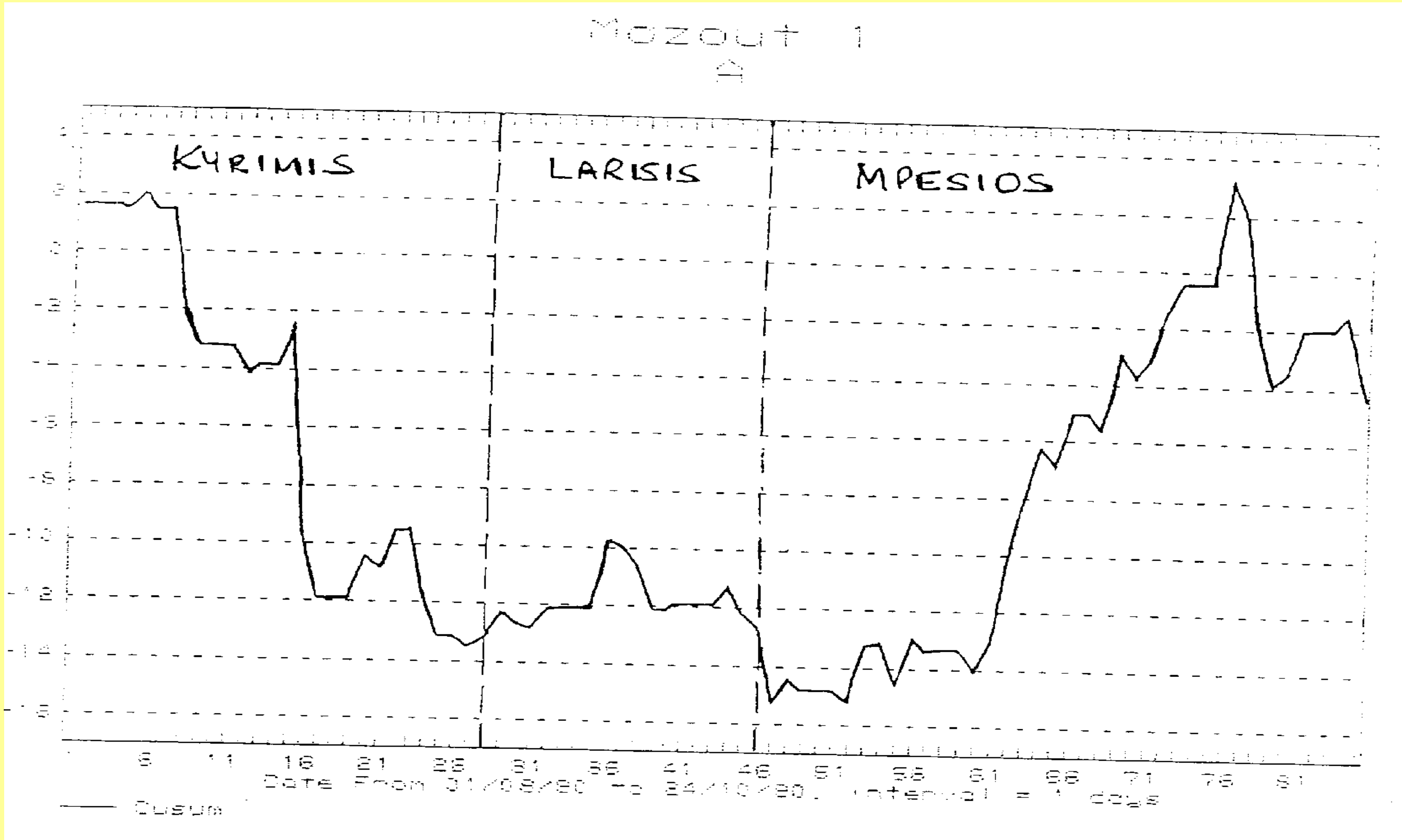
- **Identify waste in their area**
- **Improve “housekeeping”**
- **Initiate energy saving projects**
- **Carry out energy saving projects**
- **Communicate aims and activities to rest of workforce**

DEPARTMENTAL MEETINGS

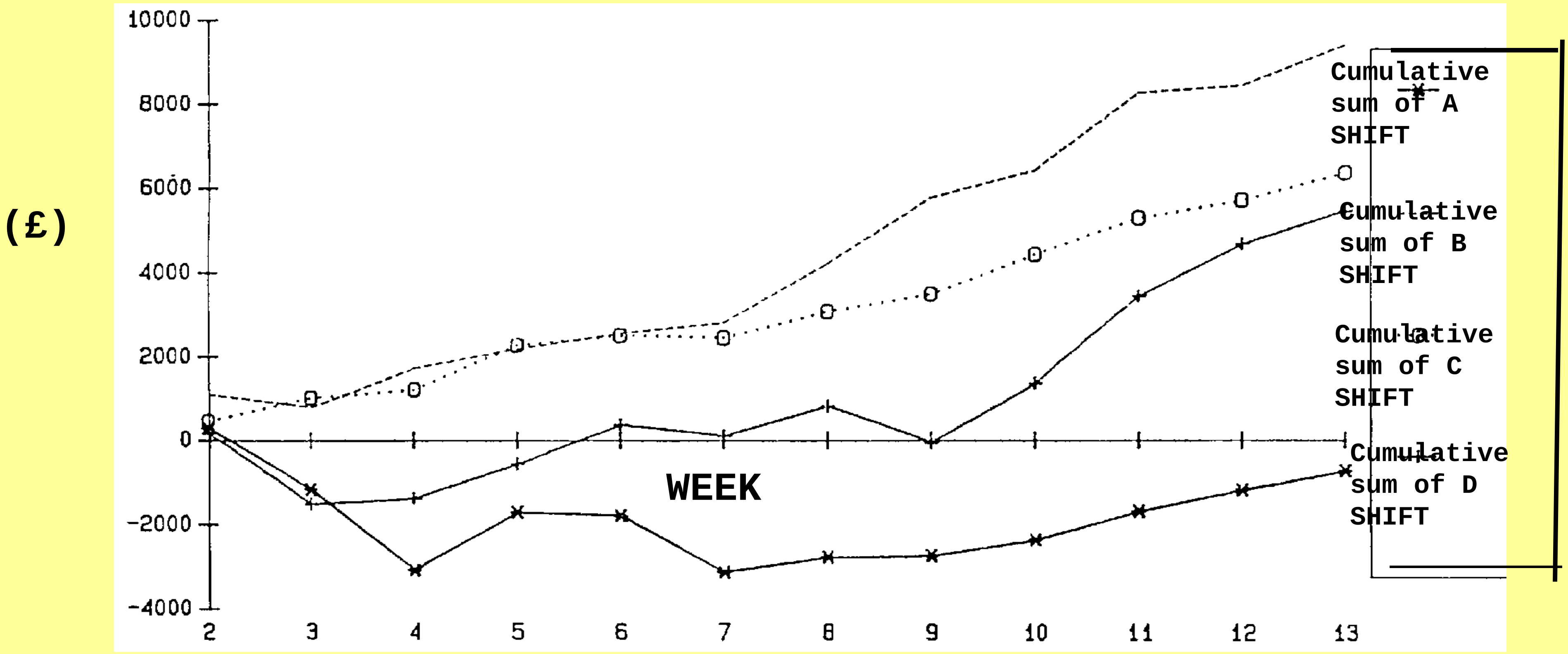
- Brainstorming sessions
- Specific actions allocated
  - Housekeeping measures
  - Further measurements
  - Project assessment
- Minutes must be taken

CASE STUDIES

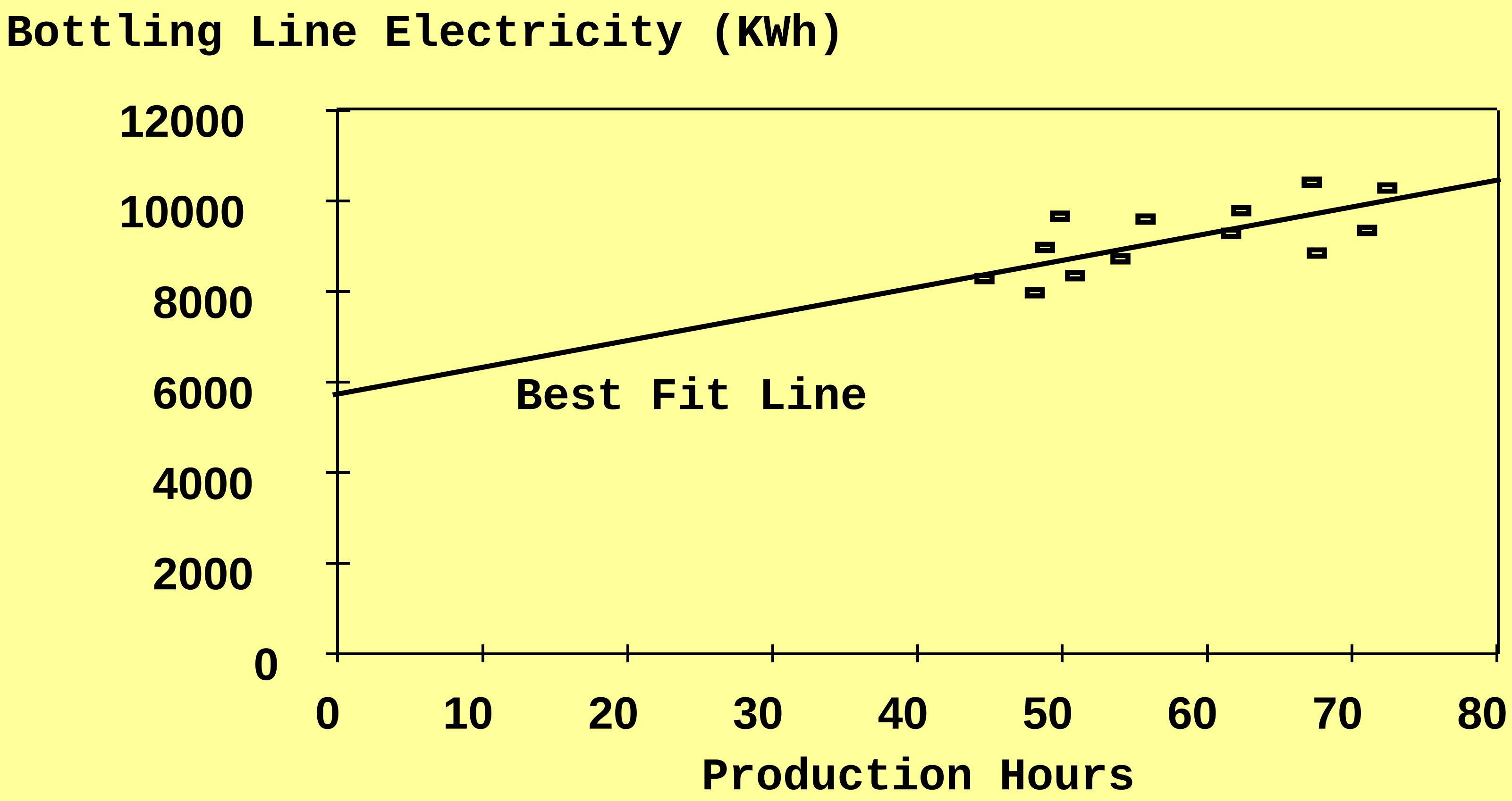
Mazout 1



33kV Energy Saving

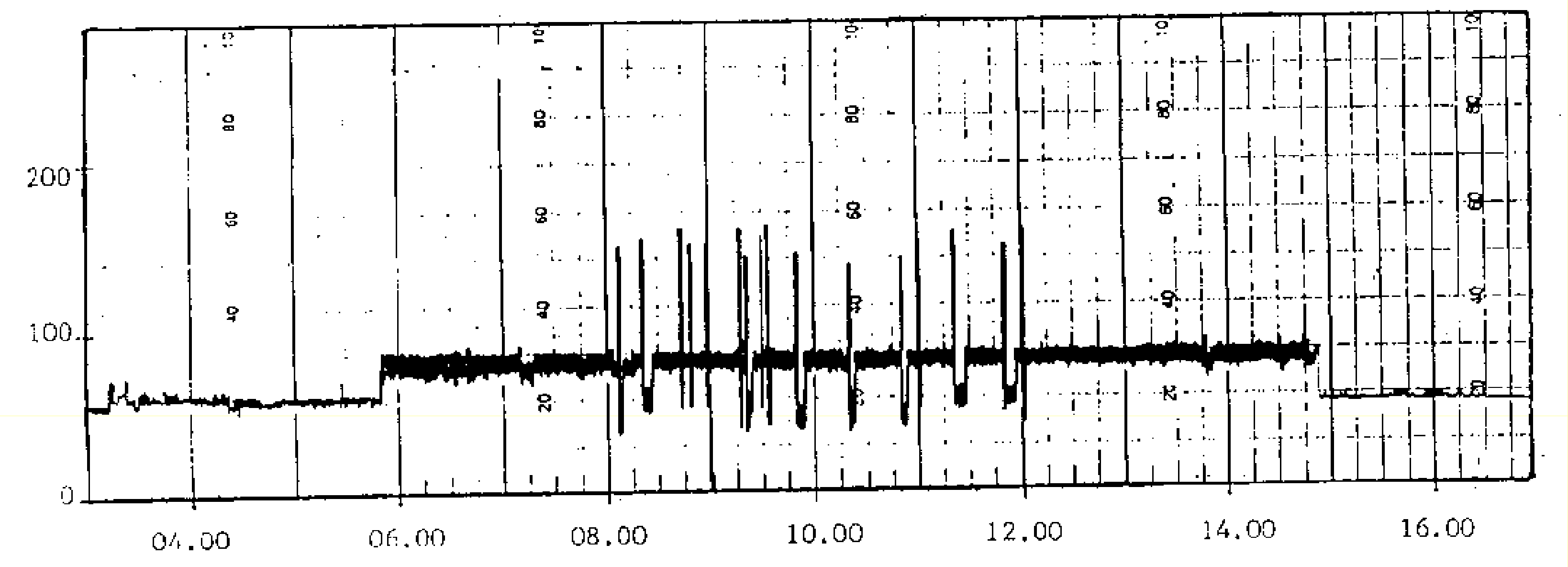


BOTTLING LINE ELECTRICITY Vs PRODUCTION HOURS



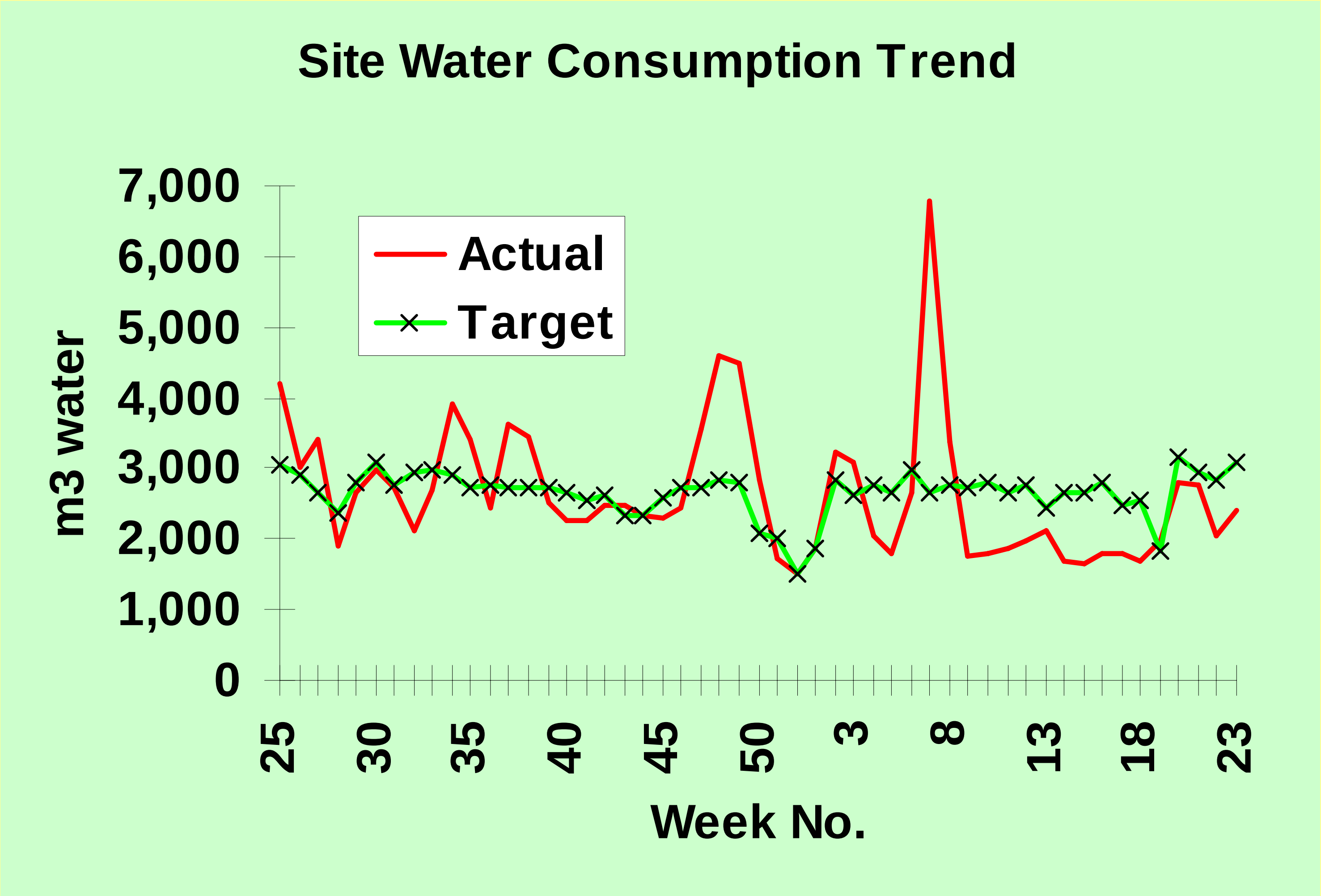
RECORDING AMMETER OUTPUT FOR BOTTLING LINE

kW

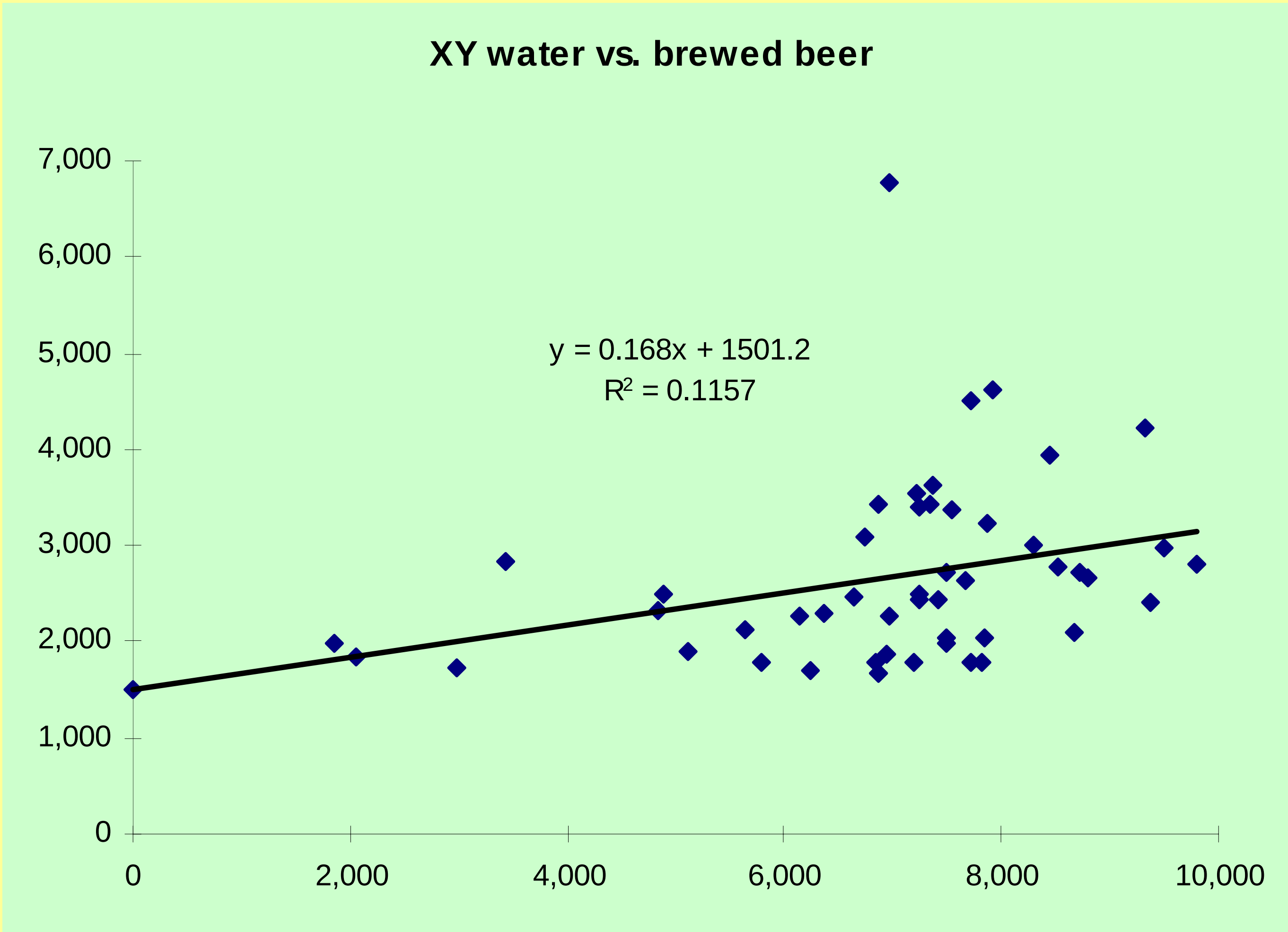


TIME

Case Study I Water Leaks



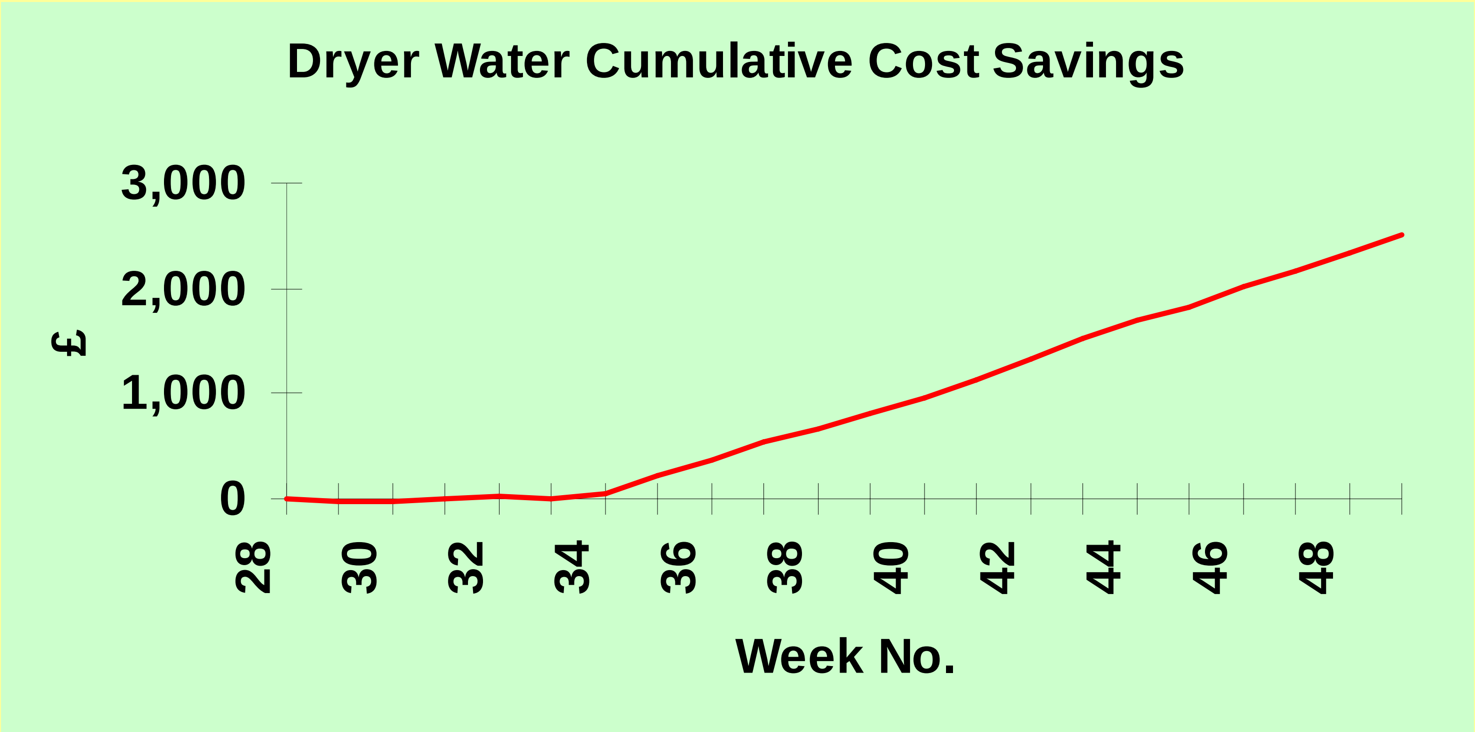
Case Study I Water Leaks



Case Study II - Water Re-use

- **Skloplast**
- **Sector: Glass**
- **Utility: Water**
- **Measure: Reusing water after cooling duty**
- **Key: Reuse**
- **Investment: Zero**

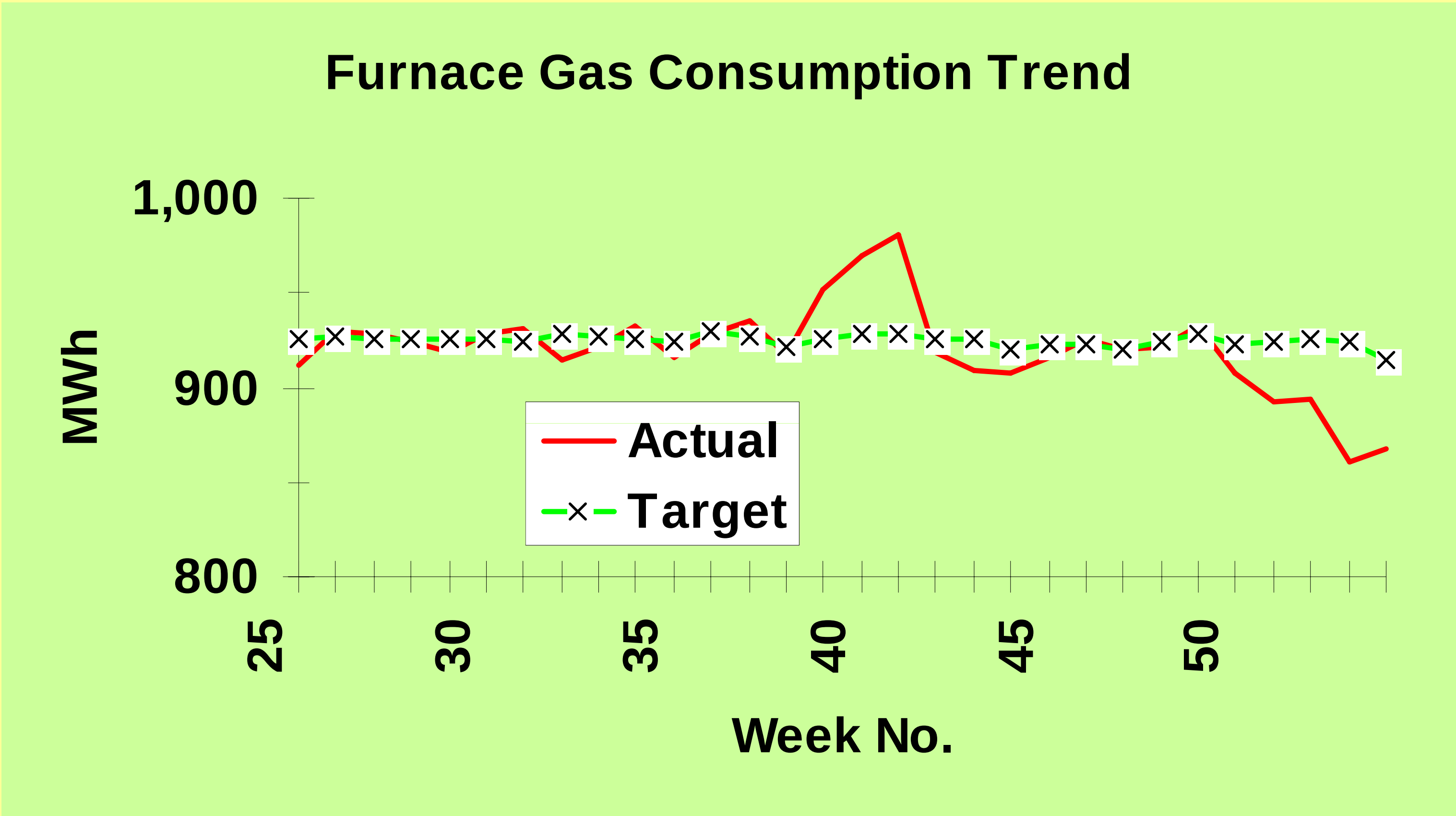
Case Study II - Water Re-use



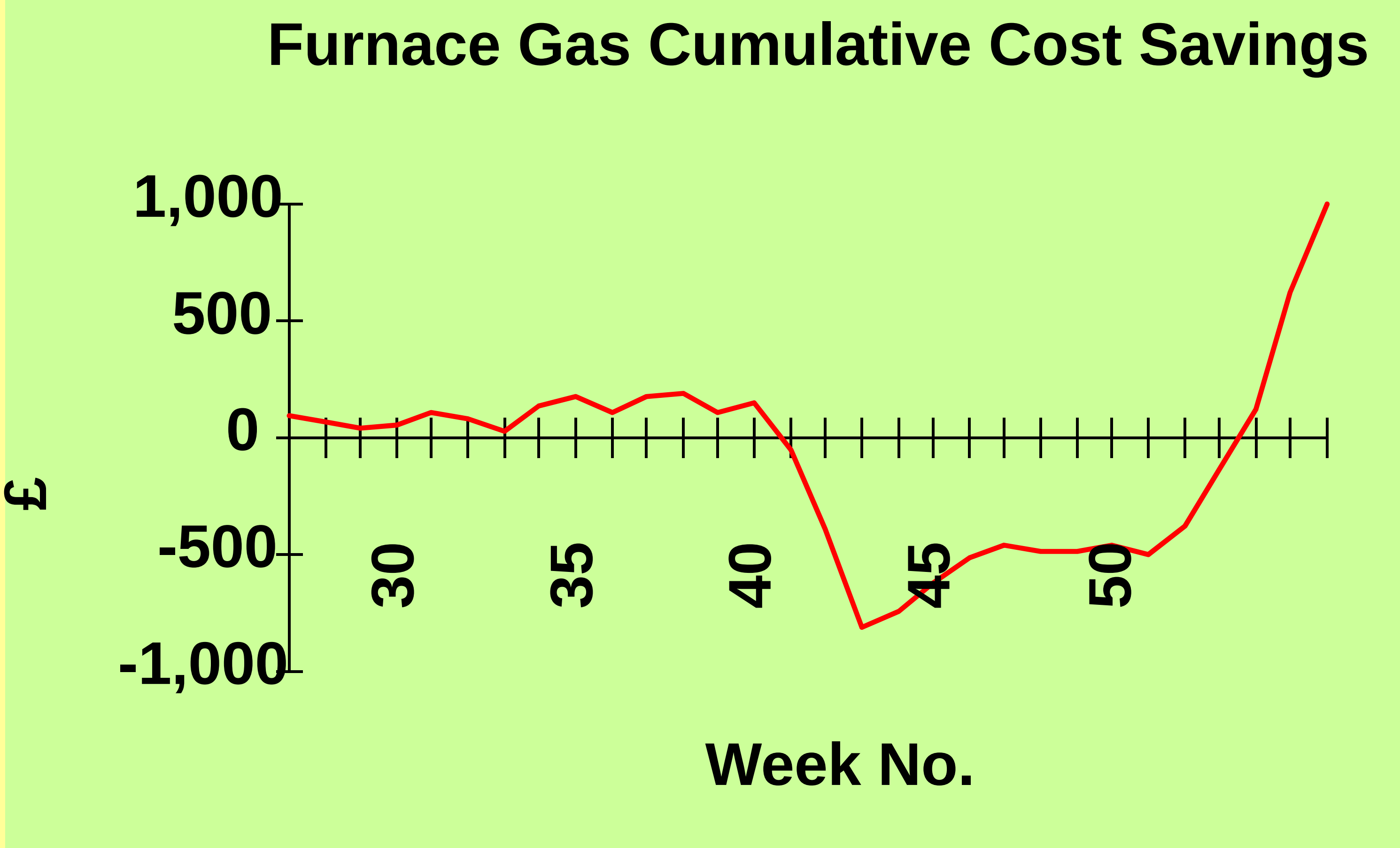
Case Study III - Glass Furnace

- Skloplast
- Sector: Glass
- Utility: Gas
- Measure: Optimised burners of a glass furnace
- Key: Act on variance
- Investment: Zero

Case Study III - Glass Furnace



Case Study III - Glass Furnace

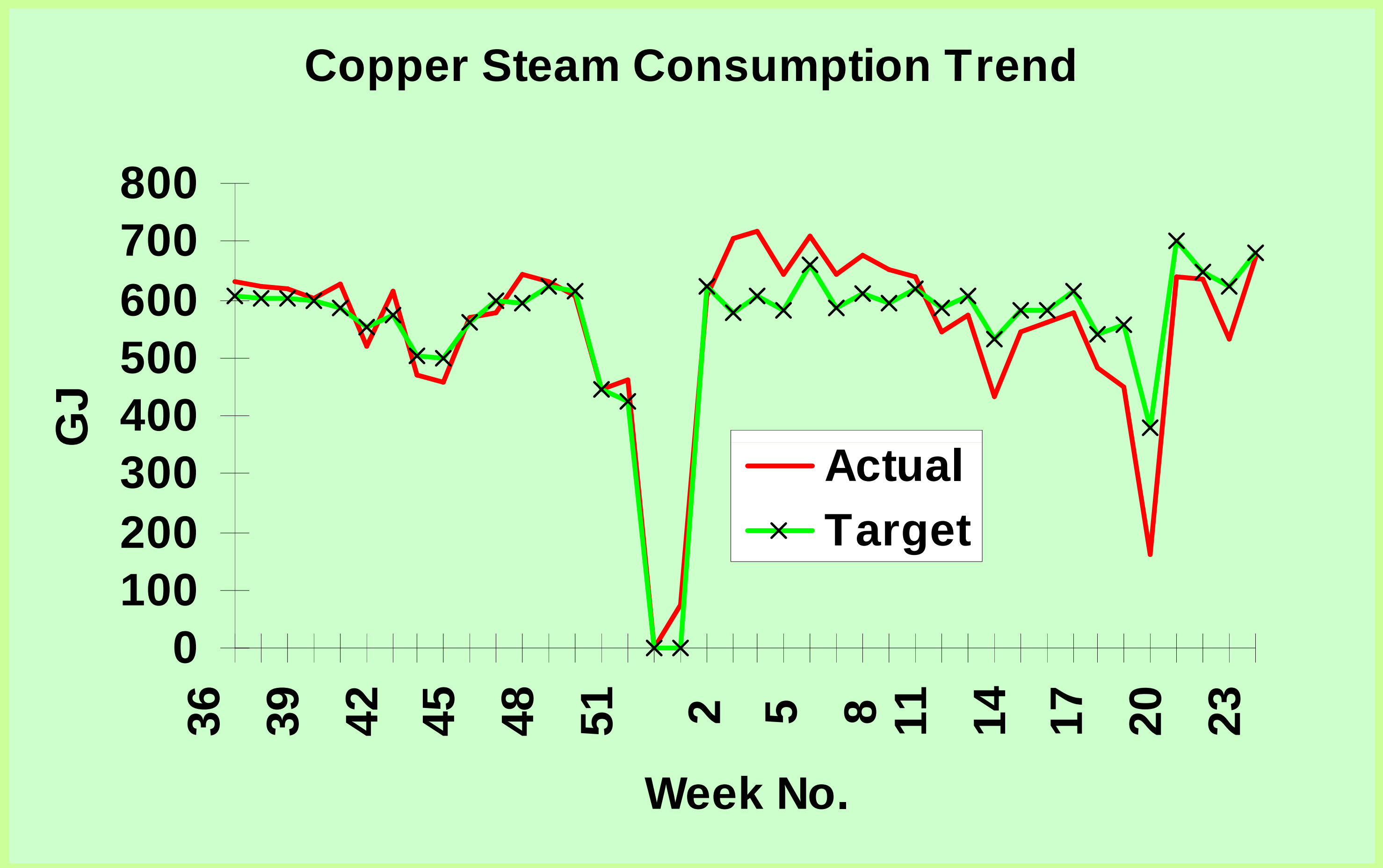


Savings: £ 63,000 per year

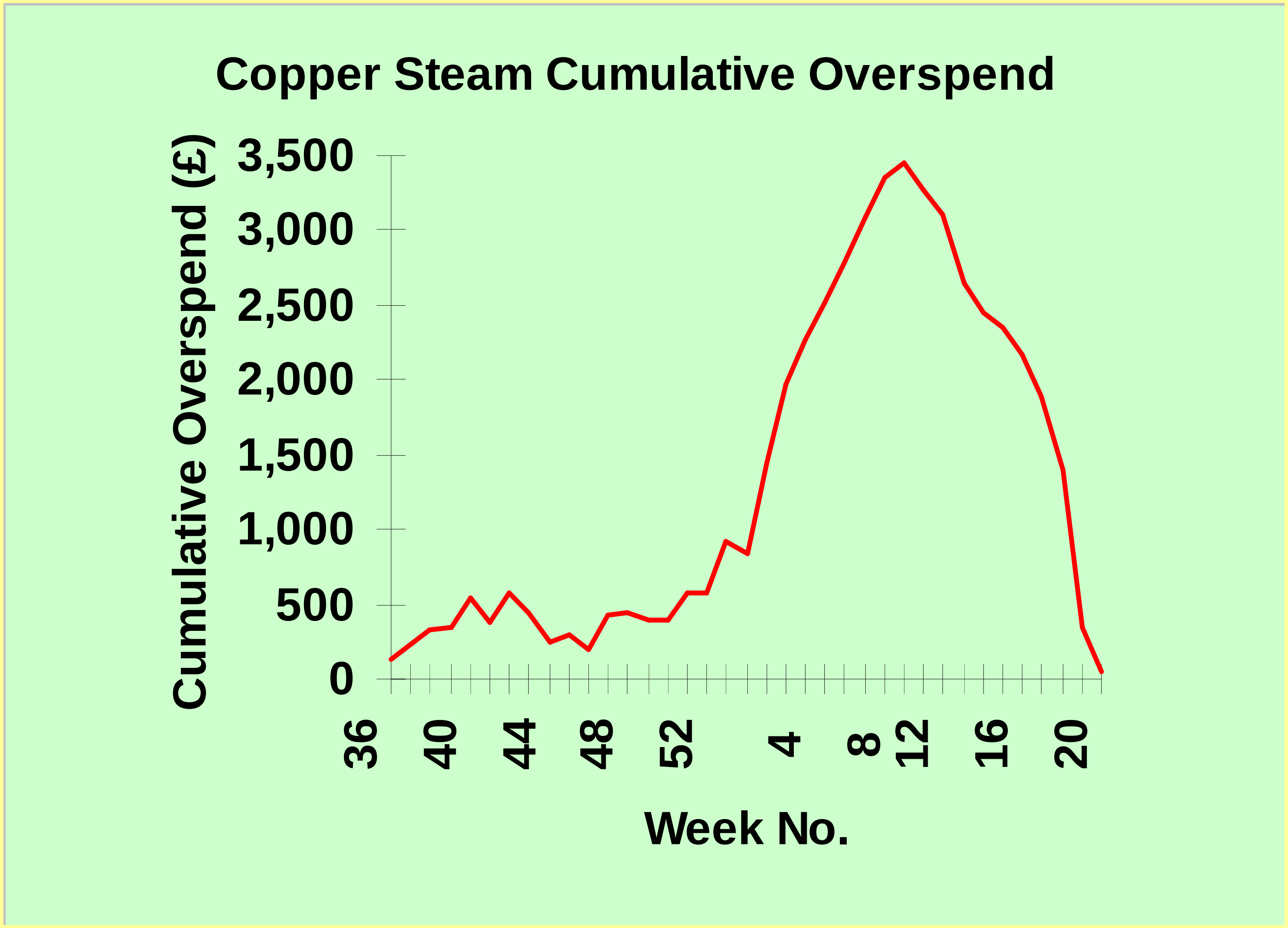
Case Study IV - Brewery

- KK Company, Martiner Brewery
- Sector: Food
- Utility: Steam
- Measure: Improved cleaning using pressurised water
- Key: Act on Variance
- Investment: Zero

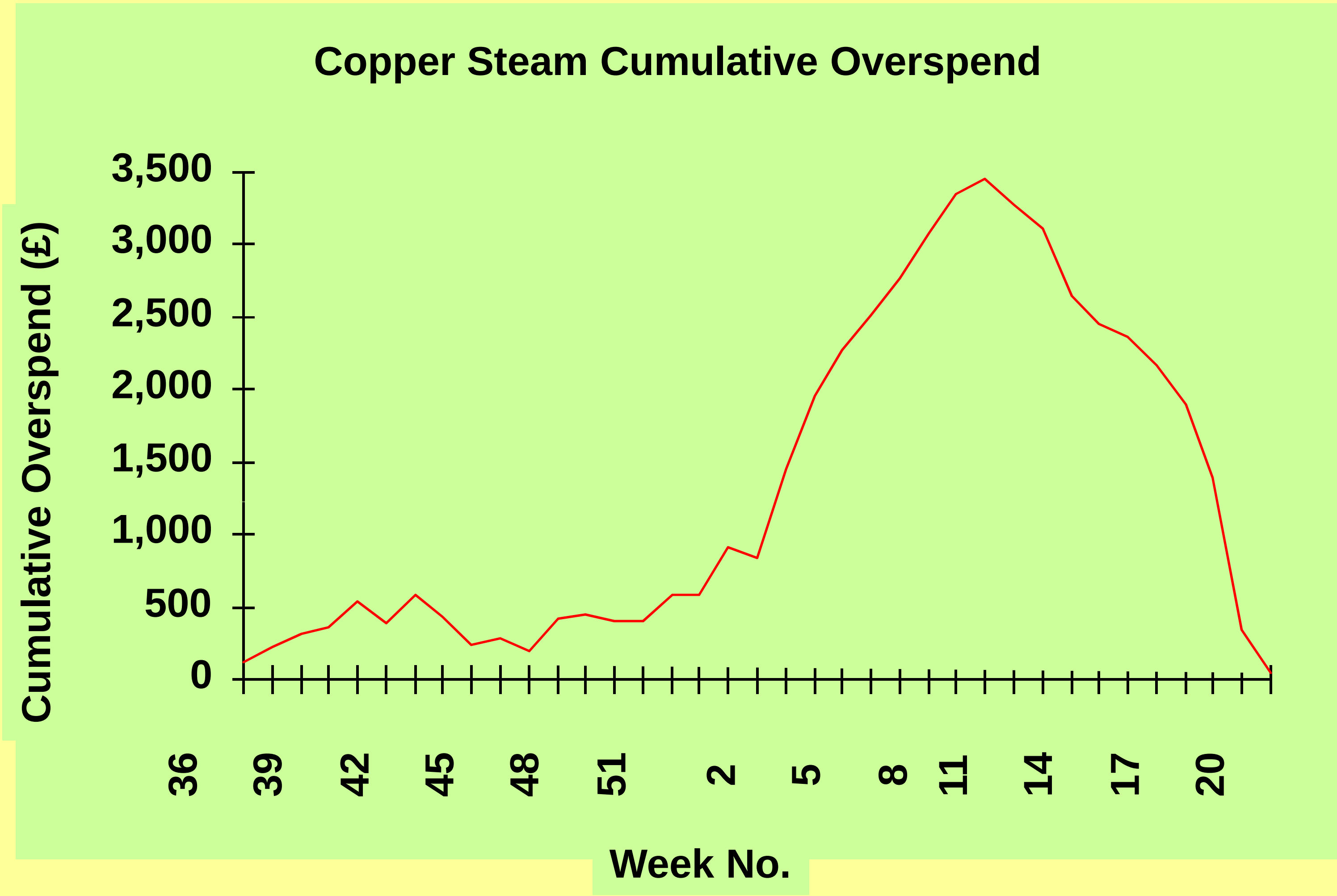
Case Study IV - Brewery



Case Study IV - Brewery



Case Study IV - Brewery

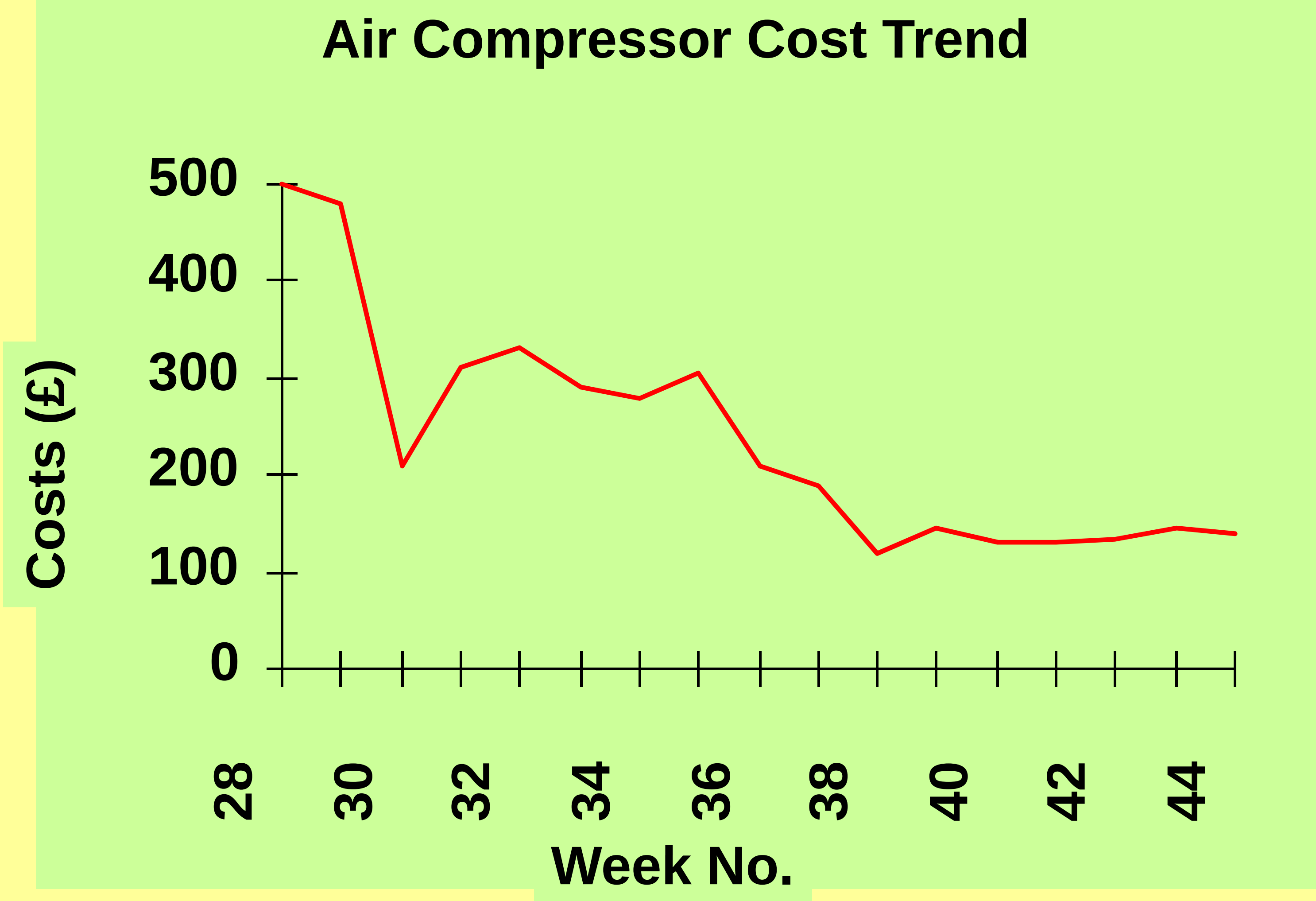


Savings: £ 19,000 per year

Case Study V - M&T Fertiliser Plant

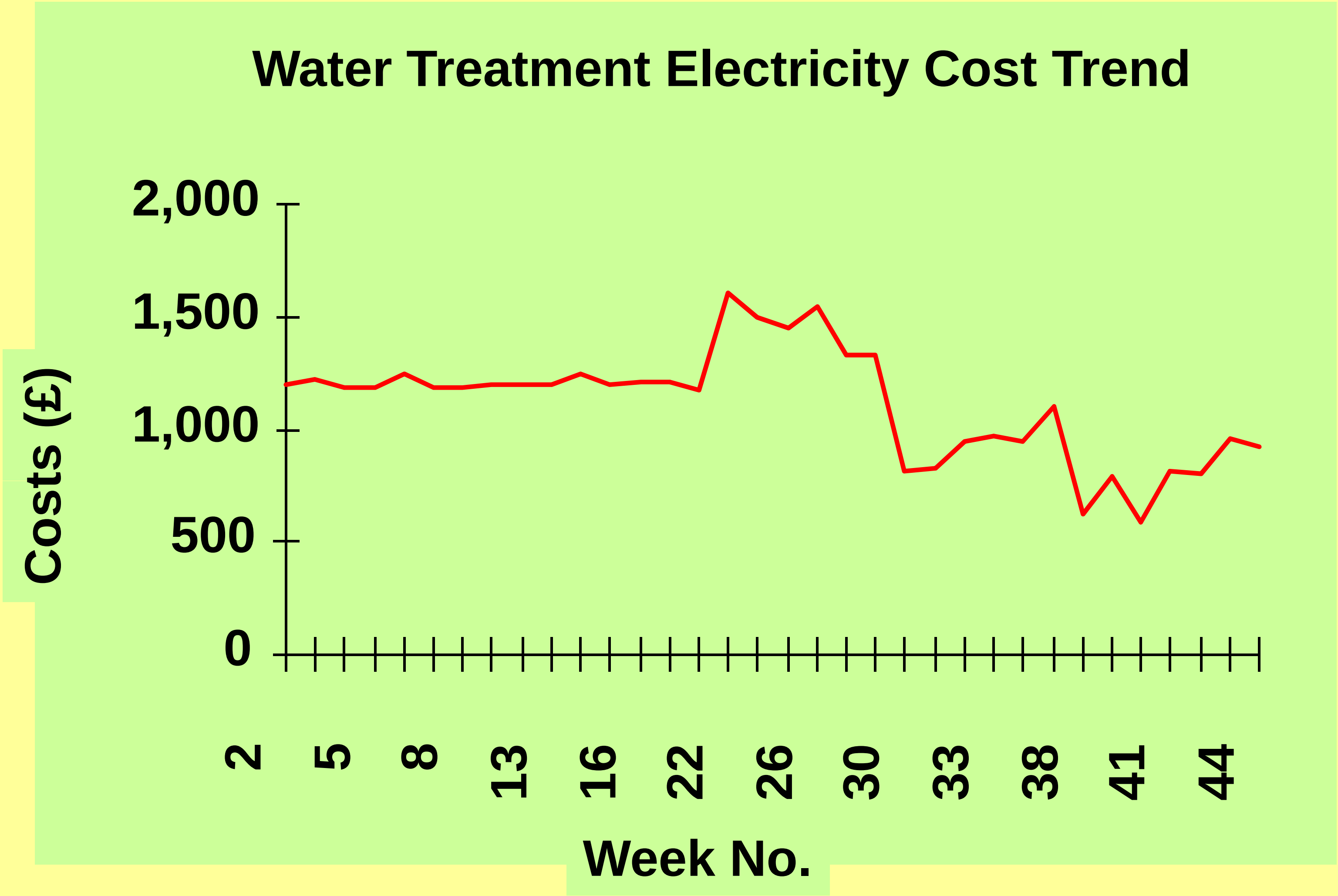
- **Irish Fertilizers Industries, Arklow**
- **Sector: Fertiliser**
- **Utility: Electricity, Water and Steam**
- **Measure: Various**
- **Key: Trend Analysis**
- **Total Savings: £ 110,000 per year**
- **Investment: Low**

Case Study V - M&T Fertiliser Plant



Savings: £ 18,000 per year

Case Study V - M&T Fertiliser Plant



Savings: £ 31,000 per year

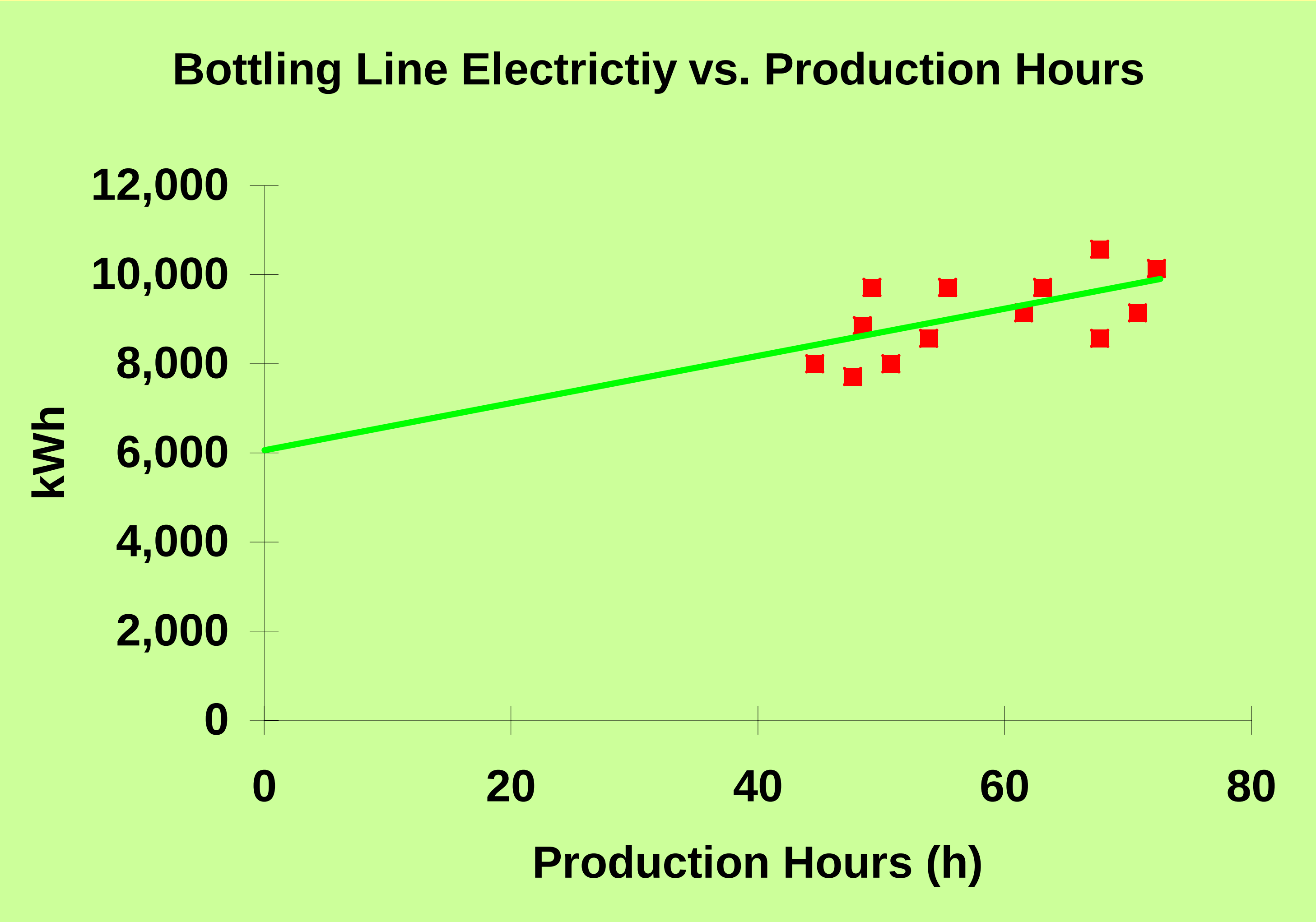
Case Study V Range of Savings

Area of Savings	Savings per year (£)
• Lighting	9,800
• Process Air Compression	18,000
• Instrument Air Compression	7,000
• Water Treatment Pumps	31,000
• Cooling Water	22,000
• Acid Pumps	2,000
• Boilers	26,000
Total	**115,800**

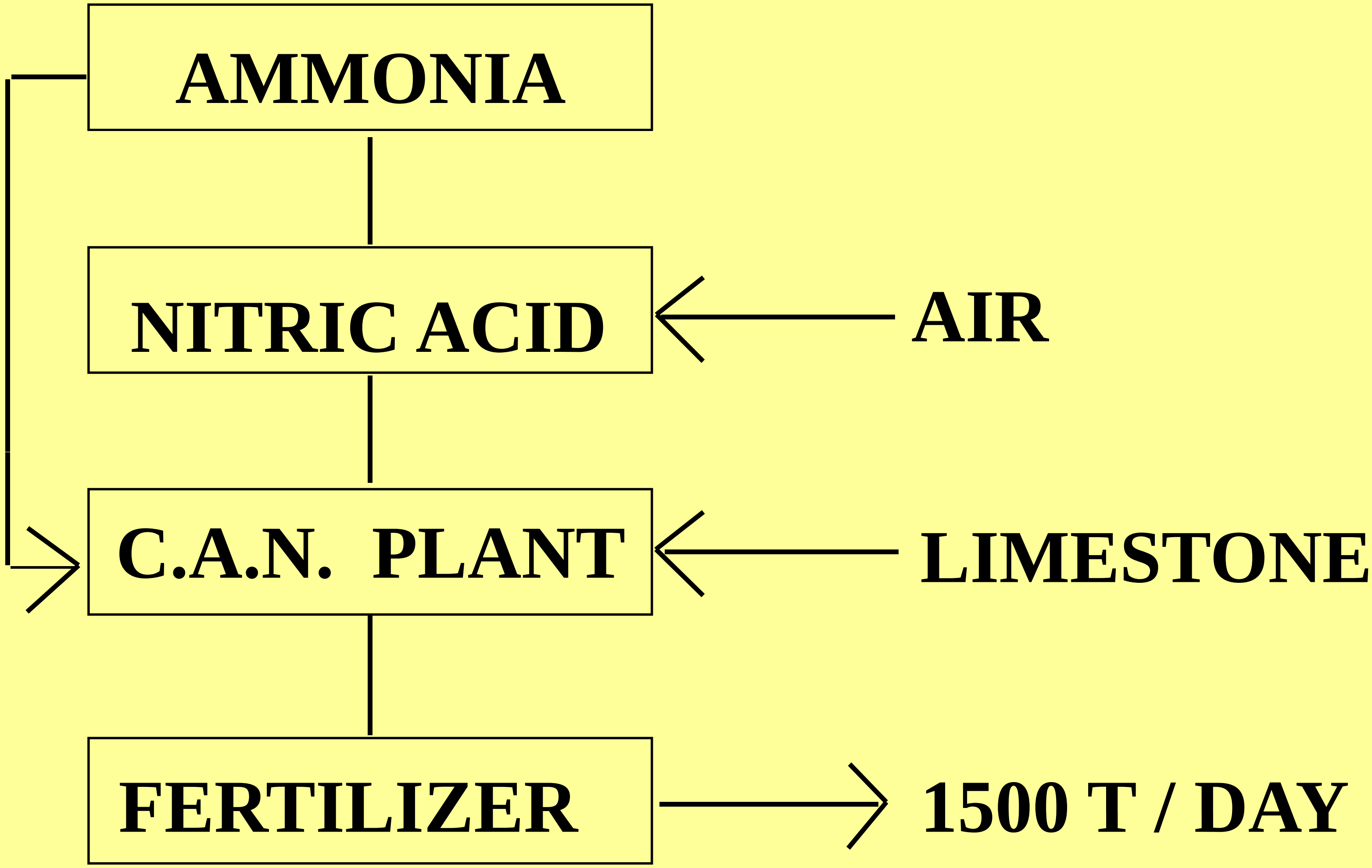
Case Study VI Excessive Air Extraction

- Company: Express Dairy
  Sector: Food
- Utility: Electricity
- Measure: Time Switch on Ventilation Plant
- Key: Adapt Supply to Demand
- Savings: £ 8,000 per year
- Investment: Low

Case Study VI Regression Graph



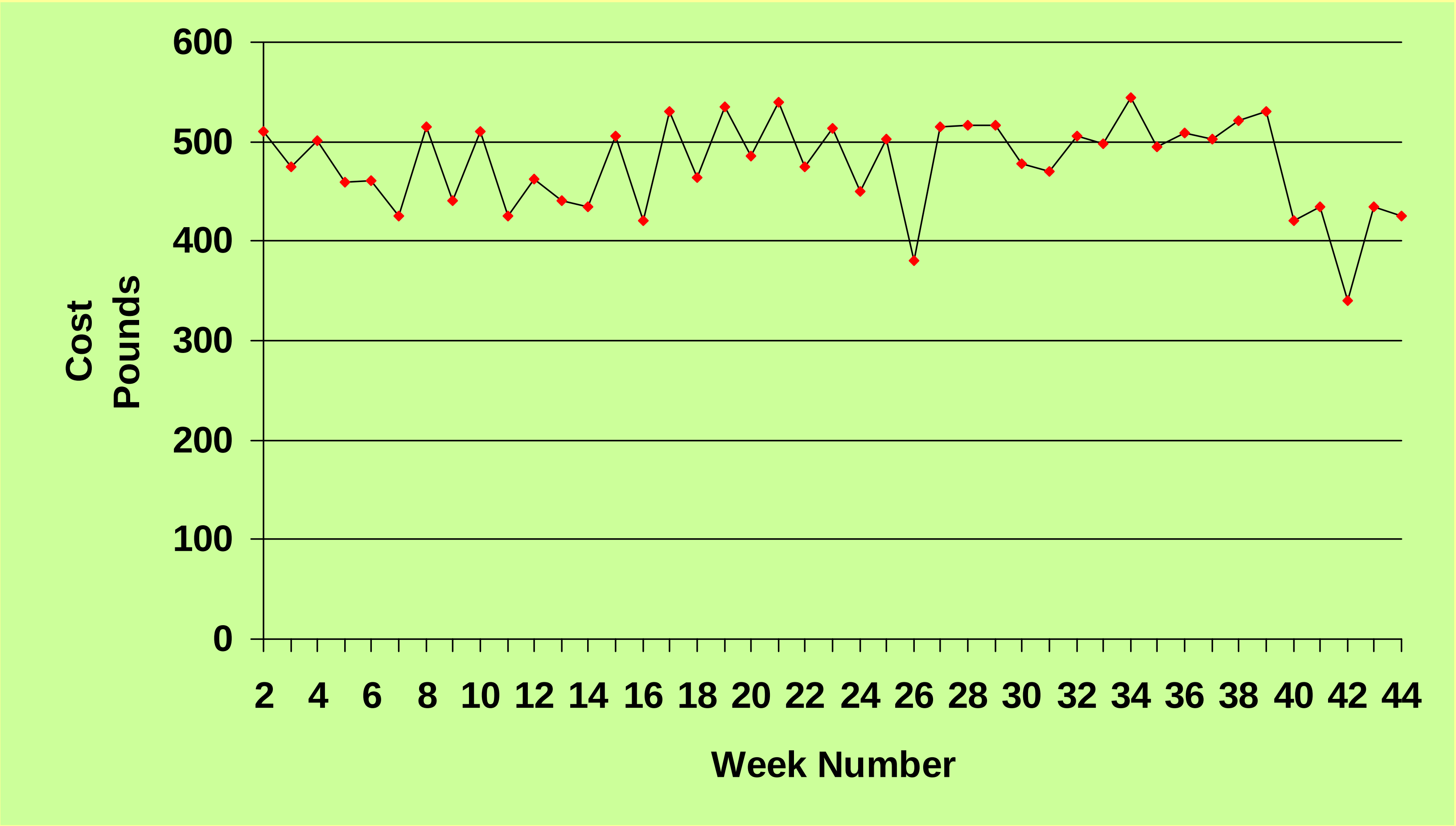
Case Study VII IFI Ireland



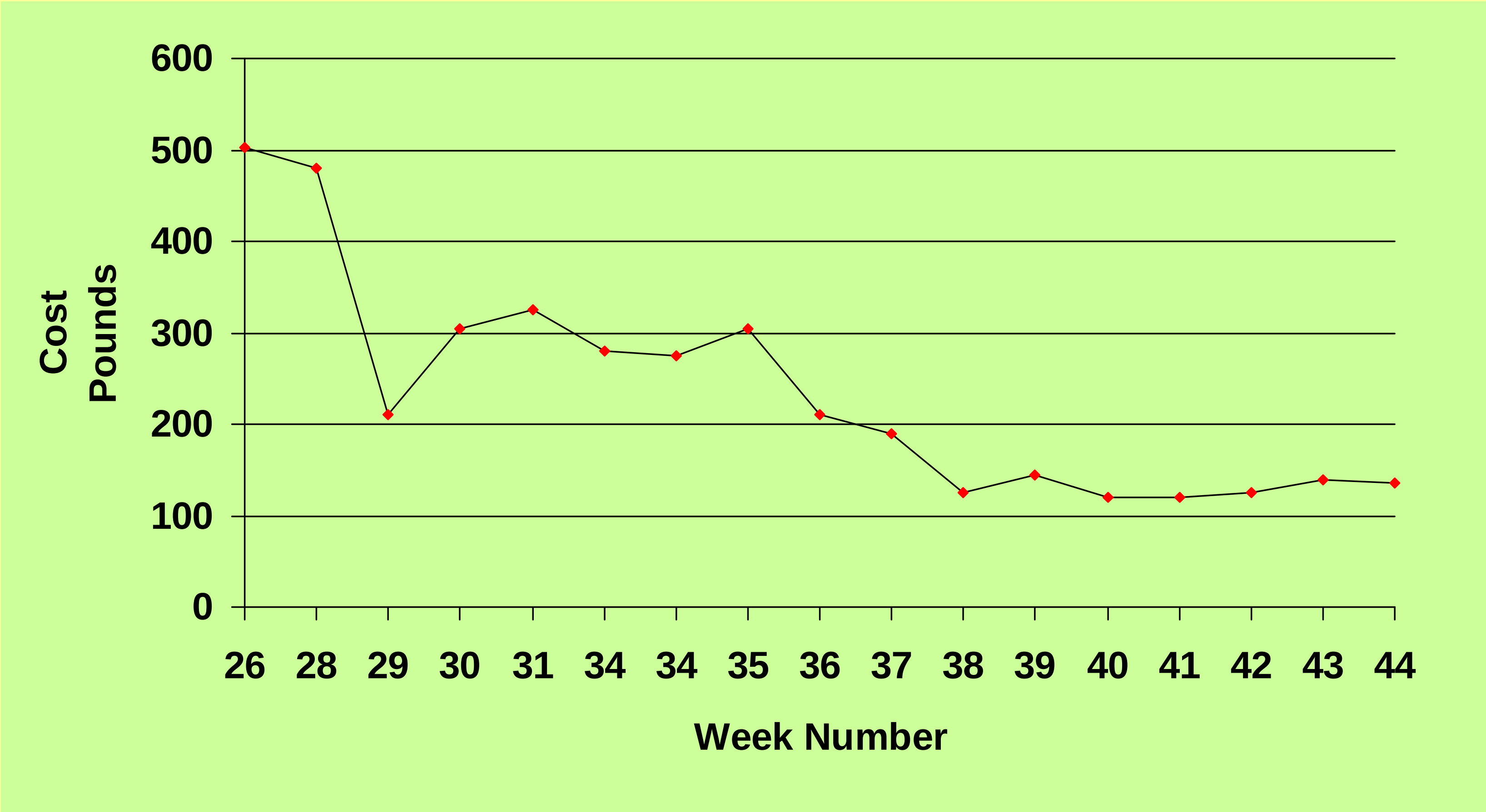
Case Study VII - Projects Implemented

- **INSTRUMENT AIR**
- **PROCESS AIR**
- **WATER TREATMENT PUMPS**
- **ACID PUMPS**
- **GENERAL LIGHTING**
- **BOILERS**
- **COOLING WATER PUMPS**

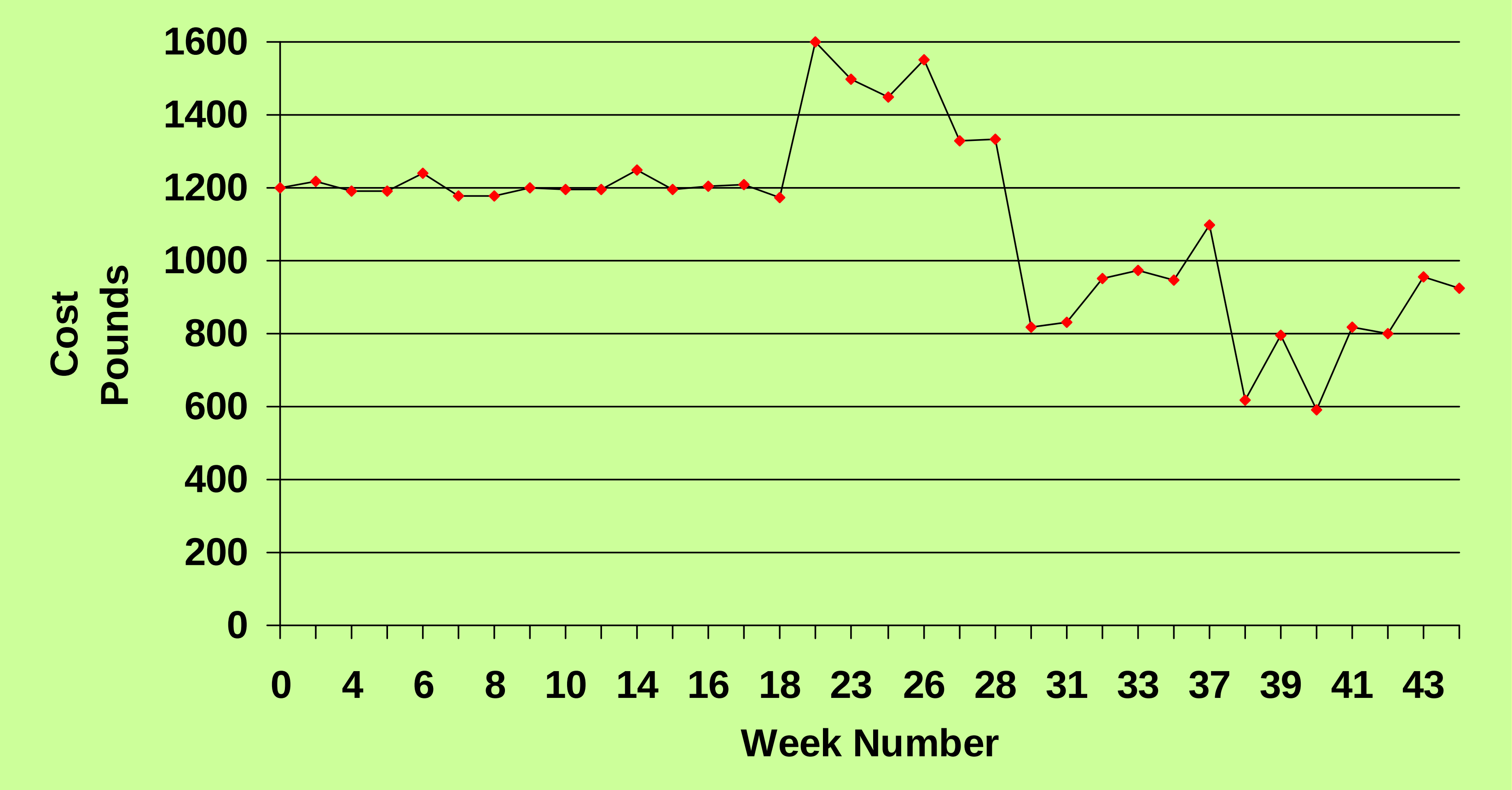
Case Study VII - INSTRUMENT AIR
Cost Vs Week number



Case Study VII - PROCESS AIR
Cost Vs Week Number

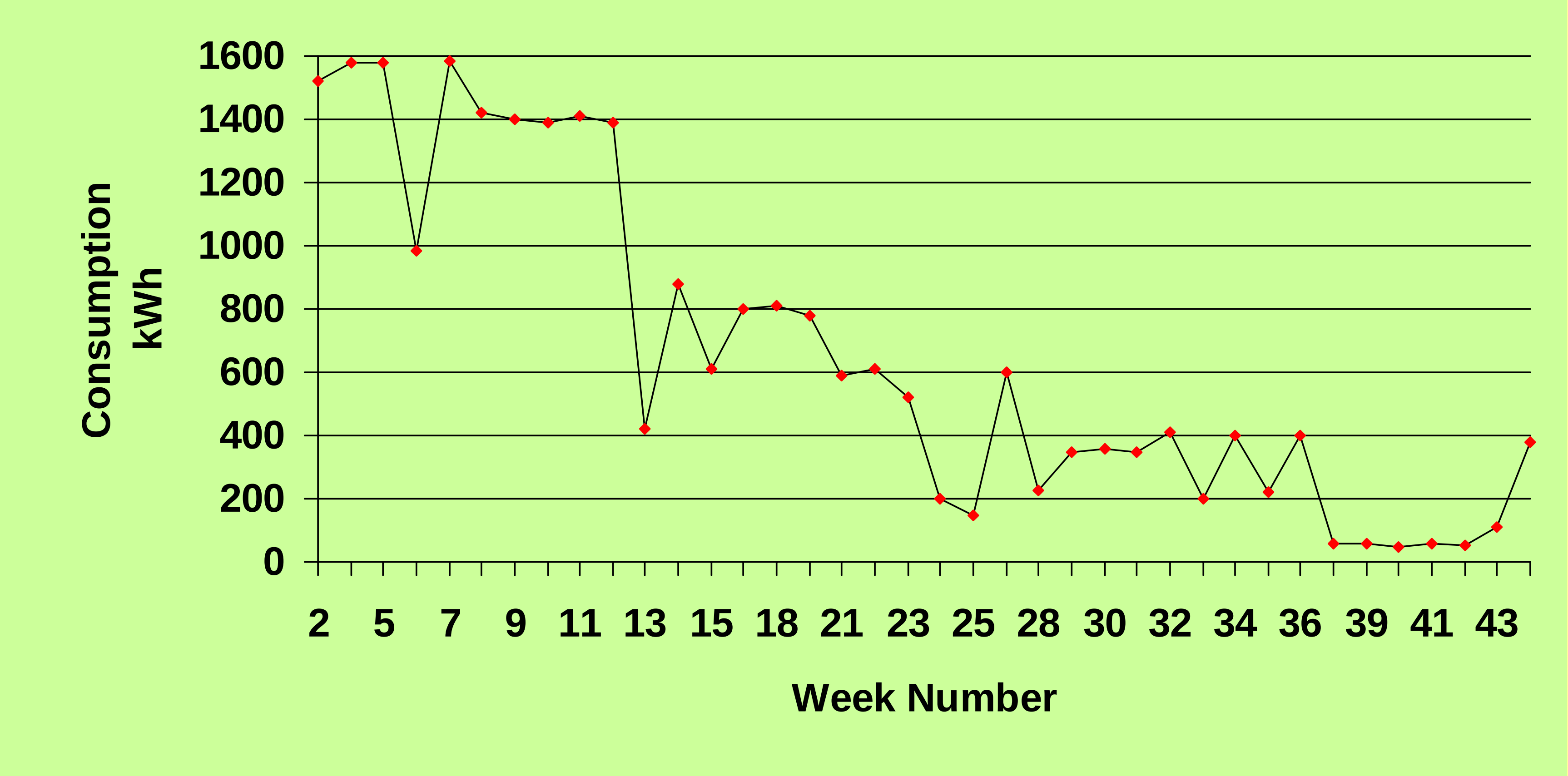


Case Study VII WATER TREATMENT
Cost Vs Week Number



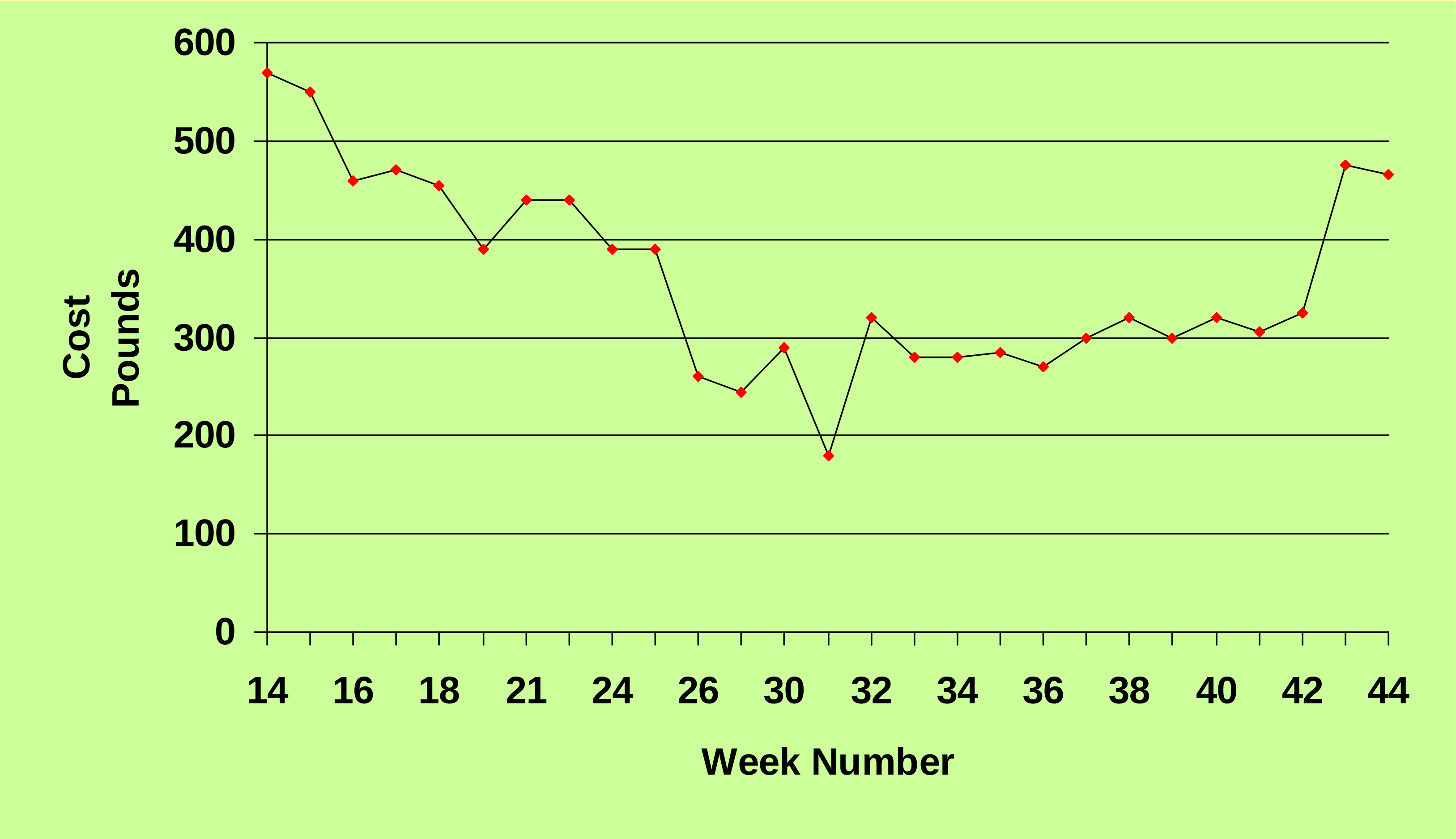
Case Study VII - ACID PUMPS

Meter Consumption Vs Week Number

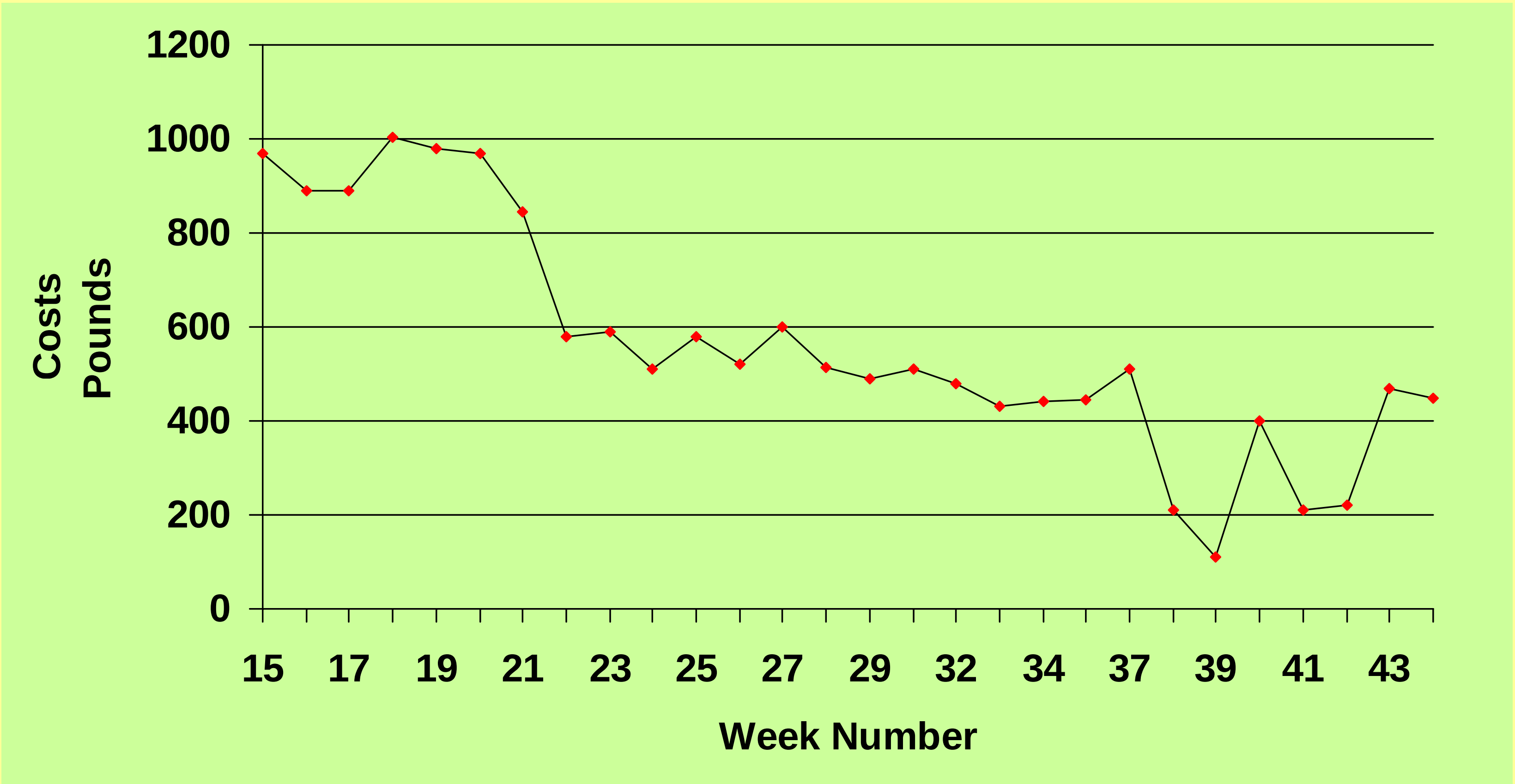


Case Study VII - GENERAL LIGHTING

Cost VS Week Number

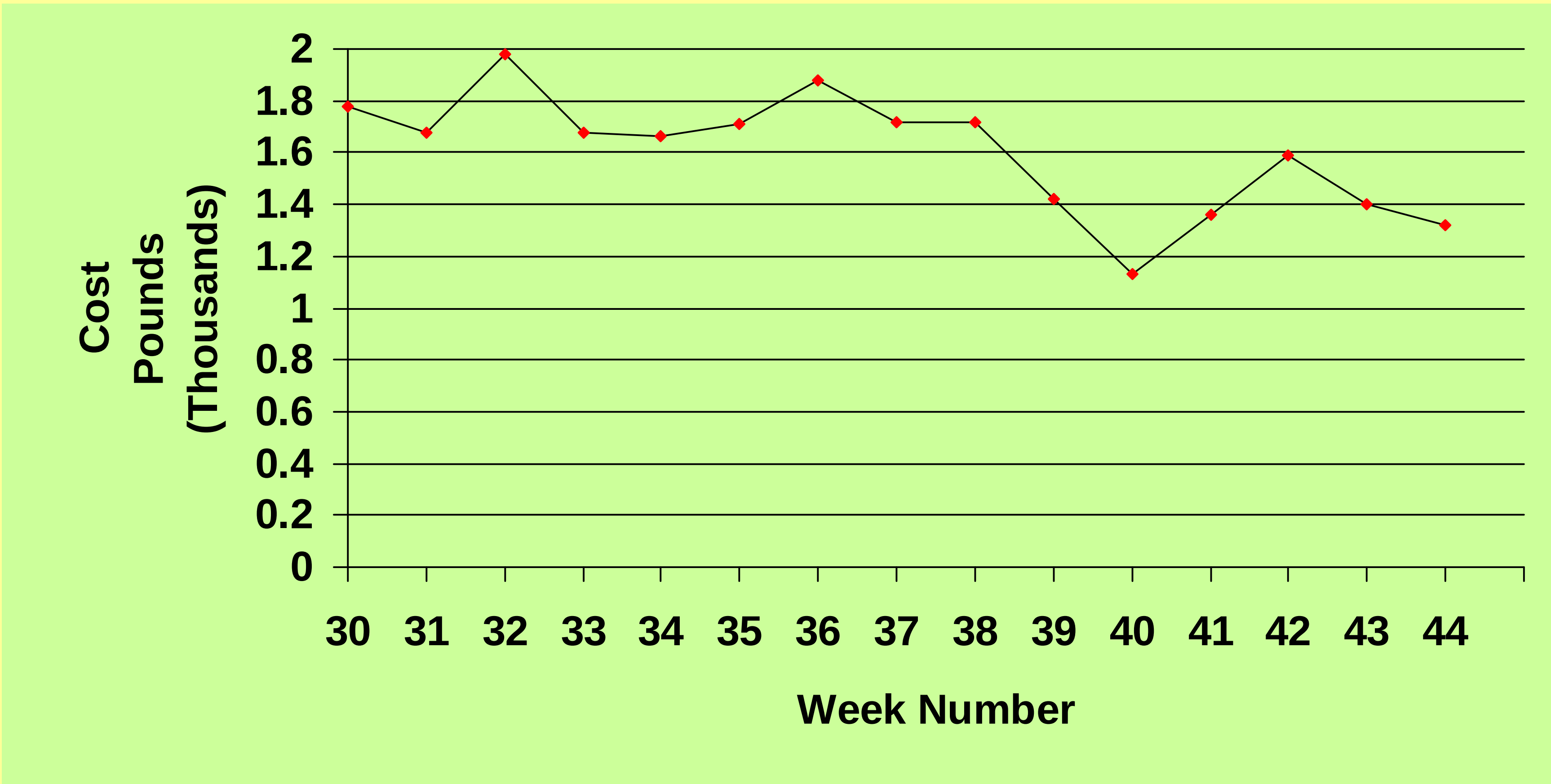


Case Study VII - <u>TOTAL BOILERS</u>
Cost Vs Week Number



Case Study VII - COOLING WATER

Electricity Cost Vs Week Number



RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 6:

Reference(s): none provided

For each proposed program please indicate whether higher participation rates could be cost-effectively achieved and if so how. Where higher rates are cost-effective and achievable please discuss THESL's rationale for not pursuing such savings.

RESPONSE:

In designing these programs, THESL has aimed for maximum market penetration for each application. Notwithstanding, THESL's projected participation rates are conservative and based on its experience and using best available information obtained from existing research in other similar jurisdictions. While higher participation rates are possible, and would be welcome, the current levels are believed to be realistic.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 7:

Reference(s): none provided

Please provide the ratio of incentive costs to total program costs for each program.

RESPONSE:

Please refer to the table below for the ratio of incentive costs to total program costs for each Board-Approved program other than education programs.

Program	Ratio
Multi-Unit Residential Demand Response	86%
Flat Rate Water Heater Conversion & Demand Response	84%
Commercial , Institutional & Small Commercial Monitoring & Targeting	68%
Hydronic System Balancing Program	74%
Commercial Energay Management & Load Control	82%

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 8:

Reference(s): none provided

Please provide a description of the process THESL undertook to:

a) determine cost-effective and achievable CDM potential in the franchise area for CDM that is non-duplicative with the OPA programs

b) to prioritize and select the proposed programs

RESPONSE:

a) THESL completed an analysis of the energy use and demand within each sector and estimated the impact of the OPA Province Wide programs. Important sectors that contribute to the summer peak demand were then examined for potential additional programs that could impact the load. The potential programs were then filtered to remove those that were duplicative of OPA programs, could be added to OPA prescriptive measures or that were not achievable within the 2011-2014 time frame. Each of these programs were then examined to determine whether a program would be cost effective by developing program costs and assessing the market for potential savings.

b) Programs were not prioritized. The applications represent the programs that could be developed within the time frame of the application. Additional programs could follow as needed to meet the prescribed targets.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 9:

Reference(s): **none provided**

Please provide any studies that THESL relied upon to determine cost-effective and achievable potential for CDM in the THESL franchise area.

RESPONSE:

The analysis was conducted internally using the knowledge and experience of staff in the conservation and demand management field. The key reports that were referred to during the course of the evaluation are listed below and attached as Appendices A-I.

Reference
Altech Environmental Consulting & Marbek Resource Consultants. Conservation Bureau (Ontario Power Authority), (Sept. 2006). *Market profile and conservation opportunity assessment for small and medium-sized industry in Ontario*
World Business Council for Sustainable Development (Aug. 2009). *Energy efficiency in buildings transforming the market*. Switzerland
DeCanio, Stephen J. Department of Economics, University of California. (1993). *Barriers within firms to energy-efficient investments.* Butterworth-Heinemann Ltd.
Gregerson, Joan. (Mar. 1997). Tech Update. *E-source - commissioning existing buildings*. Vol 97 (Issue 3)
Energy @ Work. Ontario Power Authority, (Oct. 2007). *Energy efficiency barriers in Ontario - Listening to the 'interval meter customer' view*

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

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SAVE (Specific Actions for Vigorous Energy Efficiency), (1998). *Good Practice Guide 112 - Monitoring and Targeting in Large Companies*. Oxfordshire, UK: Energy Efficiency Enquiries Bureau.
Marbek Resource Consultants Ltd., . Toronto Hydro Energy Services, (May 27, 2008). *Market profile and opportunity assessment of the commercial and institutional sectors in the greater toronto area*. Ottawa, ON
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Seiden, Ken (Quantec, LLC). Seattle City Light, (Oct. 13, 2006). *Conservation Potential Assessment*
Marbek Resource Consultants Ltd. & M.K. Jaccard and Associated, Inc. Canadian Gas Association, (May 2006). *Demand Side Management Potential in Canada: Energy Efficiency Study*
Friedrich, Katherine, Amann, Jennifer, Vaidyanathan, Shritu, & Elliott, R. Neal. American Council for an Energy-Efficient Economy, (Oct. 2010). *Visible and Concrete Savings: Case Studies of Effective Behavioral Approaches to Improving Customer Energy Efficiency* (Report Number E108). Washington, DC
Hooke, James H., Landry, Bryon J., & Hart, David. CIPEC (Canadian Industry Program for Energy Conservation), (2004). *Energy management information systems: Achieving improved energy efficiency: a handbook for managers, engineers and operational staff*
Anderson, Soren T., & Newell, Richar G. (2004). Information programs for technology adoption: the case of energy-efficiency audits. *Resource and Energy Economics*, Vol. *26*, Pgs. 27-50.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

Reference
Rocky Mountain Institute & CoreNet Global. (Aug. 1, 2006). *Energy Efficiency Research in Corporate Real Estate*

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 6
Schedule 9
Appendix A
Filed: 2011 Apr 1
(24 pages)

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Resource and Energy Economics 26 (2004) 27–50

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Information programs for technology adoption: the case of energy-efficiency audits

Soren T. Anderson[a], Richard G. Newell[b,*]

[a] *University of Michigan, Ann Arbor, MI, USA*
[b] *Resources for the Future, 1616 P St. NW, Washington, DC 20036, USA*

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Abstract

We analyze technology adoption decisions of manufacturing plants in response to government-sponsored energy audits. Overall, plants adopt about half of the recommended energy-efficiency projects. Using fixed effects logit estimation, we find that adoption rates are higher for projects with shorter paybacks, lower costs, greater annual savings, higher energy prices, and greater energy conservation. Plants are 40% more responsive to initial costs than annual savings, suggesting that subsidies may be more effective at promoting energy-efficient technologies than energy price increases. Adoption decisions imply hurdle rates of 50–100%, which is consistent with the investment criteria small and medium-size firms state they use.

JEL classification: Q41; Q48; O33; O38; C25

Keywords: Energy efficiency; Information; Technology adoption; Energy audits

1. Introduction

Interest in energy-efficiency improvements has been reinvigorated by concerns ranging from the environmental effects of fossil fuel combustion—such as climate change due to carbon emissions or environmental damage caused by other pollutants (e.g., SO_x and NO_x)—to energy price volatility and national security. The US National Energy Policy, for example, recommends establishing “a national priority for improving energy efficiency” (White House, 2001), which supports the Bush Administration’s climate policy goal of decreasing the “greenhouse gas intensity” of the economy. As policies that would entail

* Corresponding author. Tel.: +1-202-328-5111; fax: +1-202-939-3460.
E-mail address: newell@rff.org (R.G. Newell).

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significant energy price increases are unlikely to be politically attractive in the near term, the focus has been on the development and diffusion of technology through other means. Thus, policy proposals have tended to emphasize programs that foster research, development, and deployment of technologies, government–industry partnerships, tax credits and other financial incentives, minimum appliance efficiency standards, voluntary agreements, and information programs.

Information programs, which seek to encourage energy efficiency by increasing awareness of conservation opportunities and offering technical assistance with their implementation, are an important element of this energy-efficiency policy portfolio. These programs take a variety of forms, including educational workshops and training programs for professionals, advertising, product labeling, and energy audits of manufacturing plants. In addition to alerting firms to profitable conservation opportunities, access to more accurate performance information can reduce the uncertainty and risk associated with adopting technologies that are new, or that receive differing reviews from equipment vendors, utilities, or consultants. The economic rationale for these programs lies primarily in public good aspects of knowledge and information provision. Although these public information programs are not free, the cumulative benefit of educating many users with similar information can greatly exceed the costs. Such information, however, tends to be under-provided by the private sector. Concerns about environmental externalities associated with energy production and use provide additional justification for these programs.

Despite the role that information programs play in existing and proposed energy-efficiency policy portfolios, surprisingly little is known about how participants respond to such programs. Although a reasonably large literature surveys various market barriers and market failures in energy-efficiency investment,[1] few analyses have focused specifically on information programs. This is in part due to a lack of adequate data for analysis. One exception is Morgenstern and Al-Jurf (1999), who analyze data from the Department of Energy's 1992 Commercial Buildings Energy Consumption Survey. They find that information provided through demand-side-management utility programs appears to make a significant contribution to the diffusion of high-efficiency lighting in commercial buildings. Although not the focus of their examination of energy-saving product innovation, Newell et al. (1999) find that the responsiveness of energy-efficient innovation in home appliances to energy price changes increased substantially during the period after energy-efficiency product labeling was required. DeCanio and Watkins (1998) investigate voluntary participation in the US Environmental Protection Agency's Green Lights Program, which offers companies technical expertise while committing them to a set of energy-efficient lighting improvements. They find that the characteristics of individual firms influence their decision to participate in the program.

We focus here on actions taken by manufacturing plants in response to energy audits offered through the US Department of Energy's Industrial Assessment Centers (IAC) program, which has been providing energy assessments at no financial cost to small and medium-sized manufacturers since 1976. This program is of interest for several reasons. First, significant opportunities to conserve energy may exist in the industrial sector, which represents 37% of total national energy consumption. Second, the opportunity to focus on the behavior of

[1] See, for example, Ruderman et al. (1987), Sutherland (1991), Jaffe and Stavins (1994), and Metcalf (1994).

small and medium-sized firms is rare due to data constraints, even though these firms represent over 98% of all manufacturing firms and more than 42% of total manufacturing energy consumption. This focus is particularly appropriate given that smaller firms are more likely to benefit from access to information and expertise, which tend to be more readily available to larger firms. Finally, the IAC program has generated an unusually extensive set of data on the characteristics of conservation opportunities identified and actions taken under the program (US Department of Energy, 2001). One attractive aspect of these data is that there are multiple observations available for each firm, allowing us to employ a fixed effects model to control for unobserved differences in firms' propensities to adopt technology.

Because of their detail, these data provide a unique opportunity to quantify the factors that encourage small and medium-sized industrial firms to invest in energy-conserving technologies. After summarizing the general character of projects adopted under the IAC program, we explore the influence of technology costs, expected energy savings, and individual firm characteristics on the likelihood of adopting projects. We employ models of varying flexibility to examine and compare the degree of response to differences in capital costs and operating cost savings, as well as the energy price and quantity differences that underlie savings. The results strengthen our understanding of how certain factors influence technology adoption decisions, and whether this behavior is consistent with economic expectations. In addition, the results offer evidence on the likely relative effectiveness of policies aimed at increasing energy efficiency, such as energy or carbon price increases, technology subsidies, and policies that directly alter the energy use of technologies.

Another important aspect of this type of investment decision-making is the "payback cutoff," "hurdle rate," or other discounting factor that firms employ when measuring current costs against future benefits. There is a substantial literature that suggests that "implicit discount rates," which one can calculate based on the capital cost versus operating cost savings of various implemented and unimplemented projects, can in practice be quite high relative to market interest rates (Hausman, 1979; Train, 1985). A related literature further contends that these high implicit discount rates are attributable to various market barriers and market failures—including information problems—and that these problems can be ameliorated by appropriate policies (Ruderman et al., 1987; Jaffe and Stavins, 1994).

Accordingly, several analyses of carbon mitigation costs have modeled the effect of information programs and other policies by significantly lowering the discount rate used for energy-conservation decisions. The clean energy futures study (Brown et al., 2001; Interlaboratory Working Group, 2000), for example, lowered investment hurdle rates to 15% in the industrial sector (and 7% in the residential sector) to capture the effect of information programs and other energy-conservation policies. Such lowering of hurdle rates has the intended effect of decreasing estimated energy use in the model, but modeling the effect of information programs in this way also leads to a number of side effects. Lower hurdle rates also increase the rate at which energy use declines in response to energy price increases resulting, for example, from a carbon permit system or carbon tax. This implies a reduction in the cost of carbon mitigation efforts through carbon price policies.

By expanding the perceived range of investment opportunities available to firms, information programs may indeed lead to the adoption of profitable but previously unimplemented technologies, associated energy use reduction, and lower observed *implied* hurdle rates. But this does not imply an across-the-board reduction in the *actual* investment hurdle rate, which is unobserved and could remain at pre-policy levels. In other words, it is entirely possible that managers continue to apply hurdle rates well above market interest rates to the new set of possibilities brought forth by an information program. On the other hand, it is possible that information programs actually do significantly alter the way in which firms trade off the current costs and future benefits of all energy-conservation opportunities, for example, by educating managers to focus more on the operating cost savings of projects.

We explore these issues by examining the rates of return for potential projects faced by firms that participated in the IAC program to determine whether the level of implicit discounting used by plants that received information assistance may have decreased to levels that some studies suggest. Finally, we analyze the reasons given by firms for not adopting recommended projects in order to determine whether this decision is due to the economic undesirability of the projects, or to some remaining type of market barrier or failure.

We find that about half of the projects recommended by energy assessment teams are actually adopted by the plants receiving these recommendations, although we cannot say how many of these projects might have been adopted in the absence of the energy audit. We find that that firms respond as expected to marginal changes in the financial characteristics of projects (i.e., technology costs, energy prices, the quantity of energy saved, energy operating cost savings, and the payback period). Firms are about 40% more responsive to investment costs than to energy savings, suggesting that policies to reduce implementation costs may be somewhat more effective than various mechanisms that raise energy prices. Although the financial characteristics of projects are clearly important, there also appear to be other, unmeasured project-specific factors (e.g., individual project lifetimes, unmeasured costs and benefits, uncertainty regarding costs and benefits, or project complexity and risks) that influence the investment decision. In contrast to previous studies, we find that plant size has no measurable effect on the adoption decision among the small and medium-sized firms in our sample.

We estimate that the investment threshold typically used by the plants in evaluating which energy audit recommendations to adopt was about a one to 2-year payback, which corresponds to an implicit hurdle rate of 50–100% for projects lasting 10 years or more. Although we are unable to determine whether participation in the IAC program actually lowered investment hurdle rates, these payback thresholds are consistent with what many surveys of plant managers suggest that they deliberately use for many types of investments, including those for energy conservation. In any event, these hurdle rates are many times higher than those assumed in many analyses of the effects of various climate policies.

Finally, the reasons given by program participants for not adopting certain project recommendations suggest that most of these disregarded projects may have been economically undesirable. Many of these reasons hint at various unmeasured costs, project risks, and uncertainty that are unlikely to be reflected in estimated implementation costs and projected annual savings. On the other hand, many projects were likely rejected because of institutional or bureaucratic barriers within firms, and most of the reasons are sufficiently vague that we cannot rule them out as indicative of institutional or bureaucratic barriers.

Overall, one can view the glass as either half full or half empty. Although the results suggest that the IAC program has led to the adoption of many financially attractive energy-conservation projects, plants found about half of the projects recommended by assessment teams to be unattractive. This suggests that other, more costly policies targeted at increasing the financial attractiveness of these projects (e.g., energy/carbon taxes, or tax breaks/subsidies for implementation) may be needed to further promote energy efficiency in these sectors. Furthermore, it would seem that policies that could lengthen the short paybacks that firms routinely demand from all types of projects (not just those for energy efficiency) would have implications that extend well beyond the realm of energy and climate policy.

2. Data

2.1. The IAC program and database

The Industrial Assessment Centers program has been providing free industrial assessments to small and medium-sized manufacturers since 1976. The program operates as an extension service through 26 participating universities, whereby teams of engineering students and faculty help manufacturers identify opportunities to conserve energy, reduce waste, and improve productivity (US Department of Energy, 2002). In addition to these direct benefits, the program also generates indirect benefits by educating participating firms and university students (who may become future employees) to the presence of potential future investment opportunities (Tonn and Martin, 2000). Approximately 500 manufacturers and 150 university students participate each year. Out of the program's current federal outlay of about US$ 7 million per year, each school receives about US$ 180,000 annually, or about US$ 7000 per assessment.

Since 1981, a record of each assessment has been stored in the IAC database.[2] With entries for over 10,000 assessments (recommending over 70,000 individual projects), the database covers virtually every US geographic region and manufacturing industry. Nearly half of these assessments have been conducted in the foods, rubber and plastics, fabricated metals, and commercial machinery industries.

Assessments provided by the IAC program typically follow a standard protocol. Manufacturers that express interest in the program must first meet several eligibility requirements.[3] IAC teams then perform a preliminary assessment (e.g., by reviewing the plant's energy bills) followed by a visit to the plant site, which includes an interview with management, a thorough tour of the plant, and time to gather technical data (e.g., measure lighting levels or check for air leaks). Following the site visit, IAC teams provide plant management with an assessment report that highlights specific opportunities to increase energy efficiency, reduce waste, and improve productivity. Finally, after an appropriate interval (usually 6–9 months), IAC teams contact plant management by phone to determine which projects were

[2] The database is compiled and maintained by the Center for Advanced Energy Studies at Rutgers University, http://caes.rutgers.edu.

[3] Plants must have a standard industrial classification (SIC) code of 20–30 (i.e., manufacturing) and be within 150 miles of an IAC host campus. In addition, plants must have gross annual sales of less than US$ 100 million, fewer than 500 employees at the plant site, annual energy bills between US$ 100,000 and 2 million, and no professional in-house staff to perform the assessment.

actually implemented—or will definitely be implemented within 12 months of the call.[4] For projects that were not adopted, IAC teams try to determine the reason or reasons why (US Department of Energy, 2000, 2002).

The information garnered during the assessment process provides the substance of the IAC database. The database contains information for each recommended project, including the project type, estimated implementation cost, quantity of energy conserved, annual operating cost savings, and confirmation of whether or not the recommended project was implemented. The database also contains other useful information, including the date of the assessment and plant-specific variables such as manufacturing sector (SIC code), annual sales, annual energy costs, and number of employees. Finally, the database contains information indicating why many projects were not implemented (US Department of Energy, 2000, 2002). A rare aspect of these data is that they include multiple project investment decisions for each plant, allowing us to control for plant-level fixed effects that may affect the adoption decision.

2.2. *Data procedures*

Our data come from the IAC database for the years 1981–2000.[5] We focus exclusively on energy management projects, which are present in 97% of all assessments and represent 83% of all recommended projects during this period.[6] We adjust all monetary figures for inflation, scaling to year 2000 US dollars using the producer price index (finished goods, series WPUSOP3000) from the US Bureau of Labor Statistics (2001). We omit approximately 35% of energy-related projects for various reasons, as explained below, resulting in a sample of 39,920 projects from assessments at 9034 plants. Our results are robust to the inclusion or exclusion of these observations.

In our econometric estimation of the project adoption decision, we employ a discrete dependent variable indicating whether or not a plant adopted a recommended project.[7] Each project is classified by a four-digit assessment recommendation code (ARC), and we include dummy variables for eight two-digit ARC classifications: combustion systems, thermal systems, electrical power, motor systems, industrial design, operations, buildings and grounds, and ancillary costs.[8] These variables are intended to capture heterogeneity across different types of projects (e.g., project lifetimes).

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[4] Implementation must occur within 24 months of the assessment date for projects to be considered implemented. This interval accounts for the fact that some projects are not implemented immediately due to annual capital investment cycles.

[5] Although the database covered 1981–2001, the data were incomplete for many assessments conducted during 2001, presumably because many plants had not yet received their callback interviews at the time the data were downloaded.

[6] The sample includes 9827 assessments and 59,961 recommended energy management projects before cleaning.

[7] The IAC database codes most projects as I (implemented), N (not implemented), P (pending), or K (data excluded or unavailable); some projects are missing this code. Our dependent variable equals 1 for projects coded as I, and 0 for projects coded as N. We omit projects with P, K, or missing implementation codes.

[8] There are a total of nine two-digit ARC classifications for energy management. We omit three observations classified as "alternative energy usage" due to a lack of degrees of freedom for the corresponding dummy variable.

In addition to implementation codes and project type classifications, IAC data contain information regarding the estimated implementation cost and annual operating cost savings of each project. Using these figures, we generate the simple payback for each project, which is defined as cost divided by annual savings. This figure can be interpreted as the number of years before the cost of a project is recovered through annual savings. We focus only on projects with paybacks between 0.025 and 9 years, because careful inspection of the data revealed that data outside this range were of dubious quality.[9]

The data for most projects also include information regarding the estimated quantity of energy that would be conserved annually (e.g., kWh or Btu). We compute the average energy price associated with each project by dividing annual savings by the corresponding quantity of energy conserved.[10,11] In order to make these prices comparable, in percentage terms, across different energy types (e.g., electricity versus natural gas), we normalize the prices within each energy type to have a mean of one. That is, for example, we divide each natural gas price by the mean natural gas price in our sample, and we divide each electricity price by the mean electricity price. We call these new prices our *energy price index*. Finally, we divide annual savings by our new energy price index to generate quantity figures that are also comparable in percentage terms across different energy types.[12] We call these new quantities our *energy saved quantity index*. To ease interpretation of parameter estimates, continuous variables are normalized so their means equal unity, or zero after taking natural logarithms.

2.3. Descriptive statistics

As shown in Table 1, the 9034 manufacturing plants in our sample average about US$ 30 million in annual sales. The 38,920 energy management projects recommended to these plants have an average estimated implementation cost of US$ 7400 and estimated savings of US$ 5600 per year. The average estimated payback period for these projects is only 1.29 years. In spite of these seemingly quick payback periods, however, firms adopted just 53% of these projects. We explore the reasons in depth below. The IAC audit teams estimate that over the 20-year period 1981–2000 the adopted projects in our sample represented about US$ 103 million in energy-conservation investment, resulting in aggregate per year savings

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[9] Overall, we observe that adoption rates fall from approximately 65 to 40% as payback increases from 0.025 years to 9 years. Adoption rates for projects outside this range do not follow the same pattern, however. In fact, adoption rates for these projects regress toward the mean for all projects, suggesting that the information supposedly conferred by these payback values is of negligible value.

[10] We focus only on projects whose prices and quantities have a clear and interpretable meaning (e.g., "other gas" or "other energy" would not qualify). In some cases, net savings are associated with more than one energy type (e.g., switching from electric to natural gas heating), making it impossible to identify individual energy prices and quantities. Thus, we focus only on projects with positive annual savings for a single energy type. After generating prices, we drop projects whose prices are clear outliers. The average annual energy prices derived from the data are consistent with historical energy prices.

[11] Electricity-related dollar savings is often the result of reductions in electricity usage (i.e., kWh $\times$ \$/kWh) plus reductions in demand charges (i.e., max kW $\times$ \$/kW). We treat all electricity-related dollar savings as having come directly from reductions in usage.

[12] Equivalently, the quantity index can be calculated by weighting the original quantities within each energy type by the mean price for that energy type.

Table 1
Descriptive statistics

Variable	Mean	S.D.	Minimum	Maximum
Adopted	0.53	0.50	0.00	1.00
Payback (years)	1.29	1.29	0.03	9.00
Implementation cost (US$)	7400	82714	3.47	10100000
Annual savings (US$)	5574	27881	8.45	2661508
Energy price index	1.00	0.38	0.12	4.56
Energy saved quantity index	6091	42853	6.96	4650939
Annual sales (US$)	29156398	37715612	41503	684192832
Employees	170	147	1	4000
Floor area (square feet)	253887	3208579	300	150000000
Annual energy costs (US$)	486969	702126	2502	11951324

Statistics are based on the sample of 38,920 observations for energy-related project recommendations, representing 9034 plant assessments. Monetary figures are in 2000 US dollars.

of about US$ 100 million, as shown in Table 2. This represents an estimated aggregate payback period of about 1 year for adopted projects. By contrast, projects that were not adopted would have cost an estimated US$ 186 million for an aggregate estimated per year savings of only US$ 117 million. These numbers imply that firms tend to adopt the most profitable projects, an issue we explore in our econometric analysis below. Overall, adoption of projects recommended by the IAC program led to an estimated 20 trillion Btu of aggregate per year energy conservation, or about 45% of total recommended energy conservation.[13]

Breaking these numbers down by project type, Table 2 shows that 90% of the projects in our sample affect *building and grounds* (e.g., lighting), *motor systems*, and *thermal systems*, while a smaller but significant number of projects affect *combustion systems* and *operations*, and just a handful of projects affect *electrical power*, *industrial design*, and *ancillary costs*. We also see significant variation in terms of cost, annual savings, payback, and adoption rates. *Thermal systems*, *electrical power*, and *industrial design* projects have high costs and low adoption rates. *Building and grounds* and *ancillary costs* projects have average costs, close to average annual savings, and longer than average payback periods; firms adopt these projects about 50% of the time. *Combustion systems* and *motor systems* projects have lower than average costs, average or less than average paybacks, and relatively high adoption rates. Overall, it appears that project types with high annual savings relative to cost (as reflected by low payback periods) are correlated with high rates of adoption, as long as costs are not too high.[14] This is consistent with survey findings (e.g., US Department of Energy, 1996)

[13] There is evidence, based on comment fields within the IAC database, that some projects are only partially implemented (e.g., plant installed 50% of recommended energy-efficient lighting), so the above estimates may overstate actual aggregate costs and per year savings. The data also suggest that partial implementations can be more profitable than the original recommendation (e.g., plant installed 50% of lighting for 75% of predicted savings).

[14] The exception is *operations* projects, which have low implementation costs and short payback periods, yet are only adopted 50% of the time. *Operations* projects may be associated with significant unmeasured opportunity costs, however (e.g., temporary plant shutdowns).

Table 2
Adoption rates, payback, cost, and annual savings by project type

Project type	Number of projects	Adoption rate	Mean payback (years)	Mean cost (US$)	Mean annual savings (US$)	Aggregate cost of adopted projects (US$)	Aggregate annual savings of adopted projects (US$)
Building and grounds (e.g., lighting, ventilation, building envelope)	14208	0.51	1.47	6217	4347	39995506	31349388
Motor systems (e.g., motors, air compressors, other equipment)	13783	0.60	1.22	5297	4123	36891259	32818958
Thermal systems (e.g., steam, heat recovery and containment, cooling)	6790	0.44	1.23	9021	8273	16670472	20203020
Combustion systems (e.g., ovens, furnaces, boilers, fuel switching)	2358	0.56	0.99	5131	7442	4611227	9570203
Operations (e.g., use reduction, maintenance, scheduling, automation)	1471	0.50	0.93	2617	4267	1716740	3483098
Electrical power (e.g., demand management, generation, transmission)	155	0.30	1.82	287100	94215	953399	602745
Industrial design (e.g., modify thermal, mechanical systems)	145	0.38	1.44	34013	25537	1634788	1487817
Ancillary costs (e.g., administrative, shipping, distribution)	10	0.50	1.76	7160	4715	43788	15363
All projects	38920	0.53	1.29	7401	5574	102517178	99530592

Statistics are based on sample of 38,920 project recommendations, broken down by project type. Aggregate cost and aggregate annual savings are for the years 1981–2000. Monetary figures are in 2000 US dollars.

that suggest projects above a certain cost may not get adopted, regardless of their benefits, due to budgeting constraints or differing management control depending on project cost.

Most energy savings have come from the adoption of projects affecting *building and grounds*, *motor systems*, and *thermal systems*. This is not surprising, given that these projects represent the bulk of all recommended and adopted projects. In terms of return on investment, however, it is clear that *combustion systems* and *operations* projects have been the most profitable. The aggregate annual savings for adopted projects in these categories are roughly double their aggregate cost. *Thermal systems* projects have also proven profitable overall, with aggregate per year savings exceeding aggregate cost by 21%. Overall, these numbers suggest that the IAC program has alerted manufacturers to a large number of new energy-conservation investment opportunities that appear profitable based on the IAC estimates of costs and benefits. Anecdotal evidence from general comments in the IAC database also suggests that the program has helped participating plant managers demonstrate the profitability of known investment opportunities to upper-level management.

Finally, there is evidence based on project-specific comments that a relatively small number of projects would have been implemented within a short time frame without IAC involvement (e.g., due to routine maintenance schedules). There is also evidence that a gradual move toward energy efficiency would have occurred over time without IAC involvement (e.g., due to retirement of aging equipment and replacement with more energy-efficient models). In general, however, it appears that the IAC program has either been the primary impetus for the adoption of most recommended projects, or has at least accelerated the progress of energy-efficiency improvement.

In order to gain a more systematic understanding of firm behavior in response to the IAC program, we develop an econometric model that formally relates the energy-conservation investment decision to the economic incentives of recommended projects, including payback, cost, annual savings, energy prices, and quantities of energy conserved. We discuss the econometric model and results below.

3. Modeling and estimation approach

Given a set of potential energy-conserving projects recommended by IAC auditors, we posit that a firm will adopt a particular project if the perceived expected net benefits of the project are positive given the project's characteristics and relevant investment hurdle rate.[15] We begin by defining π^*_{ij}, the expected net benefits resulting from the adoption of project i at plant j

$$\pi^*_{ij} = \varphi(C_{ij}, B_{ij}, Z_{ij}) + \varepsilon$$

[15] Note that program participants' perceptions of net benefits may not be consistent with IAC estimates due to real or perceived bias in these estimates. If estimated project returns differ from actual or perceived returns, then projects that appear profitable based on IAC estimates may be systematically rejected. We also note that various institutional or bureaucratic issues within the firm (e.g., capital budgeting constraints or principal-agent problems) could lead to the systematic rejection of projects that may be profitable, though this issue is not unique to energy-efficiency projects. Therefore, the relevant investment hurdle rate does not necessarily equal the market interest rate. We return to these issues below in Sections 4.2 and 4.3.

where C is the expected cost of a project, B the expected annual benefits of the project, Z a vector of individual plant and project characteristics (e.g., investment hurdle rates and project lifetimes), φ a function relating C, B, and Z to π^*, and ε a mean-zero independent, identically distributed error term.[16] The error term reflects uncertainty regarding the perceived net benefits of projects, leading to the possible rejection of projects that have positive net benefits, and vice versa.

We do not observe expected net benefits, π^*. Rather, we only observe whether a project is implemented or not. We therefore define a dichotomous variable, π, which indicates whether or not a project is adopted:

$$\pi_{ij} = 1 \quad \text{if } \pi^*_{ij} > 0$$

and

$$\pi_{ij} = 0 \quad \text{if } \pi^*_{ij} \le 0$$

It follows that

$$\Pr[\pi^*_{ij} > 0] = \Pr[\pi_{ij} = 1], \qquad \Pr[\pi^*_{ij} > 0] = F(\varphi(C_{ij}, B_{ij}, Z_{ij}))$$

where F is a cumulative probability distribution function for ε. Assuming F is logistic leads to the familiar logit model, whereas assuming F is standard normal leads to the probit model (Maddala, 1983). As discussed further below, because we have observations for multiple potential projects at each plant, we can estimate a logit model with plant-level fixed effects (Chamberlain, 1980; Hamerle and Ronning, 1995), thereby controlling for unobserved plant differences in the propensity to adopt.

Our most basic econometric specification, the *payback* model, is given by

$$\varphi = \beta_1 \ln \mathrm{PB}_{ij} + \beta_2 \ln \mathrm{PB}^2_{ij} + \gamma A_i + \alpha_j + \varepsilon \tag{1}$$

where PB is the expected simple payback period for the project (cost divided by annual savings, $\mathrm{PB} = C/B$), A a vector of dummy variables indicating the project type, and α a firm-specific fixed effect. Although it is well known that using a payback threshold is inferior to the net present value criterion (Lefley, 1996), the two criteria lead to the same investment threshold in the case of constant annual cash flows and for a given investment hurdle rate and project lifetime.[17] More importantly, simple payback analysis is the most common technique for project appraisal in general (Lefley, 1996) and, in particular, for firms that receive IAC audits (Muller et al., 1995; US Department of Energy, 1996).

We found that entering PB and the other continuous variables described below in their logged form improved the model's fit of the data and eased interpretation of the results since changes in the probability of adoption correspond to percent changes in the logged variables. Further, PB has been normalized to equal one at its mean so that the marginal probability of adoption at the mean payback is given directly by the coefficient on the linear

[16] Note that we suppress i, j subscripting in the text where this does not lead to confusion.

[17] The three most serious flaws associated with using a constant payback criterion to rank projects are (i) that it does not consider differences across projects in the time profile of the flows of cost and benefits; (ii) that it ignores differences in project lifetimes; and (iii) that it does not consider differences in the total net benefits from implementation (i.e., it uses the ratio).

term.[18] The plant fixed effects control for unobserved individual plant differences in the propensity to adopt, as well as other assessment-related factors, such as the assessment date and IAC school conducting the assessment.

Because payback is equal to cost divided by annual savings, Eq. (1) implies that percent changes in cost and savings have the same effect on the probability of adoption. Theory suggests that they *should* have the same effect. Nonetheless, previous empirical studies have found that implementation cost has a stronger effect on energy-conservation investments than energy savings (Jaffe and Stavins, 1995; Hassett and Metcalf, 1995). In order to test whether this is also the case for IAC program participants, we explore less restrictive specifications. The *cost–savings* model is given by

$$\varphi = \beta_3 \ln C_{ij} + \beta_4 \ln C_{ij}^2 + \beta_5 \ln B_{ij} + \beta_6 \ln B_{ij}^2 + \gamma A_i + \alpha_j + \varepsilon \tag{2}$$

where C is the expected implementation cost of a project, B the expected annual savings in energy costs, and the other variables are as above. Like PB in Eq. (1), both C and B have been normalized and enter in their logged forms. Note that although it is discounted energy savings that matter for the investment decision (rather than simply the annual flow of savings, B), the discount factor multiplying B becomes additive after taking logarithms. As the discount factor depends on the firm's investment hurdle rate and the project lifetime, its effect will be captured in the plant and project-type fixed effects, α and A.

The *cost–benefit* model can also be made less restrictive. Because annual savings equals the quantity of energy conserved multiplied by the energy price, Eq. (2) implies that percent changes in energy prices and quantities have the same effect on the probability of adoption. But one might conjecture, for instance, that energy prices are perceived as being less permanent than the quantity of energy saved, or that plant managers with engineering backgrounds are more sensitive to physical energy savings than to differences in the dollar value of these savings. For this reason we explore the possibility that energy prices and quantities have different effects on the probability of adoption. Our *price–quantity* model is given by

$$\begin{aligned}\varphi = {} & \beta_7 \ln C_{ij} + \beta_8 \ln C_{ij}^2 + \beta_9 \ln P_{ij} + \beta_{10} \ln P_{ij}^2 + \beta_{11} \ln Q_{ij} \\ & + \beta_{12} \ln Q_{ij}^2 + \gamma A_i + \alpha_j + \varepsilon \end{aligned} \tag{3}$$

where P and Q are the price and quantity indexes described in Section 2.2, with Q also normalized to equal one at its mean, and the other variables are as above.

We estimate the *payback*, *cost–benefit*, and *price–quantity* models using a maximum likelihood, conditional fixed effects logit estimator, with plant-level fixed effects (Chamberlain, 1980; Hamerle and Ronning, 1995). First note that assessments with either all positive or all negative outcomes do not contribute to the log-likelihood and are therefore dropped from the estimation. About 52% of these dropped assessments correspond to plants that adopted *all* recommendations, whereas 48% correspond to plants that adopted *none*. If the responsiveness of omitted plants to financial costs and benefits was systematically different from plants that were included in the analysis, then the omission of these observations could potentially

[18] The percent effect of payback is found by differentiating φ with respect to ln PB, which yields $\beta_1 + 2\beta_2 \ln \mathrm{PB}$. Evaluated for the mean payback, however, this simplifies to β_1, since we have normalized payback to equal one at its mean and $\ln(1) = 0$. The corresponding change in predicted probability is proportional to β_1 (see footnote 19).

lead to misleading coefficient estimates. As we discuss below, however, our results are robust to alternative models that include these observations. Although these observations are not included in our formal econometric estimation, they are included in our earlier calculations of overall adoption rates, mean costs and benefits, and other important summary statistics.

Second, note that because firms only participate in one assessment at a single point in time, variables such as annual sales, number of employees, and year of assessment are perfectly collinear with the plant-level fixed effects and cannot therefore be included in the estimation. We also estimated logit, random-effects logit, probit, random-effects probit, linear, linear fixed effects, and linear random-effects models, adding plant size and dummy variables for year, SIC code, and IAC school to models without plant-level fixed or random-effects. Our overall results (i.e., the effect of payback, cost, annual savings, prices and quantities) are robust to these alternatives. In addition, unlike other studies, we do not find a significant effect for plant size in models where it was included, whether measured by annual sales, annual energy costs, floor area, or employees. We note, however, that the IAC database only includes small and medium-sized firms, and that the effect of plant size on technology adoption may only be evident relative to larger firms. The results of the fixed effects logit estimations are presented below.

4. Results

4.1. Estimation results

Table 3 presents the results of our three econometric models of increasing flexibility. We transformed the coefficient estimates and standard errors so that they are presented as marginal effects at the means of the continuous variables.[19] Note also that we have transformed the variables so that the marginal effects for continuous variables are given directly by the coefficients on the linear terms, as discussed in Section 3. Effects for the project type dummy variables have also been transformed so that they reflect the full change in predicted probability associated with each project type, relative to building and grounds projects (the omitted dummy variable).[20]

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[19] Given the form of the logistic distribution, $\Lambda(\boldsymbol{\beta}'\boldsymbol{x}) = \exp(\boldsymbol{\beta}'\boldsymbol{x})/(1 + \exp(\boldsymbol{\beta}'\boldsymbol{x}))$, marginal effects in a logit model are equal to $\partial E[\pi]/\partial \boldsymbol{x} = \boldsymbol{\beta}\Lambda(\boldsymbol{\beta}'\boldsymbol{x})(1 - \Lambda(\boldsymbol{\beta}'\boldsymbol{x}))$ for continuous variables. With all continuous variables normalized to one at the mean, or zero after taking logs, and setting all fixed effects to zero, the marginal effects simplify dramatically to $\partial E[\pi]/\partial \boldsymbol{x} = \boldsymbol{\beta}/4$ at the mean (Anderson and Newell, 2003). The assumption of setting the fixed effects to zero is both convenient and necessary because the conditional logit estimator does not produce individual parameter estimates for the fixed effects. Standard logit estimates of the same specification yielded a constant term estimate of −0.07, suggesting that the "average" fixed effect is indeed close to zero. Including a fixed effect of this magnitude in the calculation of marginal effects would reduce the factor multiplying $\boldsymbol{\beta}$ only negligibly from 0.2500 to 0.2497. Standard errors are estimated using the delta method and, like the marginal effects, simplify dramatically to $\boldsymbol{\sigma}/4$, where $\boldsymbol{\sigma}$ is the estimated standard error of $\boldsymbol{\beta}$.

[20] The effect of a categorical variable, such as our project-type fixed effects, is found by taking the difference in the predicted probability with and without the categorical variable set to one. Given our normalizations described above, this results in the following simple relationship for the effect of categorical variable x_i: $E[\pi|x_i = 1] - E[\pi|x_i = 0] = \exp(\beta_i)/(1 + \exp(\beta_i)) - (1/2)$. Again, standard errors are estimated using the delta method and, given a number of simplifications, equal $\sigma_i/4$, where σ_i is the estimated standard error of β_i.

Table 3
Fixed effect logit estimates of project adoption

	Payback model	Cost–benefit model	Price–quantity model
ln(payback = savings/cost)	−0.083** (0.005)		
ln(payback = savings/cost)^2	−0.009** (0.002)		
ln(project cost)		−0.087** (0.005)	−0.085** (0.005)
ln(project cost)^2		−0.005** (0.001)	−0.005** (0.001)
ln(annual savings)		0.061** (0.006)	
ln(annual savings)^2		0.000 (0.002)	
ln(price of energy)			0.043** (0.016)
ln(price of energy)^2			−0.030 (0.018)
ln(quantity of energy saved)			0.058** (0.006)
ln(quantity of energy saved)^2			−0.001 (0.001)
Motor systems	0.092** (0.008)	0.090** (0.008)	0.090** (0.008)
Thermal systems	−0.167** (0.011)	−0.165** (0.011)	−0.165** (0.011)
Combustion systems	0.002 (0.016)	−0.002 (0.016)	−0.003 (0.016)
Operations	−0.094** (0.019)	−0.095** (0.019)	−0.095** (0.019)
Electrical power	−0.273** (0.060)	−0.253** (0.061)	−0.250** (0.062)
Industrial design	−0.214** (0.060)	−0.198** (0.061)	−0.197** (0.061)
Ancillary costs	−0.038 (0.211)	−0.048 (0.213)	−0.049 (0.213)
log-likelihood	−10133	−10118	−10116
Likelihood ratio	1278**	1308**	1312**

Asterisks denote statistical significance at various levels: (**) = 99%. Data are observations of energy-conserving project recommendations made under IAC program from 1981 to 2000. Dependent variable equals 1 if project is adopted and 0 otherwise. Estimation method is ML conditional fixed effects logit with plant-specific fixed effects. Each model is estimated on an effective sample of 5263 plant visits representing 26,068 recommended projects. 3771 plants (12,852 projects) in the full sample were dropped due to their having no variation in whether projects were adopted or not. Marginal effects at variable means are given directly by linear terms, setting fixed effects and project type dummies at zero. Marginal effects for dummy variables give change in predicted probability associated with changing dummy variable from 0 to 1 (see Sections 2 and 3 for further detail).

Our overall results are consistent with economic expectations. To provide a sense of how our model fits the pattern of the data, Fig. 1 plots the observed fraction of projects actually adopted at various payback levels, along with the estimated probability of adoption based on the *payback* model given by Eq. (1). As expected, projects with a longer payback period (i.e., greater ratio of costs to annual benefits) are less likely to be adopted. Further, the predicted probability corresponds quite well to the actual adoption rates of projects with various paybacks. Specifically, the results indicate that a 10% increase in payback leads to about a 0.8% decrease in the probability of adoption. The negative coefficient on the squared term for payback indicates that percentage increases in the payback period have an increasingly negative effect on adoption rates. This result manifests itself in Fig. 1 as downward curvature in the adoption function.

The *cost–benefit* model relaxes the implicit restriction that costs and benefits have the same magnitude effect. According to the results of this model, a 10% increase in cost decreases the probability of adoption by 0.8%. The negative coefficient on the squared term

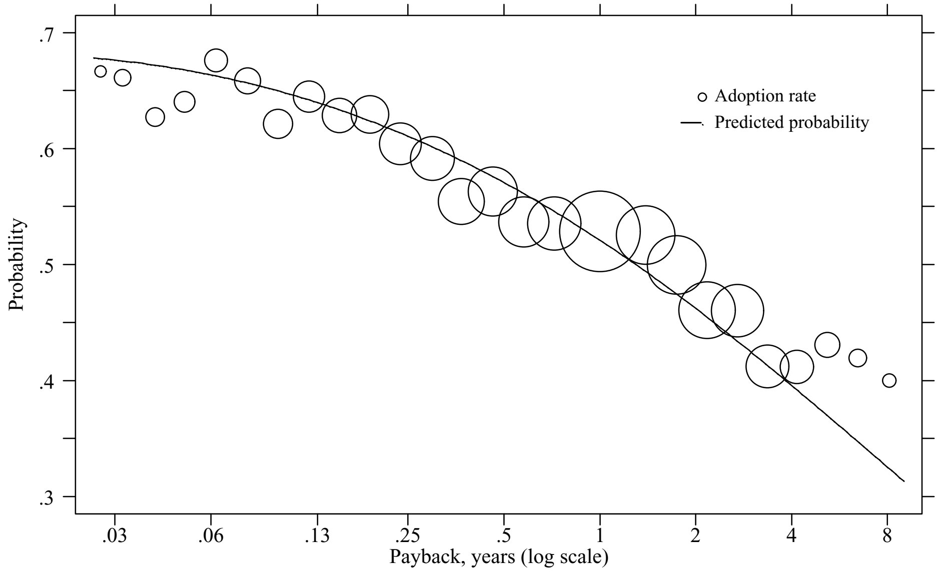

Fig. 1. Probability of adoption vs. payback. Circles represent the observed adoption rates for fixed intervals of payback in log scale. The areas of the circles are proportional to the number of observations in each interval. The solid line is the predicted probability of adoption for the *payback* model (see Table 3). All fixed effects are set to zero for the figure.

for costs indicates that the effect of costs is increasingly negative, suggesting that very costly projects are especially unlikely to be adopted. This result is consistent with survey findings that show that most firms consider an investment of US$ 5000 or more to be large, regardless of the benefits, and higher cost projects (e.g., US$ 10,000 or more) are subject to greater scrutiny since they often must be approved on a capital budgeting basis rather than out of production and maintenance budgets (Muller et al., 1995; US Department of Energy, 1996). This result is suggestive of potential market imperfections—namely, problems in institutions efficiently allocating funds to profitable investment opportunities.

On the other hand, a 10% increase in annual savings increases the probability of adoption by only 0.6%. The magnitudes of the cost versus savings effects are statistically different at the 99% level.[21] These results are consistent with previous literature, which finds that up-front implementation costs have a larger effect on energy-conservation decisions than future annual savings. The magnitude of the difference, however, is much less pronounced in our results. We find that costs have a 40% greater percentage effect relative to future energy savings at the mean of the data, whereas Jaffe and Stavins (1995) found that costs had about three times the effect, and Hassett and Metcalf (1995) found that costs had about eight times the effect of energy savings. One difference between our study and these, however, is that we have data that directly measure the estimated dollar value of energy savings, which includes both price and quantity information, whereas these other studies only used

[21] Using Wald tests, we reject the hypotheses that $\beta_3 = -\beta_5 (\chi^2(1) = 37.22)$ and that $\beta_4 = \beta_6 (\chi^2(1) = 5.16)$.

variation in energy prices to identify the effect of future energy dollar savings. It has also been suggested that IAC estimates of energy savings may be more accurate than estimates of implementation cost, perhaps leading to an "errors in variables" bias of the implementation cost coefficient toward zero relative to annual savings.[22] We discuss this issue further below in the context of the *price–quantity* model.

The *price–quantity* model relaxes the implicit restriction that changes in energy prices have the same percentage effect as changes in the quantity of energy conserved. The results indicate that a 10% increase in energy prices increases the probability of adoption by 0.4%, but that a 10% increase in the quantity of energy conserved increases the probability of adoption by 0.6%. Although the parameter estimates indicate that energy-conservation *quantities* have about a 30% greater effect on adoption likelihood than energy *prices* (i.e., the per unit value of conservation) at the mean of the data, these estimated effects are not statistically different at any reasonable confidence level.[23] Still, they suggest that plant managers may be more responsive to differences in the quantity of energy conserved for alternative projects than to differences in energy prices. Perhaps plant managers with engineering backgrounds are inherently more responsive to technical energy savings than to their dollar value. Alternatively, energy quantity changes may be perceived as less uncertain or subject to change than energy price changes.

The *price–quantity* model also permits a more direct comparison to the studies cited above regarding the relative effects of up-front costs versus energy prices. Our results indicate that costs have a little more than double the effect of energy prices, which is more dramatic than the difference between cost and savings in our *cost–savings* model above, but still not as large as the three or eight times larger effect cited in previous studies.[24] These results imply that a policy of subsidizing energy-conserving technologies may be more effective in spurring the adoption of these technologies than a policy of taxing resource use.[25]

Jaffe et al. (2003) suggest several possible explanations for this divergence. One possibility is a behavioral bias that leads plant managers to focus on implementation costs more than on lifetime operating costs and benefits.[26] An alternative view is that plant managers focus equally on both, but that uncertainty about future energy prices or whether they will face such costs (e.g., due to a location change) makes them place less weight on energy prices than on implementation cost, which is known. Finally, plant managers may have fairly accurate expectations regarding future energy prices, and make investment decisions

[22] According to IAC contacts (Heffington, 2003), most engineering programs provide student IAC team members with solid training for calculating energy and cost savings early in their curriculum, whereas training for calculating implementation costs comes later, if at all. Moreover, data regarding implementation costs may be harder for students to obtain. By contrast, plant personnel are typically better equipped to accurately estimate implementation costs due to their more frequent interaction with vendors and installers.

[23] Using Wald tests, we cannot reject the hypotheses that $\beta_9 = \beta_{11}(\chi^2(1) = 0.87)$ or the joint hypothesis that $\beta_9 = \beta_{11}$ and $\beta_{10} = \beta_{12}(\chi^2(2) = 2.69)$.

[24] Using Wald tests, we reject the hypotheses that $\beta_7 = \beta_9(\chi^2(1) = 56.10)$ and the joint hypothesis that $\beta_7 = \beta_9$ and $\beta_8 = \beta_{10}(\chi^2(2) = 88.55)$. We also reject the hypothesis that $\beta_7 = \beta_{11}(\chi^2(1) = 225.74)$ and the joint hypothesis that $\beta_7 = \beta_{11}$ and $\beta_8 = \beta_{12}(\chi^2(2) = 391.36)$.

[25] Note, however, that unlike taxes on resource use, policies that reduce technology costs do not provide the continued incentive to reduce energy consumption.

[26] This is consistent with the observation that plant managers are often better equipped to estimate implementation costs (e.g., through interactions with equipment vendors) than future energy savings (Heffington, 2003).

accordingly, but researchers (or, in this case, IAC teams) may use imperfect or flawed proxies of these expectations, causing their measured effect to be smaller than their true effect.[27]

Although our results demonstrate that firms generally respond as predicted by economic theory to the incentives of payback, cost, savings, energy prices, and conservation quantities, these variables do not fully explain the technology adoption decision. Indeed, holding these variables constant, certain types of projects are more likely to be adopted than others, as measured by the project type dummy variables. *Motor systems* projects are the most attractive type of project, with a 9% greater probability of being adopted than *building and grounds* projects, the omitted group. *Combustion systems* and *ancillary costs* projects are about as likely to be adopted as *building and grounds*. Projects affecting *operations, thermal systems, industrial design* and *electric power* have, respectively, a 10, 17, 20, and 25% lower probability of being adopted than *building and grounds* projects. Interestingly, we also find that as paybacks approach zero, adoption rates increase only to about 70%; similarly, as paybacks approach our sample maximum of 9 years, adoption rates decrease only to about 30%.

These results are consistent with the descriptive statistics on relative adoption rates for the various project types listed in Table 2. Further, they suggest that the IAC program's measures of financial costs and benefits do not fully capture the relative desirability of alternative projects. There may be many missing factors—such as individual project lifetimes, unmeasured costs and benefits, uncertainty regarding costs and benefits, project complexity and risks—that are crucial to understanding the adoption decision. Errors in measuring the true costs and benefits of projects could also be leading to an "errors in variables" bias of the coefficients toward zero, resulting in estimated effects that are smaller in magnitude than their true values.

4.2. Payback thresholds and implicit discount rates

Previous literature has posited that information programs and other policies may lower the sometimes seemingly high implicit discount rates observed for firms with respect to their energy-efficient investment decisions. Undoubtedly, one source of high implicit discount rates may be that firms are unaware of particular energy-efficient investment opportunities, or at least the relative costs and benefits of such opportunities. By conveying information regarding such opportunities, information programs may lower observed implicit discount rates. The observation that the IAC program has led to the adoption of many previously unimplemented projects attests to this possibility.

We address this issue by looking at the observed level of implicit discounting for firms that participated in the IAC program. We focus on the 5264 firms in our final sample that adopted some, but not all of the energy-related projects recommended through IAC energy audits. This group is equivalent to the estimation sample from our econometric analysis. By sorting the payback periods of each plant from shortest to longest, one can in principle locate a "payback threshold" for that plant, below which all projects are adopted and above which

[27] For example, studies often use current realized energy prices as a proxy for expected future energy prices. Current prices fluctuate more than expected future prices, however, leading to a downward bias in the coefficient on the energy price proxy relative to the true relationship with expected prices.

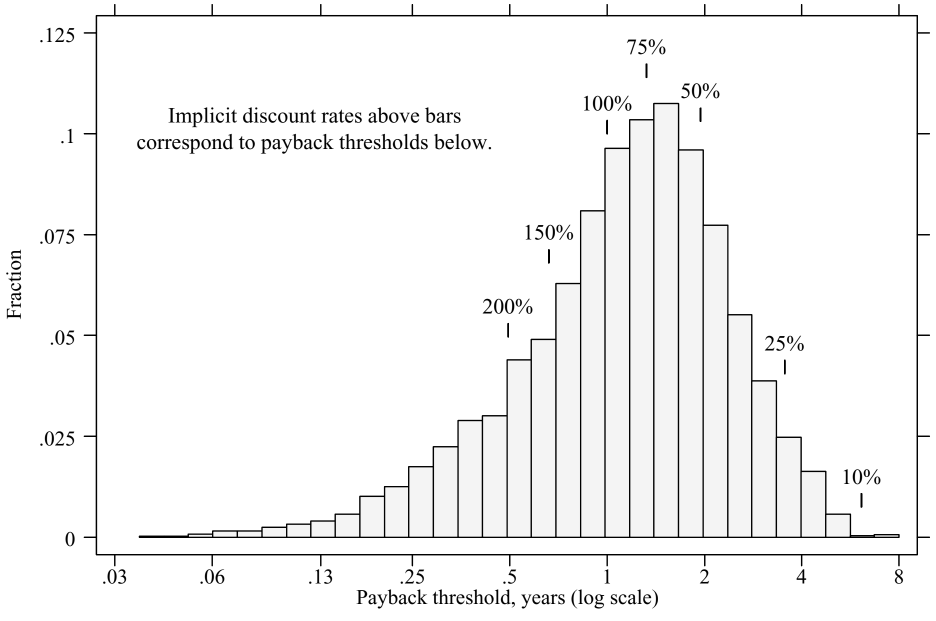

Fig. 2. Histogram of payback threshold values. Figure shows fraction of plants having a payback threshold within fixed intervals of payback in log scale. Based on sample of 5263 plants that adopted some (but not all) projects. Payback threshold values are given by midpoint between maximum payback for adopted projects and minimum payback for projects that are not adopted within each assessment. Mean payback threshold is 1.4 years; median is 1.2 years. Implicit discount rates above bars correspond to payback thresholds assuming a 10-year project life; if project lives are shorter than 10 years, implicit discount rates are lower (e.g., about 5% lower for a project life of 5 years and a 1.5-year payback) (see Section 4.2 for further detail).

all projects are rejected. The payback threshold is an analogue to an investment hurdle rate. In reality, however, we observe that most firms exhibit some overlap in the paybacks of projects that are adopted and those that are rejected (i.e., some adopted projects have longer paybacks than rejected projects). For each plant, we therefore find the shortest payback amongst the projects that are rejected and the longest payback amongst the projects that are adopted, and we take the average of these two paybacks as an estimate of the plant's payback threshold. After conducting the same analysis for plants that do not exhibit any overlap in the paybacks of adopted and rejected projects, we obtain very similar results.

Fig. 2 shows the distribution of payback thresholds. Over 98% of firms have estimated payback thresholds less than 5 years, and about 79% have payback thresholds less than 2 years. The mean payback threshold is 1.4 years, and the median is 1.2 years. These payback cutoffs correspond to implicit discount rates of about 70 and 80% for a 10-year project, respectively, as indicated in the figure.[28]

[28] Implicit discount rates are calculated by solving $\mathrm{PB} = (1/r) - 1/(r(1+r)^{\mathrm{T}})$ for r, where PB is the payback cutoff value, T the project lifetime, and r the investment hurdle rate to be calculated. We assume a project lifetime of 10 years. Assuming a shorter project lifetime of 5 years would lower our estimates of the mean and median implicit discount rate by only about 5%, and would alter higher implicit rates by an even smaller amount.

Although these payback periods may seem quick, and the corresponding hurdle rates high, they are consistent with the investment thresholds that small and medium-sized manufacturers report that they routinely employ for all types of projects, including energy-efficiency projects. For example, a series of industry roundtables conducted by the alliance to save energy found that acceptable projects were typically limited to a 2-year payback or shorter, although larger companies sometimes considered 3-year paybacks to be acceptable (US Department of Energy, 1996). This is consistent with other broad surveys of the use of the payback criterion, not just for energy-conservation projects, but much more widely (Lefley, 1996). Likewise, in a follow-up survey of plants that had received an IAC audit, Muller et al. (1995) found that 85% of firms reported that they considered paybacks of greater than 2 years financially unattractive. The median threshold in that survey was a 1–1.5 year payback, which again is consistent with our findings.

Of course, our analysis of paybacks is predicated on the assumption that IAC estimates of project costs and benefits are reasonably accurate, or at least not systematically biased. Evidence from previous studies, however, suggests that analysts have substantially overestimated energy savings due to optimism or due to reliance on highly controlled studies. For example, previous studies have found that actual savings from utility-sponsored programs typically achieve 50–80% of predicted savings (Sebold and Fox, 1985; Hirst, 1986). Based on an analysis of residential energy consumption data, Metcalf and Hassett (1999) find that the realized return on conservation investments in insulation was about 10%, well below typical engineering estimates that returns were 50% or more.

If IAC estimates are similarly biased, and if program participants have a relatively accurate perception of likely project returns, then it may be that implicit discount rates based on IAC estimates appear higher than they really are. Alternatively, program participants may not know actual project returns, but may have formed prior notions regarding the likely magnitude and direction of such bias and compensate by "padding" their investment hurdle rate accordingly. Of course, it is also possible that program participants perceive bias that does not exist, in which case program participants are likely missing profitable investment opportunities. Once again, however, the fact that our estimates of payback thresholds (and implicit hurdle rates) are consistent with the investment criteria these types of firms have repeatedly said (in other surveys) they deliberately use suggests that our estimates are not far off.

Comment fields within the IAC database contain some information regarding actual costs and benefits obtained during post-assessment interviews with plant management, but unfortunately, such information is not recorded systematically. After searching through these fields, we were only able to identify 210 (out of nearly 40,000) recommended projects that contained useful, quantitative information regarding actual project costs and benefits.[29] Not surprisingly, analysis of this information yields only inconclusive and speculative results. The limited evidence we have suggests that IAC auditors sometimes overestimate and sometimes underestimate actual costs and benefits of projects. We attempted to find a

[29] These include both actual cost and benefit figures for adopted projects, as well as client firm estimates of what actual costs and benefits would have been for non-adopted projects based, for example, on actual price quotes or further analysis. A smaller number of projects also provided qualitative information regarding actual costs and benefits. Including both quantitative and qualitative data, actual savings were higher than predicted in 121 cases and lower than predicted in 83 cases; actual costs were higher than predicted in 34 cases and lower than predicted in 24 cases.

pattern in these differences, but estimates of a relationship between actual and predicted costs and benefits were imprecise.[30]

Although we are unable to determine whether the IAC program actually lowers investment hurdle rates, implicit discount rates based on the revealed behavior of program participants remain above 50% for most firms after program participation. Since these discount rates are based on projects and technologies that firms *knew about*, it is unlikely that they can be explained by informational market failures of the type the IAC program is designed to alleviate, although other market failures may play a role, as we discuss in Section 4.3. Alternatively, if IAC estimates of project returns are biased upward, but firms know actual returns, then actual hurdle rates may be lower than they appear based on IAC estimates. Another possibility is that program participants apply high hurdle rates relative to market interest rates to compensate for real or suspected bias in estimates of project returns. In any event, the widespread use of short payback thresholds remains a puzzle, the possible answers to which lie beyond the scope of this paper.

4.3. Reasons given for not adopting projects

In order to explore the extent to which high implicit discount rates may be the result of remaining market failures or imperfections, we examine the reasons given by firms for not adopting projects. Since about 1991, these reasons have been coded and recorded in the IAC database. For the purposes of our analysis, we focus on the 93% of rejected projects between 1991 and 2000 that provide at least one reason for not adopting the project. We classify these reasons as possibly having an *economic*, *institutional*, or *financing* rationale, as shown in Table 4. Note that some reasons given for not adopting projects correspond to multiple categories, as we discuss in below.

As can be seen from Table 4, as much as 93% of projects were not adopted for what we classify as *economic* reasons. Many such reasons suggest an unattractive balance between the financial costs and benefits of a project (e.g., “unsuitable return on investment”), which should be reflected in IAC estimates of implementation cost and annual savings. But some reasons hint at opportunity costs (e.g., “lack staff for analysis/implementation”) and various project risks (e.g., “risk or inconvenience to personnel” or “suspected risk of problem with equipment”) that are not typically reflected in the IAC cost estimates. Firms report that the risk of technologies not working properly, which can lead to production halts or changes in product quality and cost is, in fact, a strong deterrent to adopting certain projects (US Department of Energy, 1996). The implication of this result is that simple financial measures alone do not determine the decision to invest in energy-efficient technologies. Analysts or policymakers that look at these measures, see that measured financial benefits outweigh financial costs, and then assume that projects that are not adopted reflect market barriers or market failures may be overlooking many unmeasured costs and benefits.[31]

[30] We also experimented with various sample selection models, since information for actual costs and benefits is more likely to appear for adopted projects (which may not exhibit significant bias), but the results of this experimentation were not robust.

[31] In our econometric model, many of these differences should be captured with our project type dummy variables and plant fixed effects.

Table 4
Reasons given for not adopting projects

Reason for not adopting	Number	Percent	Percent by category		
			Economic reasons	Institutional reasons	Financing reasons
Still considering	3295	27.1	×	×	×
Other	1169	9.6	×	×	×
Too expensive initially	858	7.1	×		×
Lack staff for analysis/implementation	820	6.8	×	×	
Cash flow prevents implementation	810	6.7		×	×
Not worthwhile	688	5.7	×		
To be implemented later	643	5.3	×	×	×
Unsuitable return on investment	616	5.1	×		
Impractical	591	4.9	×	×	
Facility change	582	4.8	×	×	
Process/equipment changes	513	4.2	×	×	
Unknown	472	3.9	×	×	×
Unacceptable operating changes	423	3.5	×	×	
Personnel changes	368	3.0	×	×	
Disagree	295	2.4	×	×	
Bureaucratic restrictions	246	2.0		×	
Risk of problem with product/equipment	219	1.8	×		
Risk/inconvenience to personnel	124	1.0	×	×	
Rejected after implementation failed	73	0.6	×		
Production schedule changes	71	0.6	×	×	
Material restrictions	33	0.3	×		
Could not contact plant	5	0.0	×	×	×
Total projects that provided reason	12147	100.0	93.0	82.0	58.2

Table summarizes reasons for non-adoption of projects between 1991 and 2000. Table excludes projects that did not provide a reason for non-adoption. Some projects list more than one reason for why the plant did not adopt, so numbers sum to more than 12,147 and percentages sum to more than 100% percents by category also add to more than 100% reflecting the fact that some reasons for not adopting correspond to multiple categories (see Section 4.3 for further detail).

On the other hand, many of these reasons are sufficiently vague that it is not altogether clear that they should be categorized solely as economic factors. For example, program participants may be averse to “process or equipment changes” or “facility changes” for personal or other non-economic reasons. Thus, we also classify many of these reasons as possible *institutional* factors, totaling as much as 82% of projects that were not adopted. One clear institutional reason for non-adoption was “bureaucratic restrictions” within the firm (e.g., plant managers may need CFO approval before undertaking energy-conservation projects), perhaps indicating certain principal-agent market failures.

Finally, according to the IAC data, as much as 58% of the projects were not adopted possibly for *financing* reasons (e.g., limited cash flow), perhaps indicating a failure of capital markets to efficiently allocate financial resources. Again, many such reasons overlap with the economic and institutional reasons, though some (e.g., “too expensive initially” or “cash flow prevents implementation”) more clearly suggest some type of financing issue. It is possible that loans directed at energy conservation could be effective in ameliorating this problem if that was desired.

5. Conclusion

The US Department of Energy's Industrial Assessment Center program provides a unique opportunity to quantify the effects of an information program for energy-efficient technology adoption. We find that 53% of the projects recommended through the IAC program were adopted, representing 45% of total recommended energy savings and 46% of total recommended dollar savings. Overall, our results indicate that firms respond as expected to the economic incentives of different energy-conserving investment opportunities. Rates of adoption are higher for projects with shorter payback periods, lower implementation cost, greater annual energy savings, higher energy prices, and greater quantities of energy conserved. These simple financial measures do not explain everything, however. Indeed, holding these factors constant, we find that certain project types are more likely to be adopted than others, suggesting that there may be many economic costs, benefits, risks, and other factors that the IAC program's simple financial measures do not capture.

We find evidence that firms are more responsive to implementation costs than to annual energy savings, although this difference is not as pronounced as in previous studies. Similarly, firms seem to be more responsive to energy savings based on the quantity of energy conserved than to energy prices, though these effects are not statistically different. These results suggest that policy mechanisms to reduce costs (e.g., tax breaks or subsidies for implementation) and directly promote technical efficiency improvements may be somewhat more effective in the short term than price mechanisms (e.g., energy or carbon taxes). Only energy price increases, however, also provide the continuing incentive to reduce energy use.

As in previous studies, the firms in our sample demand quick paybacks of 1–2 years (implicit hurdle rates of 50–100%) for project adoption, as revealed through their technology adoption decisions. These results are consistent with the investment criteria that small and medium-size firms typically state that they *intend* to use. Our assessment of the reasons given for not adopting projects reveals that most may have been rejected for economic reasons, though some of these reasons may be difficult to quantify financially. On the other hand, many other projects appear to have been rejected for institutional reasons or lack of financing, and many of the "economic" reasons could also be indicative of institutional factors.

Overall, one can view the glass as either half full or half empty. The data suggest that during 1981–2000 the IAC program led to the adoption of many financially attractive energy-conservation projects. For an estimated aggregate financial outlay of about US$ 103 million by firms, the projects in our sample have yielded an estimated US$ 100 million and 20 trillion Btu in aggregate per year energy savings. Cumulative savings are likely many times as high. Note that these figures do not include Department of Energy spending on the program nor do they include various indirect program benefits (e.g., training of students and firm participants).

Still, nearly half of the projects recommended by the program are not adopted, and implicit discount rates remain seemingly high relative to market interest rates, despite the provision of free information. Nonetheless, these implicit discount rates are in the same range as what firms have stated in other surveys that they intend to use. Analysis of the reasons given for not adopting projects does little to explain why so many projects are not adopted—though we do find evidence that there are likely many unmeasured costs and risks not captured in the IAC program's simple financial estimates, so that *estimated* rates of return likely differ from *realized* rates of return.

To the extent that the routine use of short payback cutoffs (i.e., high hurdle rates) is a symptom of remaining market imperfections in corporate management, such as problems of agency, moral hazard, imperfect or asymmetrical information, and incentive design (DeCanio, 1993), there may be opportunities for increased energy efficiency through policies that can correct such imperfections. To the extent that such policies are costly or impractical, our results suggest that policies targeted at increasing the financial attractiveness of energy-efficiency projects (e.g., subsidies for implementation or taxes on energy use) could be used to further promote energy-efficient technology adoption.

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Barriers within firms to energy-efficient investments

Stephen J. DeCanio

Many investments in energy efficiency fail to be made despite their apparent profitability. Internal hurdle rates are often set at levels higher than the cost of capital to the firm. Reasons for these practices include bounded rationality, principal–agent problems, and moral hazard. The policy implication is that government can simultaneously improve overall energy efficiency and increase private sector productivity by providing informational and organizational services that go beyond the traditional regulatory framework.

Keywords: Energy efficiency; Principal–agent problem; Bounded rationality

A considerable body of evidence suggests that the US economy could become much more energy efficient than it presently is. Opportunities to improve energy efficiency can be found in residential and commercial buildings and industrial processes.[1] A study by the Office of Technology Assessment of the US Congress (OTA) recently found that the government could save at least 25% of the energy used in federal buildings, with no sacrifice of comfort or productivity.[2] Of perhaps greater significance from the economic point of view, many of these potential energy saving investments appear to have very high rates of return in comparison to the economy-wide average cost of capital. Residential consumers resist energy saving investments that have rates of return of 30% to 40% or more, while detailed, on-site surveys of selected industrial corporations have uncovered energy conservation projects with rates of return frequently in excess of 30%.[3]

The author is with the Department of Economics, University of California, Santa Barbara, CA 93106, USA and The Fielding Institute, Santa Barbara, USA.

The existence of such sizable unrealized profits poses both theoretical and policy problems. On the theoretical side, how can we account for such a deviation from the standard economic presumption of cost minimization or profit maximization? What characteristics of the markets, agents, or of the observations themselves account for the discrepancy? On the policy side, it is natural to ask how government might intervene to improve the situation. The difference between what is and what could be realized suggests that well designed policies to improve energy efficiency might achieve one of the most sought after objectives of economic policy – Pareto improvement with gains for all concerned. Before ambitious policy goals can be set, however, it is necessary to examine the *causes* for the apparent gap between actual and theoretical performance.[4]

Barriers to profitable investments

Firms do not behave like individuals

In thinking about why firms may not always behave optimally, it is important to remember that a firm is a *collection* of individuals, brought together under a complex set of contracts both written and unwritten, but that the firm itself is not an entity acting with a single mind. Economists often talk about 'the firm' as though it had its own consciousness, but this is either an (often very useful) theoretical simplification or an example of sloppy thinking. The behaviour of the firm is the outcome of the interplay of the motivations of the individuals comprising it, the rules and conventions governing their interaction, and the environment within which the firm operates. The firm makes choices and decisions, but these are generated through its rules of procedure, rather than being the products of an individuated volition. The top decision makers of the firm exercise a considerable degree of control, but that is not sufficient to

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transform it into a conscious entity with a unitary will. Other hierarchical organizations (eg government bureaucracies, armies, university administrations) can experience divergence between goals and actions.

Recognizing this possibility has important consequences. The individuals making up a business firm may all be rational seekers after their own interest, but the outcome of their collective action may be suboptimal. The logic of collective action is such that, in general, '*rational, self-interested individuals will not act to achieve their common or group interests*.'[5] This principle applies to private sector corporations as well as to government bureaucracies or political collectives. The presence of public goods, externalities, and the clash between individuals' private incentives and the good of the whole all combine to produce outcomes that fall short of what could be obtained if all the resources of the group were deployed by a single guiding intelligence.

Some of the specific ways in which a corporation's internal operating rules may thwart optimization of its activities will be discussed below. Before beginning that discussion, however, it is important to note that the inefficiency of a corporation will not be easy to detect. Whatever flow of profits is being generated by the corporation's management, the capital market (ie the market for the stocks, bonds and other securities of the firm) will value the assets of the corporation at a level such that the rate of return on those assets is equal to what could be earned by investing in another activity of comparable risk. If profits are not as large as they might be, the total value of the corporation's assets will be lower than it could be, but this deficiency will not show up in a lower rate of return to the company's stock. So long as the profits of the corporation are positive, a constant level of management inefficiency will not be discernible from data on stock or bond prices. Only a takeover or replacement of the management team can reveal that the old management was not earning as much from the firm's assets as might have been possible.

The possibility of a hostile takeover or shareholder revolt exerts pressure on management to maximize shareholder wealth, but there is no automatic guarantee that this maximization will be achieved in practice. It is costly and risky to attempt to change the management of a major corporation, as many would be takeover groups have learned to their regret. Even if the management team is entirely committed to maximizing the wealth of the corporation's owners, the complexities of directing a large, multifaceted organization will cause management to fall short. Indeed, if there were no difficult challenges to be overcome in obtaining the largest possible return from a given corporate organization, top management jobs would not be so highly paid and attract such high-powered talent.

Failures of complete maximization are to be expected

It follows from these considerations that deviations from full profit maximization should not be surprising. Indeed, a long standing and respected tradition in economic thought holds that business organizations can only approach or approximate profit maximizing behaviour, because of the complexity of the environment they face and limitations on the decision making resources they command. The most famous proponent of this view is Herbert Simon, the Nobel laureate who pioneered the notion that 'satisficing' rather than 'maximizing' is descriptive of how firms actually operate.

According to this paradigm, economic agents resort to satisficing when 'approximation must replace exactness in reaching a decision'.[6] Instead of the profit maximizing first order conditions of the standard economic model, firms employ a variety of expedients in carrying out their activities:

> Several procedures of rather general application and wide use have been discovered that transform intractable decision problems into tractable ones. One procedure . . . is to look for satisfactory choices instead of optimal ones. Another is to replace abstract, global goals with tangible subgoals, whose achievement can be observed and measured. A third is to divide up the decision-making task among many specialists, coordinating their work by means of a structure of communications and authority relations. All of these, and others, fit the general rubric of 'bounded rationality,' and it is now clear that the elaborate organizations that human beings have constructed in the modern world to carry out the work of production and government can only be understood as machinery for coping with the limits of man's abilities to comprehend and compute in the face of complexity and uncertainty.[7]

Under this view of the operation of the firm, an understanding of the forces that lead to any particular pattern of behaviour (regarding, say, energy management) could only be obtained by a careful, microlevel examination of the actual decision making processes of the firms themselves. It would be necessary to see, in specific instances, exactly what sort of informational, computational and organizational constraints were faced by particular firms in order to understand why they did or did not make particular investments.[8]

Asymmetric information and divergent incentives

The conflict between individual rationality and the optimality of the firm's aggregate behaviour can manifest itself in other, quite distinct, ways. Even without limitations on the ability of individuals to 'comprehend and compute' the complex reality they face, institutional or other restrictions on information availability and real differences in the underlying interests of the parties can lead to suboptimal results. Within the framework of decentralized corporations, multidivisional structures or government bureaucracies, individual maximization can produce results contrary to the formal goals of the organization. A wide variety of circumstances can lead to a failure of the organization to maximize profits or minimize costs, even though the individual agents are fully rational wealth maximizers.

It has been known (or strongly suspected) since the time of Berle and Means or even earlier that the interests of shareholders and managers may not coincide.[9] Indeed, a major task of organizational design is to induce the managers of a stockholder owned corporation to act in a manner as consistent as possible with the interests of the owners. This manifestation of the principal–agent problem leads to a variety of reasons why profitable investments might not be undertaken.

One frequently cited factor causing underinvestment in energy saving technologies is the alleged shortsightedness of management. This myopia is usually thought of as being manifested in very short payback periods required for energy (and other) investments, or unduly high internal hurdle rates that must be met for investments to be undertaken. Recently compiled data testify to the existence of both kinds of foreshortening of the time horizons of US managers. In a survey of 228 US manufacturing firms, Poterba and Summers found that the average after-tax real hurdle rate was 12%.[10] This compares to the historical (since the 1920s) real rate of return on equities in the USA of 7%.[11] A 12% hurdle rate is much higher than the historical cost of capital for comparably risky investments. Similarly, a survey of 48 firms conducted by the EPA revealed that the median payback required for one class of energy investment was two years.[12] A payback of two years for a project with a 10-year lifetime is equivalent to a post-tax real rate of return of 56%.[13]

Yet deeper consideration of the situation facing the owners and management of a large, multidivisional corporation uncovers several factors that might lead to adoption of such overly stringent investment criteria, despite the fact that the cost of capital faced by the firms is considerably lower than the hurdle rates that projects are required to meet in order to be accepted.

Managerial compensation is often tied to recent performance, and in many corporations, managers are rotated through different jobs every few years. This sort of rotation policy may be important in maintaining managerial motivation, preventing ossification, and ensuring that managers have a perspective on the full range of the company's activities. However, this sort of frequent job turnover may lead managers to prefer projects with short payback periods even if those projects are inferior, in some global profit maximizing sense, to others of longer duration.[14] A manager who only expected to be in a particular job for two or three years would have no personal incentive to promote a project having a more distant payoff.[15]

Tying management compensation to short-term performance has the same effect. Statman and Sepe refer to a body of research indicating that 'managerial decisions are quite sensitive to compensation plans',[16] with the particular finding that capital investment in long-term projects 'increased with adoption of long-term compensation plans'.[17] Yet one observer noted that

> there is growing concern that the evaluation, reward/punishment, and executive incentive systems presently employed often emphasize short run accounting-based returns instead of maximization of the long-run value of the firm. Thus, short run earnings, earnings per share, or sales growth are often rewarded. This emphasis on short-run results may encourage management to forego investment in capital equipment or research and development which would benefit the corporation several years hence even more than the improved earnings next year would.[18]

Other features of the executive compensation system can skew decisions away from beneficial energy investments. Managers will be deterred from initiating risky projects if the personal consequences of failure seem to be much larger than the payoff to success, and if managers are risk averse while shareholders are risk neutral because the latter hold diversified portfolios of assets.[19] Human capital investment in energy conservation expertise will be low if the compensation and prestige of the managers responsible for energy use (eg facilities personnel) are less than the rewards for other positions.

Hurdle rates can be set with an eye towards the problems of control of a large organization, not just to correspond to the firm's cost of capital. Models in the managerial and accounting literature embodying this theme usually stress the asymmetry of information between stockholders or central headquarters and the divisional managers who are more familiar with local conditions, in addition to the divergence of preferences between owners and managers or between different layers of management.[20] In an important paper by Antle and Eppen, the owners set the hurdle rate substantially above the cost of capital to ensure that only highly profitable investments are undertaken.[21] The reason is that the shareholders cannot easily observe the true profitability of projects, so they may not be able to prevent dissipation of some profits into managerial slack (defined as the excess of resources allocated over the minimum necessary to accomplish the tasks assigned) if a lower hurdle rate closer to the cost of capital were applied. Imposition of a too high hurdle rate means that some profitable projects are forgone, but it still constitutes a second-best solution to the owners' monitoring and control problem.

In a related model, Narayanan shows that managers might prefer investments with rapid paybacks, because the quick return on such projects enhances the managers' reputations with the owners.[22] If a manager's true ability is not observable by the shareholders, then

> the manager hopes that if he selects the quick-return project, the stockholders may attribute the extra dollars to his ability and pay him higher wages not only in that period but also in subsequent periods, since his pay is based on current and past performances.[23]

This effect is reinforced if the market cannot observe the manager's choices of projects (which is possible because many managerial choices are small and outside the public domain). In this case, shareholders cannot know whether poor returns are

> a result of the manager's (in)ability or due to the fact that he has chosen a project with later cash flows . . . This is the primary reason why managers scramble to show quick results.[24]

Michael T. Jacobs, former Director of the US Treasury Department's Office of Corporate Finance, has recently published a book arguing that agency problems associated with a weakening of equity ownership rights and misdirected regulatory policies have led to a spread of corporate myopia and a loss of competitiveness.[25] Jacobs faults the proliferation of antitakeover laws (40 states have adopted or strengthened such statutes in recent years) and the demise of 'relationship banking' for the rise of short-term thinking on the part of top management. According to Jacobs, without effective oversight by providers of capital or the discipline of possible removal through a hostile takeover, managers often fail to make the most of the corporate assets they deploy.

Lambert has shown how, in a principal–agent framework, executives may underinvest in relatively risky projects if they perceive those projects to have a potentially negative impact on their own welfare.[26] In Lambert's representation of the situation, a conflict of interest exists because even if the principal can observe which projects are selected, the principal cannot know *why* they were selected. The effort that must be expended by the manager to discover information about projects is inextricably bound up with project selection, so the preferred contracts between owner and manager are second best. Interestingly, there are gains to both the manager and the owner from improvement of communication between them. Transmission of information about the profitability of projects may be costly, executives may not be able to articulate the information, or the principal may not be able to understand it.[27] These features may well characterize certain energy saving investments.

A similar rationale for a bias in favour of projects with rapid paybacks arises when moral hazard is present in the agency relationship. Suppose the cash flows of investment projects depend on a combination of the effort expended by management and a random state of nature unknown at the time the level of effort is selected. Moral hazard is present if the principal (the owner) cannot observe either the manager's effort or the random state of nature *ex post*, and the manager has disutility for effort.[28] In this case, projects with more rapid paybacks may enable the owner to set contract terms for the manager that control the moral hazard at lower cost:

> Usually, the manager's second-period compensation is optimally a function of both first- and second-period cash flow realizations; i.e., intertemporal linkages are optimal. The first-period compensation is always a function of the first-period cash flow. Hence, the second-period compensation is riskier in an ex-ante sense. So, an owner who wants to motivate a manager strongly in the second period to fully extract the project's economic value must impose more risk on the manager than if the owner had little value to extract in the second period. In this case, a faster payback project helps because its dominant value source is the first-period cash flow. Consequently, the faster payback project may optimally impose less contracting risk on the manager and result in lower contracting costs for the owner.[29]

The specific results of this model require risk aversion on the part of the manager (to rule out a pure rental contract under which the principal gets a fixed payment and the manager absorbs all risk) and the feature that the manager's effort affects the probability of the project's success rather than the cash flow from the project if it is successful. These details aside, the underlying idea that is common to these models is that the owner's general problem of acquiring information and exercising control leads to second-best expedients that may maximize profits subject to the organizational constraints, but which are not first-best solutions that would optimize the allocation of resources given full information and complete coincidence of interests between the owner and management.

Problems of focus and attention

Another hypothesis frequently offered to explain the failure of firms to exploit fully the cost saving energy investments available to them is that top management gives low priority to relatively small cost cutting projects (including energy saving ones). In reviewing the Alliance to Save Energy's detailed survey of energy investment practices in 15 industrial firms, Ross reports that

> [t]op corporate management is preoccupied with many other responsibilities and assigns low priority to cost cutting. Also top management feels unable to decentralize or delegate open-ended responsibility for investment in smaller projects, especially since information and decision costs for smaller projects are relatively high.[30]

The same problem of focus and priority applies to the oversight of federal government managers, and is referred to frequently in the literature on energy conservation.[31]

This problem is related to the obstacles that arise under the 'satisficing' paradigm, in the sense that management attention and resources are scarce and must be concentrated on those areas deemed crucial to the survival of the firm – expansion or preservation of market share in its main product lines, strategic development of new products and markets, and compliance with legally mandated environmental or workplace safety controls. Given limits to the amount of work that can be accomplished by those responsible for the firm's investment decisions, it is not surprising that some classes of investments (ie small projects seen as peripheral to the main thrust of the firm) get short shrift.

There are also difficulties in monitoring the savings achieved by energy management investments. A large part of corporate energy usage is tied to factors that vary unevenly over time, such as the weather or state of the economy. It is often not simple to separate the effects of changes in energy management policy from changes in these external factors. If energy management has not been a priority in the past, then the historical data needed for comparisons will be lacking.

Firms may not be able costlessly to expand or contract their management team in such a way that all the managers are optimally occupied at all times. Too much instability in the make up of management can have adverse effects on morale and, indirectly, on a firm's reputation in the market for management services. Because of training costs and the value of firm-specific human capital, employment is not perfectly correlated with output over the course of the business cycle, and similar considerations preclude a perfect match between tasks and management resources.

Statistical or selection bias in estimating investment returns

Information problems can affect the setting of investment criteria by management in another way. If the estimated returns to most types of prospective investment projects are biased systematically upward, then management may impose a hurdle rate greater than the firm's cost of capital to ensure that the returns actually realized on projects undertaken are high enough to be profitable. Such a policy could inhibit energy-efficiency investments whose returns are forecast accurately, if management fails to distinguish them from the projects whose forecast returns are upwardly biased.

Even if cost and revenue estimates for proposed projects are unbiased, it is natural to suppose that projects with higher anticipated rates of return will be the ones that tend to be selected. As a result, the selection of projects from the universe of proposals is not an unbiased sample. Some projects will be selected because they actually do have higher returns, but others will be selected because their actual returns have been overestimated. As a result, the returns on the projects selected will be lower, on average, than their projected returns.[32] Selection bias can lead to cost overruns even if the cost estimates themselves are unbiased and decision makers utilize all available information optimally.[33] This possibility could lead management to screen out some profitable low risk energy investments in the course of compensating for the general selection bias.

In addition, it is not necessarily the case that cost and revenue estimates of projects will be unbiased. Both experimental and survey evidence suggest the opposite. Statman and Tyebjee report that decision makers with prior work experience believe that investment project proposals embody an optimistic bias.[34] They find that their results are consistent with Miller's hypothesis 'that decision makers have information, gained from experience, about prior probabilities, and that this experience is not available to forecasters.'[35] These experimental results were confirmed in a survey of 121 Fortune 500 companies.[36] The survey found that nearly 80% of the respondents believed that revenue forecasts of capital budgeting proposals are typically overstated. One group of respondents

> suggested that the optimistic bias resulted primarily from 'myopic euphoria' in which the individuals responsible for preparation of the forecasts were simply too involved with the projects to be totally objective,

while another group 'felt that the optimistic bias resulted from erroneous initial information provided to forecasting staff members by *upper-level* managerial personnel' – the 'pet project' phenomenon.[37] Worries about either type of informational bias might lead managers to set overly strict criteria for new investments, thereby blocking some profitable energy saving projects.

Policy implications

None of the explanations for the existence of barriers to energy saving investments discussed in the previous section relies on irrationality or managerial irresponsibility to account for the missed profit opportunities. Yet paradoxically, the prevalence of incentive, information and organizational control problems suggests a number of areas in which government policy can make a difference. What may be required is to step away from the traditional regulatory approach and to seek precedents in some other kinds of government action not always thought of as closely related to environmental protection goals.

Government as a clearing house for information

Because of its central position and data gathering mandates, government is ideally situated to serve as a repository and distribution point for information on energy technologies. Private-sector firms often find it difficult to acquire knowledge about the set of technological options open to them, and to evaluate the characteristics of the technologies that do exist. Government agencies such as the EPA and the Department of Energy can efficiently collect, maintain, and disseminate information about energy saving possibilities. Libraries, archives, and electronic databases are universally recognized as having strong public goods features, and as such are likely to be provided best by government.

The information gathering and distribution function can directly work to lower the intrafirm barriers to efficient energy management. Providing information can help diminish the adverse effects of the principal–agent problem within firms. Many inefficiencies stem from the principal's problems in distinguishing between the effects of management decisions and the state of the world. For example, owners (or top management) may require a high hurdle rate as a second-best strategy to cope with incentive and control problems, even if this means forgoing some projects with rates of return closer to (but still above) the firm's cost of capital. (See the discussion above.) By providing good information about the economic performance of energy saving investments, government can enable both owners and management to make decisions based on realistic assessments of what those investments are likely to yield. In a similar vein, by publicizing the results of typical or representative energy saving investments, government can actually reduce the perceived risk of similar investments by firms slow to adopt the new technologies.

Management consulting

Government has large amounts of information, experience and talent at its disposal, and there is no reason why this concentrated expertise cannot be made useful to business firms. Even given a policy agenda that is distinct from the profit making objective of the private firms, government's knowhow and knowledge base can be an extremely valuable resource for the private sector.

An interesting historical example of the gains available through this channel is the case of the agricultural experiment stations. Established in each state in 1887 and supported with federal funds, the stations provided local farmers with information about plant and animal varieties, feeds and fertilizers, and best agricultural practices as they were known at the time. The agricultural experiment stations were able to balance the tension between centralized administration and the need to adapt to local variations:

> So long as communication among stations was good, and a sophisticated awareness of the limited transferability of results from one state to another was present, the system of state stations could rest like a centipede on American ground, with many feet and one body, moving as a unit, but adapting at each point to local conditions.[38]

The agricultural experiment stations were highly successful in disseminating practical technological information to a diverse and geographically dispersed population – the millions of farmers who were their targeted clientele. The productivity gains resulting from the stations' efforts were large and sustained.[39] It is not difficult to visualize a network of industrial experiment stations, demonstrating (among other things) energy-efficient technologies, serving the same sort of function in the present day economy.

The EPA has already launched a project that fits this conceptual framework – the Green Lights Program. Begun in 1991, Green Lights is a voluntary programme designed to encourage major corporations to undertake energy saving lighting upgrades that:

- maintain or improve lighting quality;
- embody the latest energy saving technology; and
- meet a profitability criterion consistent with the goal of shareholder wealth maximization.

In return for a corporate commitment to survey facilities and make the indicated lighting investments over a five-year period, the EPA provides technical information, current data on utility rebate programmes nationwide, and advertising and public relations support. In addition, EPA has developed a sophisticated and powerful expert system that can assist participating companies in analysing their lighting needs and performing economic analyses of the upgrade possibilities. Green Lights has been highly successful to date, with over 140 major corporations joining in the first year of the programme's operation.[40]

Another way in which the government can contribute to improvement of energy management practices is to suggest methods of overcoming the incentive barriers within firms. For example, the problems of focus, small scale, and lack of connection to central business objectives of the firm could be overcome if firms were to set up internal energy management profit centres. Such organizational units could consolidate projects, lend funds internally, monitor energy use, and raise energy management to the strategic priority level by acting as independent profit centres within decentralized corporations. It is within the mandate of the EPA to encourage firms to experiment with establishment of such divisions, and to share the experiences obtained from such experiments throughout the economy.

Serving as a rallying point

In any modern society, the central government is uniquely positioned as the focal point of general societal preoccupations. Simply to have the government pay attention to an issue is often sufficient to make that issue salient. The environmental concerns that are linked to generation of energy by fossil fuel combustion can be channelled by the government's giving those concerns visibility and standing.

Changes in corporate policy usually require an individual or group to champion the change. It is a fact of bureaucratic politics that efforts by such a group stand a much better chance of success if the group can point to similar efforts being made by other firms, and if the group can link its proposals to values widely shared within the corporation. The government can advance initiatives for change both by communicating directly with top management (because top management will be attentive to signals coming from the government) and by providing a frame of reference for the discussion of new initiatives. Environmental protection is broadly supported at all levels of the management of most firms, and government attention can help overcome some of the organizational inertia that slows down adoption of corporate policies to benefit the environment. Also, firms realize that because of the diffuse nature of many of the most important environmental externalities, joint action across geographical, sectoral, and even national boundaries is required for effective action. Knowing that the government is giving priority to a particular externality (such as that associated with energy production from fossil fuels) makes it more rational for a firm to adopt environmental protection measures than if it were acting alone.

Conclusion

We have seen that because of problems of information and control, a well managed corporation may still have available to it profitable opportunities that it finds difficult to realize. One task of management is to ferret out such opportunities and overcome the barriers to them. Even so, a large number of potentially profitable projects, including some that would capture substantial energy savings, fail to be undertaken.

Competitive pressure in the immediate product market in the form of potential market entry by other firms, or the possibility of changes in management through the market for corporate control, exert some pressure for efficiency. At the same time, however, the firm is shaped by internal informational and incentive factors having little to do with the neoclassical optimization paradigm. The profitability performance of the firm is influenced as much by its structure, governance, and organization as by its adherence to any set of mechanically applicable procedures for maximization of profit with a given technology.

In this context, a societal drive for greater energy efficiency can be seen as a opportunity for innovation. As shown above, non-regulatory governmental programmes to improve corporate decision making can provide benefits regardless of the specific purpose of the government's initiatives. In the case of energy efficiency, there is an added benefit. Current fossil fuel energy production technologies increase the kinds of pollution that contribute to global warming, acid precipitation and urban smog. Increasing corporate profits by improving energy efficiency can thus raise the level of society's wealth while simultaneously helping to ensure that the standard of living we now enjoy can be sustained for future generations.

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[2]US Congress, Office of Technology Assessment, *Energy Efficiency in the Federal Government: Government by Good Example?*, OTA-E-492, Washington, DC, US Government Printing Office, 1991.

[3]For resistance by residential consumers see Fereidoon P. Sioshansi, 'The myths and facts of energy efficiency', *Energy Policy*, Vol 19, No 3, April 1991, pp 231–243; *op cit*, Ref 1, Rosenfeld and Hafemeister. Hausman found an average population annual discount rate of 26.4% for the purchase of room air conditioners, with discount rates for low income family groups ranging from 39% to 89%: see Jerry A. Hausman, 'Individual discount rates and the purchase and utilization of energy-using durables', *The Bell Journal of Economics*, Vol 10, No 1, 1979, pp 33–54. Hartman and Doane found an implicit average discount rate of 31.6% for household weatherization investments, with low-income households exhibiting rates greater than 70%: Raymond S. Hartman and Michael J. Doane, 'Household discount rates revisited', *The Energy Journal*, Vol 7, No 1, January 1986, pp 139–148. For industrial corporations see James L. Wolf, Michael Reid, Robin M. Miller and Ellen Jo Fleming, *Industrial Investment in Energy Efficiency: Opportunities, Management Practices, and Tax Incentives*, Alliance to Save Energy, Washington, DC, 1983.

[4]For a valuable survey stressing explanations based on market imperfections and failures of individual rationality, see John B. Robinson, 'The proof of the pudding: making energy efficiency work', *Energy Policy*, Vol 19, No 7, September 1991, pp 631–645. My focus will be on the corporate sector rather than on households, and on the reasons business firms fail to realize their profitable energy saving opportunities even though the members of the firms are rational agents.

[5]The quotation is from Mancur Olson's path-breaking monograph, *The Logic of Collective Action: Public Goods and the Theory of Groups*, Cambridge, MA, Harvard University Press, 1965, 1971 (italics in the original). The notion that collective action will in general be suboptimal is well understood in the literature of public choice. See, for example, William H. Riker and Peter C. Ordeshook, *Positive Political Theory*, Prentice-Hall, Englewood Cliffs, NJ, 1973.

[6]Herbert A. Simon, 'Theories of bounded rationality', in C.B. McGuire and R. Radner, eds, *Decision and Organization*, North-Holland, Amsterdam, 1972, pp 161–176.

[7]Herbert A. Simon, 'Rational decision making in business organizations', *The American Economic Review*, Vol 69, No 4, September 1979, pp 493–513.

[8]It has been argued by Jensen and Meckling that satisficing

behaviour is really only maximizing behaviour in the presence of search, transactions and computation costs: Michael C. Jensen and William H. Meckling, 'Theory of the firm: managerial behavior, agency costs and ownership structure', *Journal of Financial Economics*, Vol 3, No 4, October 1976, pp 305–360. If 'costs' are defined to include those that are not measurable, this statement is tautological. For purposes of policy analysis or for direction of the operations of firms, it makes no substantive analytical difference whether the effects of such intangible or non-measurable costs are treated as deviations from profit maximization. A satisficing firm does the best it can under its unique circumstances.

[9]Adolf A. Berle and Gardiner C. Means, *The Modern Corporation and Private Property*, New York, The MacMillan Company, 1932. Jensen and Meckling *op cit*, Ref 8, cite the pertinent passage in Adam Smith:

The directors of such [joint-stock] companies, however, being the managers rather of other people's money than of their own, it cannot well be expected, that they should watch over it with the same anxious vigilance with which the partners in a private copartnery frequently watch over their own. Like the stewards of a rich man, they are apt to consider attention to small matters as not for their master's honour, and very easily give themselves a dispensation from having it. Negligence and profusion, therefore, must always prevail, more or less, in the management of the affairs of such a company.

Adam Smith, *The Wealth of Nations*, Cannan Edition, New York, Modern Library, 1937, p 700 (originally published 1776). And thinking of this particular economic problem even predates Adam Smith, as in the Parables of the Silver Pieces [Matthew 25:14–30], the Wily Manager [Luke 16:1–8] and the Good Shepherd [John 10:6–13]: Catholic Biblical Association of America, *The New American Bible: Translated from the Original Languages with Critical Use of All the Ancient Sources*, New York, P.J. Kenedy and Sons, 1970. For a useful survey of antecedents, see Oliver Williamson, *The Economics of Discretionary Behavior: Managerial Objectives in a Theory of the Firm*, Prentice-Hall, Englewood Cliffs, NJ, 1964.

[10]James Poterba and Lawrence Summers, 'Time horizons of American firms: new evidence from a survey of CEOs', unpublished manuscript, Massachusetts Institute of Technology and Harvard University, 1991.

[11]These rates are expressed in real terms, that is, after removing the expected inflation component present in the nominal interest rates observed in the market.

[12]Environmental Protection Agency, *Green Lights Partner Questionnaire*, survey responses of 48 firms, xeroxed, Washington, DC, 1991.

[13]Assuming a marginal tax rate of 34% and full straight-line depreciation over the 10 year lifetime of the project.

[14]Alfred Rappaport, 'Executive incentives vs. corporate growth', *Harvard Business Review*, Vol 56, No 4, July–August, 1978, pp 81–88.

[15]Assuming that the manager's actions have no observable effect on the net worth of the corporation, as measured by the stock price, for example. For projects that are individually small, this condition is likely to hold.

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[17]*Ibid*, citing D.F. Larcker, *The Association between Performance Plan Adoption and Corporate Capital Investment*, Working paper, Northwestern University, 1980.

[18]George E. Pinches, 'Myopia, capital budgeting, and decision making', *Financial Management*, Autumn 1982, pp 6–19. The quotation is from page 13.

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[20]M. Harris, C.H. Kriebel and A. Raviv, 'Asymmetric information, incentives and intrafirm resource allocations', *Management Science*, Vol 28, No 6, June 1982, pp 604–620.

[21]Rick Antle and Gary D. Eppen, 'Capital rationing and organizational slack in capital budgeting', *Management Science*, Vol 31, No 2, February 1985, pp 163–174.

[21]M.P. Narayanan, 'Observability and the payback criterion', *Journal of Business*, Vol 28, No 3, July 1985, pp 309–323.

[23]*Ibid*, p 310.

[24]*Ibid*, p 319.

[25]Michael T. Jacobs, *Short-Term America: The Causes and Cures of Our Business Myopia*, Boston, Harvard Business School Press, 1991.

[26]Richard A. Lambert, 'Executive effort and selection of risky projects', *Rand Journal of Economics*, Vol 17, No 1, Spring 1986, pp 77–88.

[27]*Ibid*, p 85.

[28]This definition, and the remainder of this paragraph, is drawn from Paul K. Chaney, 'Moral hazard and capital budgeting', *The Journal of Financial Research*, Vol 12, No 2, Summer 1989, pp 113–128.

[29]*Ibid*, p 119.

[30]Marc Ross, 'Perspectives on capital budgeting', *Financial Management*, Vol 15, No 4, Winter 1986, p 20.

[31]*Op cit*, Ref 2. Peter G. Sassone and Michael V. Martucci, 'Industrial energy conservation: the reasons behind the decisions', *Energy*, Vol 9, No 5, May 1984, pp 427–437; *op cit*, Ref 3, Wolf. Low priority for energy investments is also a prevalent situation in other countries, both developed and developing. See Mark D. Levine, Stephen P. Meyers and Thomas Wilbanks, 'Energy efficiency and developing countries', *Environmental Science and Technology*, Vol 25, No 4, April 1991, pp 584–589; R. Aburas, 'Energy conservation policies in Jordan', *Energy Policy*, Vol 17, No 6, December 1989, pp 591–598; and Jane Carter, 'Energy conservation in the United Kingdom: a major industrial opportunity', *The Energy Journal*, Vol 5, No 1, 1984, pp 149–158.

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[36]Stephen W. Pruitt and Lawrence J. Gitman, 'Capital budgeting forecast biases: evidence from the Fortune 500', *Financial Management*, Vol 16, No 1, Spring 1987, pp 46–51.

[37]*Ibid*, pp 47–49.

[38]William N. Parker and Stephen J. DeCanio, 'Two hidden sources of productivity growth in American agriculture, 1860–1930', *Agricultural History*, Vol 56, No 4, October 1982, p 651.

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October 2007

Ontario Power Authority

Energy Efficiency Barriers in Ontario

Listening to the 'Interval Meter Customer' View

Prepared by:
Energy @ Work
www.energy-efficiency.com
416.402.0525

Attention:
Peter Love
Chief Energy Conservation Officer
Ontario Power Authority
Suite 1600
120 Adelaide Street West
Toronto, ON M5H 1T1
416.967.7474 (Main telephone)
1.800.797.9604 (Toll free)

Executive Summary

Ontario Power Authority (OPA) requested **Energy @ Work** to canvass 'interval meter' customers and help determine their barriers to achieving energy efficiency. Ontario faces even more acute challenges in this area than many other jurisdictions in North America as electrical energy efficiency has been largely abandoned in the province, particularly since deregulation.

- *Interval meter customers represent about 30% of Ontario's energy usage and have potentially the greatest energy efficiency savings opportunity in the short term (1-5 years).*
- *Energy efficiency 'economic potential' is approximately 30% for the commercial sector and 8-15% for the industrial sector.*
- *Several interval meter customers, in each sector, have demonstrated this or greater potential and agreed to share insights into the barriers that they needed to overcome.*

A meeting in mid-July 2007 was held with several leading mid-sized interval meter customers to identify and discuss those barriers that particularly affect them. The barriers evolved into both 'macro barriers' and 'micro barriers':

- **Macro barriers**: those broader issues that fall within the scope of policy makers, regulators and program administrators. ***Most interval meter customers find these barriers to be complex, confusing and beyond their ability to affect.*** They preferred to have the confidence that a 'system' is working efficiently on their behalf without requiring an understanding of the specific issues. This confidence would be achieved by ensuring that a transparent system is in place which would weigh the true costs and benefits of energy efficiency against supply options.

- **Micro barriers**: those issues faced by customers at the facility level. These barriers exist as a result of **"too few resources chasing too many projects"** (resources were considered to include people and funding). Overcoming these barriers requires a range of solutions, including assistance from conservation and demand management (CDM) programs that are developed in response to their challenges i.e., incentives, tools, etc. and presented in the 'customer language'.

Ontario initiated a number of steps to improve efficiency. This included the $163 million spent on electricity CDM between 2004 and September 2007 by Ontario's utilities. The <u>successes and failures</u> from this investment, and the kW and kWh reductions achieved, need to be <u>leveraged, i.e. use the lessons to achieve greater success</u>. Customers recognize that waste is no longer acceptable and propose principles built around the following three concepts:

Vision: Ensure investment is directed to practical solutions that benefit the customers' needs.
Transparent Investment: Since the value of a kW 'reduced' is much greater than a kW of 'new' generation, criteria for investment should be the same and clearly laid out, i.e., transparent.
Experience: Leverage success strategies by partnering and sharing rather than re-inventing.

Interval meter customers volunteered their time & assistance to assist in identifying barriers to Energy Efficiency in Ontario.
Together, they are prepared to work with the OPA and others to identify optimum solutions and they appreciate <u>having their voice listened to.</u>

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Contact: Scott.Rouse@Energy-Efficiency.com, 416 402-0525

Disclaimer

The views and opinions expressed in this report are the sole responsibility of Energy @ Work and not the Ontario Power Authority or any other person acting on behalf of a company or organization, either directly or implied.

Contact: Scott.Rouse@Energy-Efficiency.com, 416 402-0525

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The willingness of participants in the 'interval meter sector' to step forward and share their insights and experience, and provide suggestions is particularly rewarding.

Contributors:

Representative	*Company*	*Description*
Doug Dittburner	Molson Coors Ltd.	Manufacturing
Fred Ware	Hudson's Bay Company	Retail
Bill Braun	Northam Realty Advisors Ltd.	Property management
Geoff Knowles	Cadillac Fairview Corporation Ltd.	Property management
Paul Hollins	GWL Realty Inc.	Property management
Gary Robinson	Purolator Courier Ltd.	Courier
Rob Furlan	Cadillac Fairview Corporation Ltd.	Property management
Blair Fraser	Hymopack Ltd.	Manufacturing
Scott Marshall	Techform Products Ltd.	Manufacturing
Fred Leonenko	Confederation Freezers	Cold storage
Al Smith	Toromont Cat	Manufacturing
Conan O'Connor	Energy @ Work	Energy efficiency partner
Don Harvey	Cadillac Fairview Corporation Ltd.	Property management
Patricia Squires	Enbridge Inc.	Energy Services
Tim Short	Enbridge Inc.	Energy Services

We are very grateful for the input and advice from the above.

If there are any lessons learned that result in helping to remove barriers to energy efficiency the credit belongs to those who shared their experiences and reviewed and commented on this report.

Factual errors or misrepresentations are sole responsibility of Energy @ Work.

This report was compiled by Scott Rouse and edited by Benjamin Nolan of Energy @ Work.

Comments should be directed to: **Scott.Rouse@Energy-Efficiency.com**

1.0 Introduction

Ontario's competitive position is threatened by rising energy prices, environmental pressures, and global competition. It is now necessary to 'achieve more with less', be socially responsible, while improving our environment. Conservation and Demand Management (CDM) programs, i.e., help to reduce wasted energy (kWh) and demand (kW), are a respected and recognized strategy that more and more jurisdictions are investing in. The results from CDM are proven and as reliable as supply solutions in delivering sustainable benefits. Investment becomes a natural win-win-win for government, business and Ontario rate payers.

To improve the effectiveness of this investment it is particularly important to remove the barriers that impact interval meter customers' ability to pursue CDM.

The Ontario Power Authority (OPA) requested the assistance of Energy @ Work in identifying these barriers to energy efficiency. To do this Energy @ Work was requested to initiate a dialogue with interval meter customers that represented a cross section of sectors.

A meeting with several mid-sized commercial and industrial interval meter customers was organized for 17 July 2007 and held at the OPA offices, as shown in the acknowledgements.

The objectives of the meeting were four fold:

- Review current OPA programs;
- Discuss interval meter customer issues surrounding the pursuit of energy efficiency;
- Discuss the barriers to energy efficiency identified by the OPA; and
- Discuss interval meter customer barriers as well as additional barriers to energy efficiency.

Participants are noted contributors to the achievement of energy efficiency within their sector. They possess a solid understanding of the issues, challenges and barriers to achieving energy efficiency and a 'working' knowledge of the electrical industry.

The meeting was arranged with the OPA's support and at the voluntary effort of the participants. Time was extremely limited as the meeting was held during the busy summer period.

This report summarizes the personal observations and opinions on the status of Ontario's energy market as it relates to the participants with support from available references. Several overriding facts that emerged should be noted immediately:

- ***For the most part, engagement among interval meter customers on the issue of energy efficiency is low. For most customers, achieving energy efficiency solutions is not a priority and treated the same as other investments, with one exception. Energy efficiency investment decisions are typically based on a simple payback, thus ignoring cost of money/savings, tax benefits, etc. The participants for this report were selected because of their enthusiasm for energy efficiency along with their exceptional contributions.***

- ***There is a significant lack of understanding of how Ontario's electricity sector operates which has only increased since deregulation.***

- ***Achieving sustainable energy efficiency solutions requires hard work, a high level of commitment, and the allocation of scarce resources. Customers recognize that it is their responsibility, but also that solutions go beyond raising/lowering set point temperatures or just turning off lights..***

- ***Market complexities need to be properly understood, communicated and valued before barriers can be overcome and sustainable solutions can be realized. This will require greater cooperation and support from government departments and the energy sector. Success can be enhanced through a strategy that 'leverages' experience and lessons learned instead of trying to reinvent the wheel.***

- ***An approach that favours customer benefits first will maximize economic prosperity, environmental performance and demonstrate social responsibility;***
  – <u>a triple bottom line that offers benefits for everyone to share.</u>

1.1 Background

Energy @ Work (E @ W) was asked by the OPA to canvass industrial and commercial customers for information on the barriers to energy efficiency that they face. To this end E @ W approached sector leaders who were familiar with the challenges and opportunities relating to the pursuit of energy efficiency and arranged a meeting to solicit their input.

The OPA requested that the focus be specific to mid-size interval meter customers that are subject to the Hourly Ontario Energy Price (HOEP) – as opposed to the Municipalities, Universities, Schools, and Hospitals (MUSH) sector or any of the largest wholesale customers, i.e., referred to as 'market participants' by the Independent Electricity System Operator (IESO). Participants represented the mid-size sector with the exception of Enbridge which has been proactive in the area of energy efficiency. Enbridge's experience brought an informed perspective on the challenges. Peter Love, Ontario's Chief Energy Conservation Officer, suggested involving Enbridge because of their proactive commitment to, and engagement with, interval meter customers.

Deliverables:

1) *Organizing and conducting a two hour meeting with midsized interval meter customers at the OPA offices on 17 July 2007 to review and exchange experiences on energy efficiency.*

2) *A report which identifies and offers suggestions on dealing with the barriers faced by interval meter customers by summarizing the results of the meeting, follow up discussions, and comments, along with supporting information.*

General comments:

It is clear that there is interest among selected interval meter customers to achieve energy efficiency. After explaining the objectives, several agreed to cooperate with the OPA to help identify the challenges their sector has in pursuing energy efficiency initiatives. Other participants declined. The discussion at the meeting was seen as a first step towards a much needed improvement in communication between interval meter customers and the OPA.

The barriers that utility, 'regulators' or crown corporations perceive are often very different from the barriers that the business sector is confronted with.

The initial reaction from participants to the OPA's suggested list of barriers was disinterest. Participants did not relate to the issues, finding the barriers to be overly academic and out of context to their operation. In response to this concern, OPA agreed that all barriers should be reviewed, and discussion was broadened to include barriers identified by the interval meter customers including those barriers that exist outside of the OPA's framework.

Once the meeting was held and discussion began to flow, there was overwhelming agreement on several common elements:

- Energy efficiency needs to be supported and improved to benefit Ontario;
- Significant opportunities exist to improve energy efficiency;
- Lessons are available and should be harnessed. It is not necessary to reinvent every solution;
- Solutions must be sustainable and deliver triple bottom line benefits; i.e.,
  (1) economics,
  (2) the environment, and
  (3) social responsibility;
- Better effort is needed to mobilize and coordinate the limited resources in order to achieve Ontario's full energy efficiency potential.

The participants agreed that the meeting was an effective way to identify valuable information and to improve the necessary dialogue to help deliver results – provided that their voice is listened to.

1.2 Definition of an Interval Meter Customer

Ontario's electricity customers are distributed approximately as follows (measured by energy consumption)*:

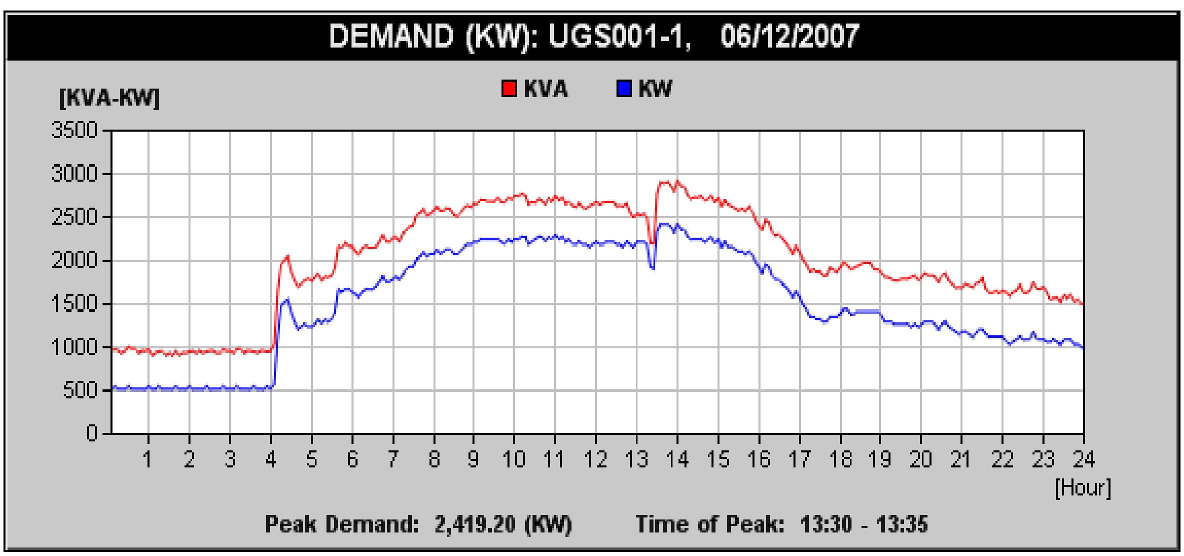
1/3	*Large Users*	*About one hundred accounts (interval meter)*
1/3	*Medium, MUSH and Commercial*	*Thousands of accounts (interval & non-interval)*
1/3	*Residential*	*Millions of accounts (non-interval meter)*

Interval meter customers pay for their electricity consumption on an hourly basis according to the Hourly Ontario Energy Prices (HOEP). The HOEP is determined through a competitive process in which generators bid to supply electricity to the market on a five minute basis which is aggregated to the HOEP. The HOEP ($/kWh) fluctuates throughout the day according to supply and demand. Price 'spikes' can happen at any time during the day from a wide range of reasons, including high system demand, a generator goes off line, a transmission line is interrupted, etc.

The electricity price for each hour is applied to the customer's hourly consumption which determines the actual hourly cost. The impact on cost ($$) by both the use (kW & kWh) and price ($$/kWh) is illustrated below, (courtesy of UGSProfiler):

Figure 1 illustrates the daily demand (kW) and the apparent power (kilovolt-amps, or kVA) for a sample interval meter customer. Note: The difference between kW and kVA is the power factor. Most utilities now charge a power factor penalty, i.e., charging for kVa rather than kW. Too often the impact of a poor power factor is hidden because the information is not clearly shown on the utility bill or hidden by not providing clear units.

Figure 1: Demand (kW) and Apparent Power (kVa)



* Supply side energy consumption is not reported, but estimated on the order of 10% for transmission and distribution use/loss. Generation efficiency is on the order of 30% to 40%.

Figure 2 provides energy consumption (kWh) as well as the Hourly Ontario Energy Price (HOEP) $/kWh.

Note: The hourly energy use (kWh) will vary based on a number of factors. The HOEP's price is volatile and unpredictable.

The combination of use and price determines the cost.

Of critical importance in taking advantage of Ontario's deregulated electricity market is the ability to control use, demand, etc. The OPA programs for conservation, load shifting, demand response, etc. offers excellent potential to manage their utilities – providing there is access to this information.

Figure 2: Electrical Use (kWh) and HOEP ($/kWh) Price

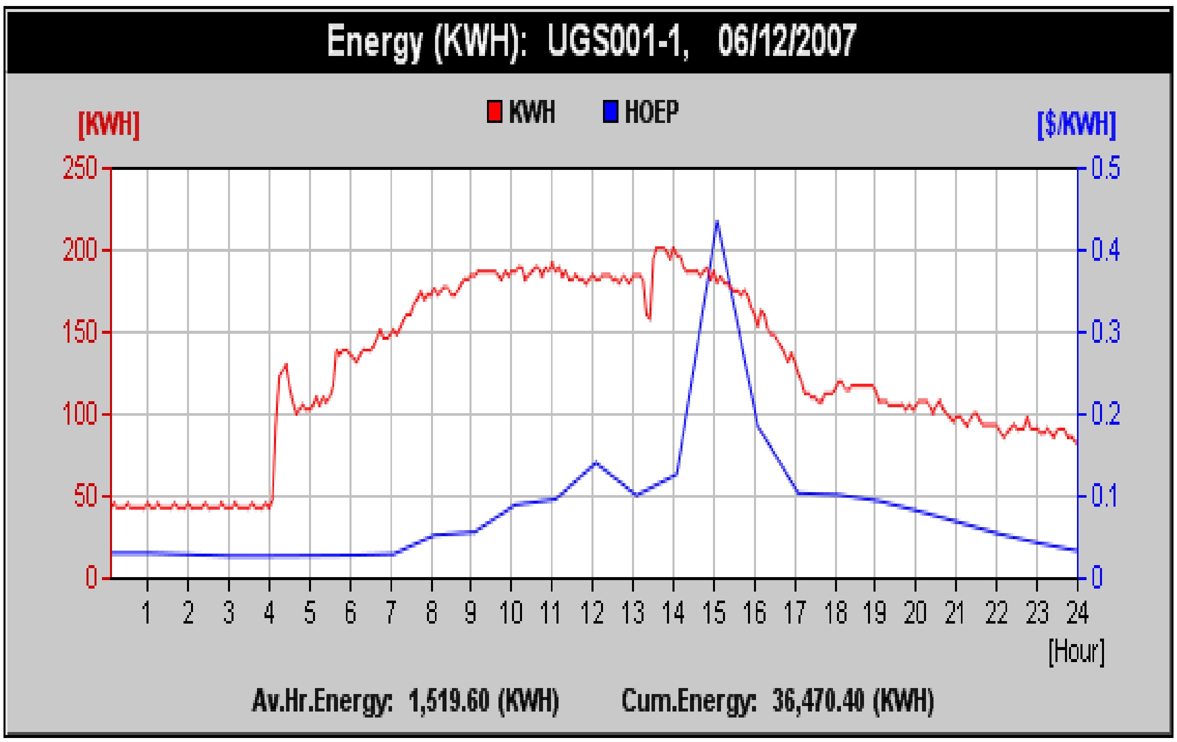
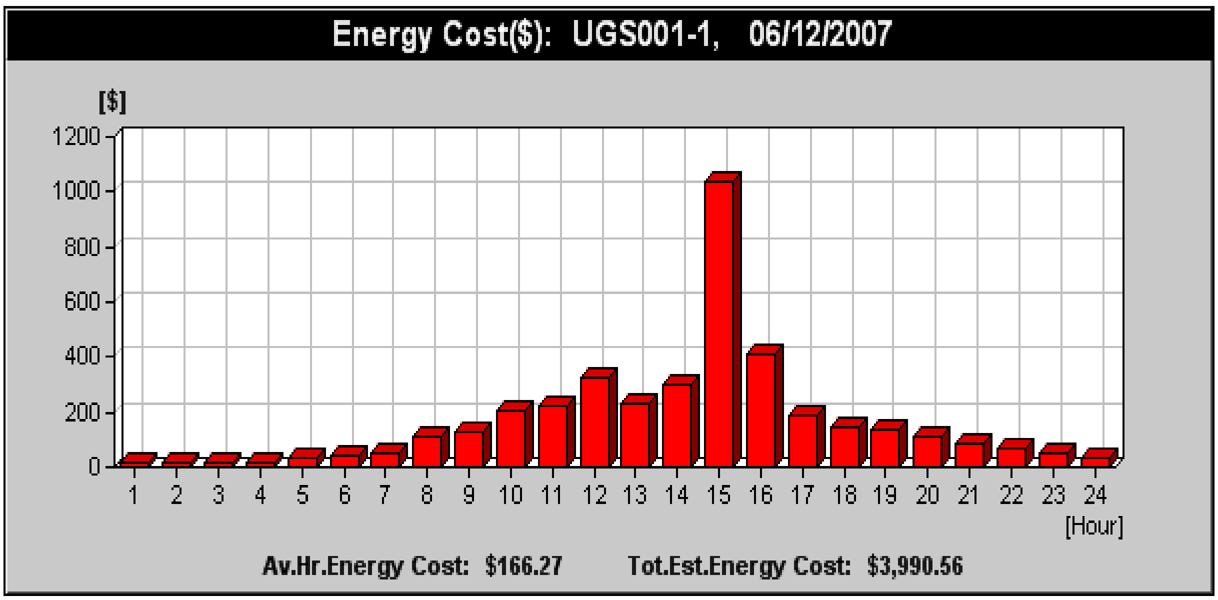


Figure 3 provides the energy cost on an hourly basis and illustrates the wide variability of cost, i.e., hour 15's cost is 5 times the cost of preceding hours because a price spike start in hour 14 and came back down in hour 16.

Unfortunately, the majority of interval meter customers do not realize this since the utility reports the 'average' price and use.

The costs for each hour will vary and can not be predicted. Having the tools, strategies and incentives can reduce costs, but utility meter information must be available and easy to access.

Figure 3: Daily Electrical Cost for 24 hours



Perhaps the biggest challenge faced by interval meter customers is the lack of detailed consumption information. Very few interval meter customers have access to real time data on their energy use and costs or realize the value of having this information. Obtaining real time information requires access to the interval meter which the utility controls and often makes it difficult to obtain.

Day delayed information on past consumption is typically available, but the systems are often difficult to use because of awkward interfaces, slow refresh times and frequent system interruptions. The dated data also requires additional steps to compile in such a way that makes it possible to assess the true impact of price/use/cost.[†]

[†] Information on this topic is available online. The article at the following link is of particular note: http://www.energypulse.net/centers/article/article_display.cfm?a_id=430

Figure 4 provides utility consumption statements (as seen below) can be included with real time monitoring. These "shadow bills" provide broader information than is available in the utility bill and can be compared against the utility bill to (1) find errors, (2) meet bill verification needs, and (3) to help better understand billing complexities. Again, this function requires access to the utility meter.

Figure 4: 'Shadow' Electric Bill

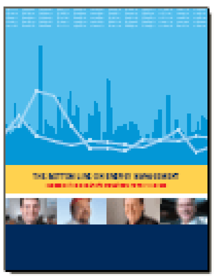
ELECTRIC DETAILS	Quantity	Rate	Cost
Energy Consumption	926,475.38(KWH) @	$0.0523	$48,417.07
Wholesale Market Services	926,475.38(KWH) @	$0.0062	$5,744.15
Debt Retirement	885,901.14(KWH) @	$0.0070	$6,201.31
Transmission Network Service	2,813.18(KW) @	$2.2508	$6,331.92
Transmission Connection	2,813.18(KW) @	$1.9763	$5,559.70
Transformer Allowance	2,813.18(KW) @	$-0.6000	($1,687.91)
Distribution charge	2,813.18(KW) @	$2.6487	$7,451.28
StandBy charge	0.00(KW) @	$0.0000	$0.00
Provincial Benefit	926,475.38(KWH) @	$0.0098	$9,079.46
Market Transition Charge	2,813.18(KW) @	$0.0000	$0.00
Customer fixed charge			$54.19
SSS Administration Fee			$0.25
New Facility charge			$242.00
Other charges			$0.00
GST			$5,243.60
Total Current Charges			**$92,637.01**

- The utility statement will vary depending on the utility company and typically provides little help in managing energy. The utility will show the 'average' use (kWh) and the 'average' rate ($/kWh). The variability of energy use and price – and thus the consequence on cost – is therefore masked.

- Additional problems with the utility statements include missing billing units, power factor, etc. Tracking such information is critical to pursuing energy efficiency. Further, the lack of a standard format between utilities often hinders the customers' ability to spot billing errors or inaccuracies.

- ***A further challenge lies in understanding the complicated utility rate structure. The 90+ utilities in Ontario have individually approved rate structures. Even when a barrier is identified the customer has limited choices. Once the Ontario Energy Board approves the rate structure there is no redress opportunity until the next rate hearing. Upon learning that there is no option, the frustration with electricity management is enhanced. This barrier is particularly important for HOEP customers because they typically are not aware, or represented or even how to participate in the rate hearing approval process.***

Ontario's deregulation created a new paradigm. Interval meter customers no longer have the information services available that Ontario Hydro once provided as part of the regulated electricity market. Services that were designed to help understand consumption, billing, rates, market changes, etc. are gone. This is particularly true for energy efficiency information.



Several references are being introduced, including this IESO publication: "The Bottom Line on Energy Management". There is the need to see more, but in the customer's language (http://www.ieso.ca/imoweb/pubs/bi/em_bottomLine.pdf).

Independent information is severely restricted, and even popular tools such as Ontario Hydro's product knowledge guides on Fans, Motors, etc have been largely lost or discontinued. Surprisingly, even those that have been updated, such as the Lighting and Power Quality guides (available at: www.energy-efficiency.com) are not being made accessible.

Reinvestment in Ontario's electricity sector represents an opportunity to revitalize the pursuit of energy efficiency. What was once available can be reintroduced to the market, and new ideas that have worked in other jurisdictions can be applied. There is a wealth of energy efficiency opportunities that are proven and worth the investment.

2.0 Barriers Faced by Interval Meter Customers

2.1 Overview

Interval meter customers' first priority is to their core business (tenant comfort for commercial facilities, and production for industrial and manufacturing facilities.) As such, it is important to recognize that energy efficiency is one of many values that must be considered in the evaluation of projects. The following two statements were made in response to the original request for input and demonstrate the breadth of the issue of barriers from the business-consumer perspective:

1) Limited Resources:

"At the moment we are in a holding pattern on energy saving measures, it is an issue, but we have <u>too few funds chasing too many projects.</u>"

2) Value of Energy Efficiency compared to New Generation:

"…The government's focus seems to be on how we can facilitate energy efficiency, and the common denominator seems to be price. What's not fleshed out is 'what's the cost'. The difference in thinking is the major hurdle. We all know about the triple bottom line yet we can't seem to quantify its true cost. If we could do that then we could see the existing generators and the conservationists on a balanced playing field. ...I don't know what the formula is for the [true] cost, but I do know that a pound of CO2 costs something to society as well as raising water temperatures in the lake and atmosphere. This stuff is beyond me but what I do know is that <u>allowing generators not to deal with the (environmental and societal) cost makes it very difficult for the consumer to overcome the market price.</u>"

These statements highlight the two levels at which these barriers should be considered: micro (the facility level); and macro, (Ontario market issues).

There is increasing consensus that solutions to barriers at both the macro and micro levels should adopt new success criteria, called the 'Triple Bottom Line' benefits to evaluate options:

- Economic Prosperity: <u>calculate the internal rate of return.</u>
- Environmental Performance: <u>going beyond compliance to the big picture</u>.
- Social Responsibility: '<u>walk the talk</u>.'

Overcoming the macro and micro barriers will require Ontario to leverage what other provinces and countries are doing by looking at their experiences and asking the right questions. Fundamentally, customers want safety, comfort, lighting, cooling, heating etc. Electricity (kW or kWh) is only a means of delivering these benefits. Considering this, perhaps the first question that electricity sector representatives should be asking is the following:

> **"How can we help Ontario's customers meet their needs at the lowest cost, with the least environmental damage and with a socially responsible solution?"**

2.2 Systemic Barrier: Ontario's Electricity Market

Ontario Hydro provided electricity through a vertically integrated market for over 100 years. On May 1, 2002 Ontario's electricity market was deregulated, giving open access right down to the retail level. On November 11, 2002, less than 6 months later, a price cap was introduced which, along with a number of other measures, essentially closed the market at the retail level. This confused the rest of the market to the point that even today many interval meter customers do not know that their electricity rate varies on an hourly basis.

The Ontario electricity market's evolution since de-regulation has been driven by a supply side focus, i.e., the customer is referred to as a 'demand'. As a result, information continues to be delivered to the customer from a supply perspective that often misses reaching the consumer.

Many interval meter customers cannot keep up with the changes that are occurring within the electricity market and feel powerless. To illustrate, most customers can identify who their natural gas supplier is. When asked who supplies their electricity they will often simply respond 'Hydro' and when pressed, 'Ontario Hydro.' Very often the correct answer is only available when the electricity bill is retrieved from accounts payable. Obtaining the bills can often be frustrating since many interval meter customers have the bills delivered directly to accounts payable or an offsite service provider to ensure the severe late penalty charges are avoided. The very restrictive period that utilities enforce for payment is not negotiable or lenient.

Confusion has also increased with the number of stakeholders coming into the market. The challenge of understanding "who is responsible for what" is clear from a quick review of a few of the most commonly used acronyms on the supply side:

- OEB / OPA – Ontario- Energy Board / Power Authority / Power Generation;
- MOE – Ministry of Energy
- MOE – Ministry of the Environment
- NGO's- the number of Non-government organizations
- IESO – Independent Electricity System Operator ;
- LDCs – Local distribution companies (there are 90+ with acronym names of their own);
- Hydro One – Transmission and distribution in some areas
- FR – Free rider, CDM terms that have specific meanings and can influence a project
- TRC – Total Resource Cost test for CDM

Understanding how to access CDM has become confusing as well. This was pointed out several times, particularly where interval meter customers have facilities in multiple locations. In some areas the LDC is aggressively engaged, while in others the LDC appear to have disinterest and in some cases actually appear to be providing disincentives to energy efficiency.

Conservation and Demand Management (CDM) should focus on the customer's needs. Ontario's energy strategy must involve more than pushing more kW or kWh into the system. A customer 'pull' strategy would take customer cues by helping customers 'shape' their use rather than increase generation/distribution of electricity by evaluating alternatives.

2.3 Barriers Identified by the OPA

The Ontario Power Authority requested that the following categories of barriers be discussed:

1. *Price signals;*
2. *Lack of awareness;*
3. *Limited product and service availability;*
4. *Consumer preference;*
5. *Limited or uncertain finance;*
6. *The level of transaction effort required;*
7. *Risk that the energy efficient product may not perform as promised;*
8. *Split incentives;*
9. *Institutional, regulatory, or legal barriers.*

Energy @ Work encouraged interval meter customer active participation to elaborate on those barriers they see as being most important but which do not fall within the OPA's suggested framework.

2.3.1 Price Signals

Participants agreed unanimously that the real-time cost of electricity must be paid and must represent the true cost of electricity. This means that previous methods that artificially protected price by increasing the 'Ontario Hydro debt'[‡] must be avoided.

They recognized that Ontario's electricity price has traditionally been kept artificially low by not transferring the true cost of electricity to the rate payer, hence the accumulated debt. More specifically, participants agreed that, as rate payers, they should not be adversely impacted by higher prices because of inefficiencies within the system including losses.

The 'price signal' barrier can best be described as a lack of transparency. Artificially capped rates mask price signals for conservation. **The true cost of supply needs to be compared to the cost of CDM using the same evaluations so the lowest cost option is selected.**

The impact of investment decisions appear at the facility level. The basic question was asked:

> ***"Does the information that is provided on individual utility bill statements reflect the true costs and is it the best that can be made available to help the customer better manage energy use?"***

The question prompted a lively discussion with a range of suggestions:

- Publish costs of new supply compared to costs of CDM programs based on 'best in class' comparisons.

[‡] The information on the dept is publicly available; however, little discussion on the size of the debt or its impact is discussed. Information is available from the Ontario Electricity Financial Corporation website: http://www.oefc.on.ca/index.html.

- Ensure every utility provides consistent billing information based on helping the customer.
- Require key information such as rates, units, power factor, consumption patterns, etc. be shown on the bill, or provided to the customer regularly.
- Utilities should be required to provide pulse outputs, properly labelled and show the appropriate pulse weight factor with each interval meter;[§]
- Additional information can be provided with the bill in the form of:
    - energy efficiency tips, (Note: tips should be valuable and not general statements) ;
    - `Value added` tools that customers want, such as weather correcting information;
    - Other information that can provide practical and meaningful advice and not just public relations messages that minimize the work required to achieve sustainable energy savings.

2.3.2 The Lack of Awareness

Note: This category includes awareness of energy efficient technologies, processes, manufacturers, distributors, retailers, trade allies and customers.

This was not seen as a specific barrier per se. ***It was seen instead as a responsibility of the interval meter customer to become educated and to find the time to make the investment to properly identify and evaluate products and services. However, where useful information is available, this should be distributed.***

Mobilizing Information Resources:

The tools and services that were once provided by Ontario Hydro's account representatives, energy advisors, and meter technicians were identified as needing to be replaced.

There are a number of potential solutions that can partner with the needs of the ***customer.***

There is an acute lack of good information resources for customers to employ in making their internal business cases on investing in energy efficiency.

- The quality of information that is being made available through CDM efforts was identified as being insufficient and, when available, often trivialized the work and commitment that is required to achieve sustainable savings for interval meter customers.

- The multitudes of 'rate funded' web sites often contain dated energy efficiency information that in many cases is repetitive and insufficient to be of practical value. ***Accessible information resources that are useful to interval meter customers need to be developed with respect to core business activities such as production or tenant comfort.***

[§] **California requires utilities to provide the pulse output, labelled leads and easy access to pulse weight factor for each interval meter. This requirement allows customers to monitor their use, price and cost for better utility control.**

- ***There are some quality resources that already exist*** such as the Lighting Guide and the Power Quality Guide, (Canadian publications funded by ratepayers), ***but these guides continue to be in low circulation and typically difficult to obtain.***

- ***Suppliers, energy partners and other channel partners are seen as having greater potential as resources when given the support and encouragement to provide better information, training, and education to customers.*** In many cases, these resources have a more acute appreciation and respect for the customer needs than the LDC.

There is a popularized myth among policy makers that 'energy efficiency will occur automatically' in accordance with Adam Smith's economic 'invisible hand' theory. The early discussions during deregulation popularized this belief to the point that support for energy efficiency disappeared, despite the proven success by Manitoba, British Columbia and of course California. ***The challenge to having an effective market system stems from ensuring that there is adequate and transparent information as well as expertise for customers to make informed choices.***

As one simple example and mentioned previously, some utilities make it extremely difficult for interval meters to have access to their own electric meter data. This makes the monitoring in real time impossible. (References in *Appendix A, Sources 1, 2, and 3*),

- **The assumption is that because a customer has an interval meter that they know their use, price and cost. This is rarely the case.**
  The challenge in obtaining a pulse output is a typical barrier that interval meter customer faces in seeking the right information to manage their electricity use.

California solved this barrier by requiring utilities to provide labeled pulse outputs with a pulse weight factor with each interval meter.

Mobilizing Expert Resources:

A challenge most interval meter customers face is that energy is not part of anyone's full time focus or 'core' responsibility. There are few energy managers, energy plans or tools available to properly assess when and where energy efficiency opportunities exist. To use a tangible example, even where there is monitoring it is not always a simple case that consumers know what to do with it. (The article contained in *Appendix A, Source 4: 'Irrational Energy Consumers?',* further explores the question of why a rational consumer might not invest in energy efficiency efforts even considering the relatively low expense and rapid payback).

Equally, there is a lack of belief in the `sustainability of CDM` by key decision makers. On frequent occasions, statements are made that CDM measures will not last as long a new supply options. This supply preference paradigm needs to review the facts. For example, the results from a properly designed lighting system that delivers the required illumination at a maintained level, **but at half the energy use will not be replaced**. ***The reality is that energy efficiency,***

when provided the same engineering expertise as supply solutions, can deliver sustainable results as supply options. These results need to be better understood and communicated.

To this end, CDM programs need to provide targeted sector education instead of 'spreading' limited resources across multiple platforms that provide little more than obvious platitudes on energy efficiency benefits.

There are excellent examples and models to choose from that show how the development and harnessing of expertise produces sustainable results. Enbridge's programs provide excellent support for both commercial and industrial customers. These programs have evolved, largely by the commitment of staff which actively works with customers and channel partners to achieve sustainable savings.

"Energy efficiency is hard work"
(see *Appendix A, Source 5: Review of best practices, JRC Report Brussels*).

2.3.3 Limited Product and Service Availability

This OPA barrier was seen as overly vague and resulted in a range of discussion as participants attempted to define what was meant. Generally, there was a common sentiment that much better information is needed. Specifically, better access to data and sub-metering would enable far more effective consumption monitoring.

- Doug Dittburner said that Natural Resources Canada was looking at developing a 'metering/monitoring program.' He emphasized that better dialogue was needed within the CDM community to work together.

Repeated messages suggesting that switching off the lights or raising temperature settings are seen as temporary and/or discomfort management strategies and not as sustainable solutions. There was also considerable frustrations with the 'on again, off again' CDM efforts.

"I'm hearing more and more people in the field start to say the same thing. Voluntary measures are largely ineffective. And if we can't raise the prices to reflect the true full costs (partly because we don't even know how to measure the full costs), society must regulate to a greater extent." —Tim Short, Enbridge

The message is loud and clear, we get what we pay for – which includes energy efficiency.

A concern that was identified in this area was the need to better communicate the experience and challenges to the Ontario Energy Board on issues around CDM approaches versus technology development. These barriers are outside of the interval meter customers' core business, and CDM is a separate industry in and of itself. (See *Appendix A, Source 6: 'Why Energy Efficiency is a Hard Sell'* for a typical example of a discussion of this and related issues).

There are numerous examples of US utilities that provide excellent CDM programs. Notably, California's CDM program can provide up to $1,000/kW. The results achieved have been outstanding in delivering sustainable savings. Presentations from the California experience are available along with contact information.

In stark contrast, Ontario LDCs have been providing incentives in the order of $150/kW, e.g., the avoided cost of distribution.

The obvious question becomes:

If we are prepared to pay thousands of dollars kW for new generation, why not exhaust what we can achieve from CDM first, particularly if the cost is less than a $1,000 kW."

Figure 5: California's Electricity Demand 1960-2000 (Ontario follows a very similar demand growth pattern to the pink line representing the United States as a whole).

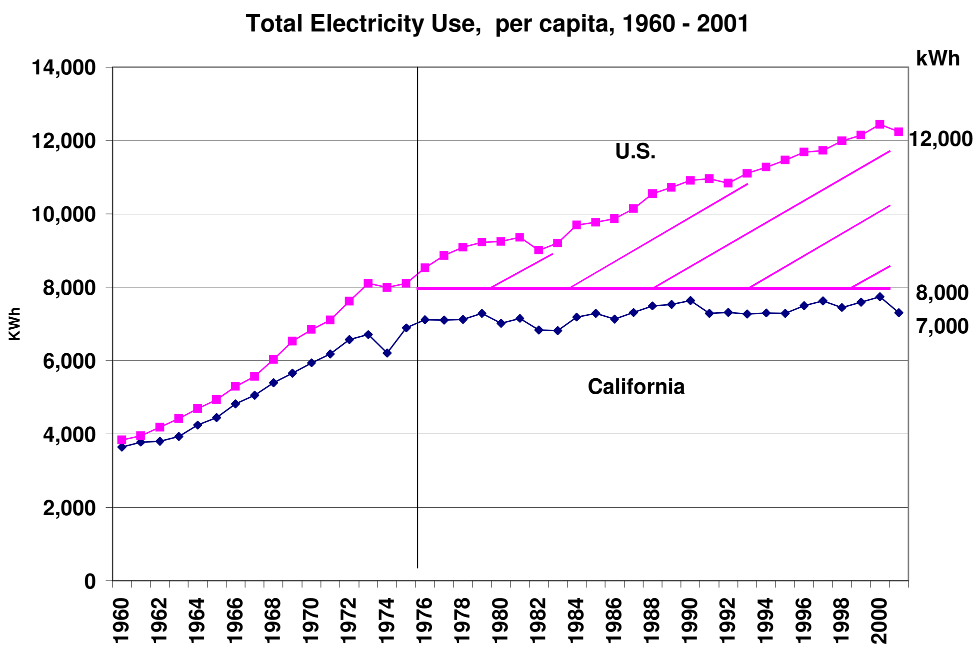


Figure 5 is courtesy of Michael Messenger, Chief of Energy Services Assessment at the California Energy Commission, who presented it at the 2004 International Seminar on Energy Conservation in Taipei Taiwan.

There was agreement that more CDM efforts and sharing of information are needed and should be encouraged to avoid duplication and to best leverage scarce resources.

2.3.4 Consumer Preference

Note: This includes energy efficient technology which may not be a perfect substitute for other, accepted technologies.

This was recognized as a challenge, particularly in trying to objectively evaluate the options and benefits at the true cost. Adding to this is the challenge of communicating a clear message to tenants and others who are often not interested in complex details.

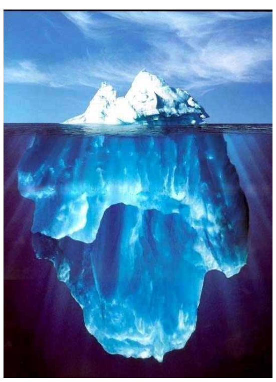
At the core of this barrier is the difficulty in finding the funding to support proper assessments of available options.

There are some sources of help: In new construction both Union Gas and Enbridge offer funding. There is also funding available through BOMA Toronto for the 416 area code.

Natural Resources Canada's cancelled Commercial and Industrial Building Incentive Programs offered initial support. The cancellation of these programs has created confusion and significantly amplified this barrier.

First Costs vs. Life Cycle Costs

Energy efficiency projects suffer another challenge unique from other types of investments. For some reason, an energy efficiency project is subjected to an economic evaluation that relies on simple payback for project evaluation (the project cost is divided by the energy savings). This type of evaluation is expedient, but ignores life cycle costs, taxation consideration as well as related benefits. The 'first costs' typically represent less than 8% of the life cycle cost of operating a system. In the majority of cases, decisions are made on the first costs, for example, of buying the lighting fixtures, compared to the cost of operating and maintaining the lighting system through its economic life.



The relationship of first to life cycle costs is like that between the tip and the submerged portion of an iceberg. Lighting fixtures, lamps, etc. represent about 8% of total costs and decisions are often made trying to shave this 8% while not addressing the 92% that lies below the surface and is the true cost of operating the lighting system. Ironically, often efforts that save on the 8% actually serve to increase the 92%.

This barrier is becoming increasingly evident as energy efficiency is being popularized. Information fails to provide confidence because:

1) Solid facts are simply lacking in Ontario;
2) The quality of what is being made available is low; and
3) The funding available to evaluate opportunities is almost non-existent.

Examples from the US and other provinces are plentiful in providing quality CDM information that can be employed and built in Ontario at little risk. (For several examples see *Appendix A, Source 7: 'ACEEE EE Savings'*).

Through investments in energy efficiency Ontario achieved breakthroughs in the late '80's and 90's in areas such as high efficiency motors, and variable speed drives. New opportunities exist for retro and re-commissioning, but information and resources are no

longer available since Ontario Hydro programs were never replaced. In cases where information was archived, there is no funding to update and distribute.

A quick 'Google' comparison of BC Hydro, Manitoba Hydro and US programs with Ontario illustrates how far Ontario has slipped with respect to supporting energy efficiency. Very little meaningful information, particularly directed at interval meter customers, is available.

Unfortunately Ontario's lack of investment in energy efficiency has also made it very difficult to get meaningful benchmarking information. This barrier will continue until comparable program investments are made to help the interval meter customer.

In addition, Ontario programs, for interval meter customers, often spend scarce resources repackaging ineffective products rather than reviewing and implementing best practices. ***This can change, if Ontario programs were available to "leverage" experience, expertise, and proven success.***

Training in maintenance and building commissioning is also needed, particularly considering Ontario's demographics: ***The experienced operators that are currently available and can provide training through mentoring and apprenticeship will be retiring in the next few years thus removing their knowledge, experience and expertise from Ontario.*** Programs need to be established before that happens. There are excellent examples in the US of training programs that provide students field experience in delivering energy efficiency.

2.3.5 Limited or Uncertain Finances

Prioritizing with competing demands for limited funds

Agreement was unanimous: there must be a clear return on investment (ROI) that uses the same yardstick for both supply and demand management decisions.

E*nergy efficiency must not be artificially favoured over other investments but must be evaluated using the same criteria. This is true at the macro and micro level.*

Better communication is needed so that the CDM programs understand the world of the interval meter customer. It is particularly important to recognize:

- Even an excellent energy efficiency project that delivers a 50% return on investment is unlikely to proceed if the project is "unbudgeted or unscheduled."
- There is a high level of effort required to identify, quantify and justify the project within the budget approval window.
- A lack of confidence or documentation can easily jeopardize a project. CDM programs are useful, but only if they are timely, consistent and respect the approval cycle.
- The lack of meaningful information on energy efficiency compared to related issues such as the environment and safety is a barrier. Confidence will drastically increase the risk for project approval if the perceived value of a project is questioned because of CDM

program uncertainty, confusing rate information or other information since every project must compete for very limited funds and within a tight timeline.

"Users who want to be able to take advantage of incentive programs should be able to 'reserve' funds to allow for the budgeting cycles of the commercial sector. This would of course be subject to project review and approval and a commitment from the user to proceed (possibly with financial penalty if the user reneges). All too often, there are great incentive programs but it can be 18 months to 2 years before a user can work this into their financial plans. Too big of a disconnect timing wise." –Don Harvey, Cadillac Fairview

Policy makers, utilities and other supply side decision makers need to be aware of the budget and schedule restrictions of the business approval process. Understanding can help overcome the challenges of achieving energy efficiency.

There is also a significant cost that must be justified to develop the expertise and experience required by businesses to use an incentive and related energy efficiency programs.

It is important that policy makers (*et al.*) should take into account these restrictions in developing programs. They need to recognize the importance of, for example, creating stable incentives that do not require a rapid turn-around time, or an excessively complicated bureaucratic process.

American Examples:

- California offers a range of CDM programs of up to $1,000/kW, still a fraction of the avoided cost for new supply; generation, transmission and distribution. California's results have proven to be sustainable and energy efficiency far exceeds that of the rest of the US or Ontario. Ontario CDM incentives average about $150/kW, which stands in stark contrast to the $2,500+/kW spent to create new supply. The stark difference between these investments is downplayed by a difference in method of evaluation: Supply is evaluated on a multi-year basis, e.g., 20 year net present value; Demand programs are evaluated using other methods, such as the Total Resource Cost Test.

Ontario Application:

It would be interesting to see the results of an evaluation of energy efficiency programs using the same standards as are applied to supply investment evaluations. For example, what would be the net present value of Toronto's deep water cooling, has successfully removed 40MW of load in downtown Toronto during he critical summer peak period, over a 20 year time frame relative to a peaking gas fired plant?

- Another example from California, cited by Tim Short of Enbridge, is their Chapter-24 legislation mandating that new construction must stay within a prescribed number of watts per square foot, leaving it to the designer to allocate the watts to her preference. If the maximum is exceeded a building permit won't be issued. This 'performance based' approach is an interesting tool in that it forces designers to economize while allowing them the freedom to pursue a desired light level according to their own priorities.

- Also worth considering is the work being done in Wisconsin (see *Appendix A, Source 8: 'Increased Incentives Will Help Businesses Save Money'*).

2.3.6 The Level of Transaction Effort

What effort is required to become informed, select products, choose contractor(s), and install an energy efficient product?

- There was insufficient time to properly address this barrier although it was generally felt that the level of required effort was too high.

2.3.7 Risk that the Energy Efficient Product May Not Perform as Promised

- There was insufficient time to properly address this barrier.

2.3.8 Split Incentive

A split incentive is where costs and benefits of conservation action accrue to different actors, as is the case in the landlord/tenant dilemma.

- This was seen as a very complicated though very important issue. To be properly addressed it was acknowledged that it requires further discussion.

Some General Points:

- For industrial applications split incentive issues become site specific or often business unit specific.
- Issues such as 'gross' versus 'net' leases in the commercial sector add to the complication and introduce a number of barriers of their own.

2.3.9 Institutional, Regulatory or Legal Barriers

Several of these barriers have already been touched upon. They are not seen as direct barriers to interval meter customers since they were widely considered outside of their ability to affect or control. ***It should be noted however that the significant confusion that these barriers consequence suggests a need for regulators to provide greater clarity and consistency (transparency).***

Examples of specific issues:

- *The Certificates of Approval required from the Ministry of Environment for waste recovery: approval time, requirements, etc. often prevent action despite support from the Ministry of Energy. Resolving these will involve a number of items including the definition of waste and the simplification of the permitting process, etc.*

- *The acceptance of stand-by generation for demand response. Although the OPA is accepting standby generation in the demand response program, the proponent is responsible to resolve environmental permitting with the Ministry of Environment. This barrier will mean that each every application will be required to use valuable resources which are much better addressed through a cooperative process.*

- *Outdated regulations: There are several examples including the requirement to have exterior stairways lit even when there is adequate daylight harvesting. The lack of support for new technology, such as photo luminescent material that will provide sufficient lighting for exiting a building without creating additional demand.*

- *With regards to enforcement, there is a lack of consequences for:*

    1. *Not meeting energy efficiency requirements. New construction and renovations are often not penalized for not meeting requirements. The non-enforcement of rules creates a system in which non- or poor performance of existing energy efficiency requirements indirectly penalizes good performers by creating a competitive disadvantage.*

    2. *Poorly understanding energy efficiency evaluating techniques. For example, the typical window will have an insulation value represented by the R value. However, the metal frame will significantly reduce the insulating value which is often overlooked, either by accident or by purpose. The result is a low R value which translates to significantly less net insulation effect.*

2.4 Interval Meter Customer Barriers

These barriers were expressed as highly relevant by the participants. They are also highly varied. The range and breadth of barriers underlines the issues that interval meter customers must address in achieving energy efficiency.

- ***There is a need for better internal communication on energy efficiency issues and barriers***. For example, building the business case cooperatively between accounting and operations to include tax advantages, incentives, regulations, etc. The lack of transparency on costs, opportunities, etc. can make it difficult to gain internal support for non-core projects, which includes energy efficiency.

- ***There is a need to engage the 'C' level of organizations on the significance of the issues and the opportunities that may be available.*** For example, if the estimated investment for new supply was used for CDM, the pursuit of options like waste recovery, co-generation, and heat recovery would be encouraged. In addition there are new programs such as demand response that require senior management understanding to in order to obtain approval. A balanced discussion of the true cost/potential savings of projects with the CEO, CFO, COO, etc., can yield different outcomes providing the rules and requirements are clearly laid out.

- Communication with interval meter customers requires a 'rifle' instead of a 'shot gun' approach. ***Information, communication, programs, etc. should be sector specific and delivered in a language that the interval meter customer can understand and apply.*** It is unrealistic to expect interval meter customers to keep up with the sheer volume of information, or more specifically understanding terms, such as the 'total resource cost test' (TRC). Terms such as 'free riders' are understood in the CDM community but not appreciated at the customer level.

- ***A better balance between CDM investment that respects and recognizes the contribution that the interval meter customer can make.*** For example: (1) calculating the net present value for deep water cooling against a new supply option, or more basically, (2) "the installation of deep water cooling at a commercial office tower is equivalent to how many fridges as part of a utility program?" What is the cost effectiveness of designing and developing CDM programs beyond dollars? Putting information in these terms makes it far easier to understand and appreciate, ultimately strengthening business cases for taking energy efficiency measures.

- ***When addressing the need for more kW or kWh, energy efficiency measures should be considered equally to supply side or other solutions***. For example the BOMA CDM offers an incentive of $400/kW or $0.05/kWh at the customer's preference within the 416 area code. In California, CDM incentives can be as high as $1,000/kW and have succeeded in keeping the demand curve flat for the past decade. The California experience contrasts starkly with supply investment in Ontario which exceeds $2,500/kW that has been necessary to meet a consistently rising demand similar to that shown in Figure 5 on pp. 20.

- ***Access to best practices and what is available and working is fundamental to breakthroughs.*** Customers routinely benchmark and compare what they are doing with what the competition is doing. CDM programs should also use best practice reviews.

- ***There needs to be a better mechanism for enhanced and sustained dialogue.*** Stakeholder meetings that request 'free' advice are common place and expected of the energy efficiency community, which is not a standard applied to building new supply.

- ***The complex issues surrounding breakthrough technologies require the same professional dedication to arrive at solutions as do supply options.*** Ontario has lost much of the expertise that once existed and needs to re-build its CDM knowledge base.

- *"Users who want to be able to take advantage of incentive programs should be able to **reserve funds** to allow for the budgeting cycles of the commercial sector. This would of course be subject to project review and approval and a commitment from the user to proceed (possibly with financial penalty if the user reneges). All too often, there are great incentive programs but it can be 18 months to 2 years before a user can work this into their financial plans. Too big of a disconnect timing wise."*

*There are a host of practical barriers that also need to be understood and respected. For example, t*enants will not invest in an energy efficiency project that provides benefits beyond the period of their lease. A building that is identified as 'historic' also limits the options available or increases the cost of improving energy efficiency.

Contact: Scott.Rouse@Energy-Efficiency.com, 416 402-0525

2.5 Additional Barriers to Energy Efficiency

Energy @ Work funded a study that asked *interval meter customers their opinion on energy efficiency potential within Ontario. Meetings were held in January 2006 and the Ontario Energy Champions Report was provided to the Minister of Energy, as well as the OPA. The report contained 12 case studies and is available on-line at www.Energy-Efficieny.com. The Energy Champions Report identified a number of relevant barriers:*

- ***The business case for retrofit projects must be based on the current and unsubsidized electricity prices.*** Better information is needed to understand expected prices.

- ***OPA (and other utility) programs require lengthy and costly application processes which discourage potential applicants.*** For example, CDM programs often do not respect internal budget approval process that companies must deal with. This is an area where the development of case studies could benefit the industry.

- ***To achieve successful energy efficiency in Ontario's deregulated energy market will require transparency in how investments are made in CDM and in increasing supply.***

- Energy efficiency takes work. ***Resources (time and money) must be allocated to CDM programs and the level of effort required to pursue such programs must be appreciated by program administrators.***

- Ontario's energy market has become very complicated. Changing rules, new programs, new stakeholders are all part of the challenge particularly for interval meter customers. ***By making Ontario's electric system more customer-focused these issues can be overcome.***

- Some utilities have been supportive of CDM programs; particularly since the CDM funding was made available, but this is not consistently the case. Several utilities have programs and agendas that only add to the confusion. ***Ontario should agree on a common value of kW and kWh (electric power capacity and electric energy) whether CDM or new supply.***

- ***Initial issues related to the lack of adequate monitoring of energy consumption and bill verification persist.*** The information provided by utilities in particular continues to be inconsistent, particularly on bills.

- ***Internal training, capacity building and the hiring of external expertise is very helpful in overcoming challenges.***

- ***There is a need to educate 'internally' in order to emphasize the importance of energy conservation and efficiency.*** This goes even beyond internal 'triple bottom line' benefits, to support collateral benefits for Ontario in terms of pollution prevention, competitiveness as well as the reduction of harmful emissions and wasteful practices.

2.6 Supply Side Energy Inefficiency: Accepting Losses

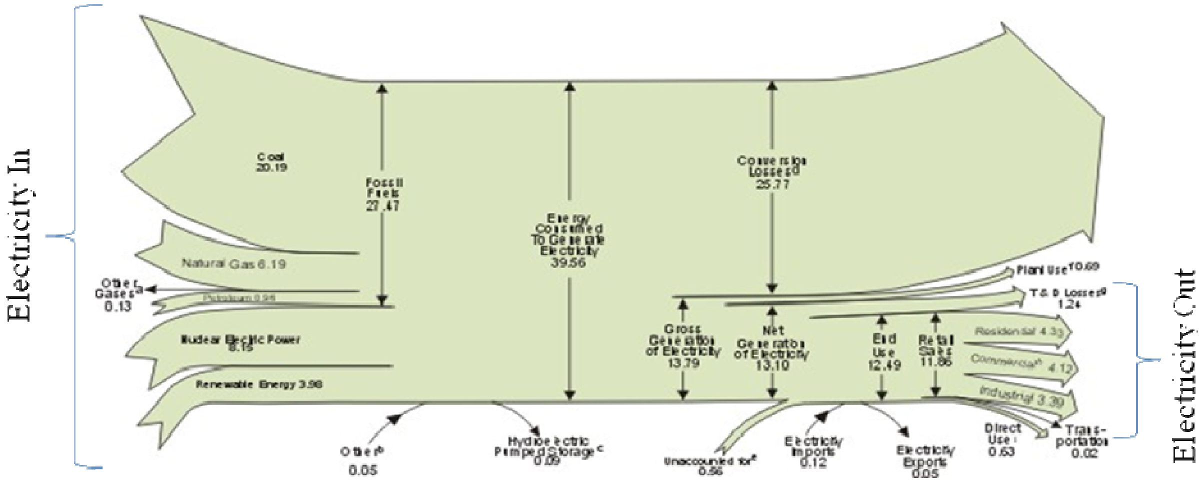


Figure 6 – Typical Energy Diagram: Source, US Department of Energy

Figure 6 shows how energy moves from the source of supply to the customer and is typical to Ontario. Note the loss from primary energy that goes in and the useable electricity that comes out.

Interval Meter Customers want to pay the true cost of electricity and do not want to be burdened with supply side inefficiency. The opportunity to improve energy efficiency on the supply side is well documented, and it is another area where deregulation in Ontario has had a negative impact.

It is clear that a strong and efficient energy infrastructure is critical for Ontario. Programs such as the 'smart grid' are being explored in other jurisdictions where there are significant opportunities to improve reliability with customer focused solutions. Often these solutions can be achieved in partnership with the interests of the interval meter customer.

Ontario's Bill 100 requires an energy plan to be developed and is pending enabling legislation. ***What stands out is the reluctance to adopt an energy plan to reduce system losses relating to things like transmission and distribution.*** The *1998 Electricity Act,* which was amended by Bill 100, strengthened the importance of energy efficiency on both sides of the meter. On the supply side, the act reads:

"…to promote economic efficiency and cost effectiveness in the generation, transmission and distribution, sale and demand management of electricity and to facilitate the maintenance of a financially viable electricity industry."

Implementing a Performance Based Result (PBR) would provide the required incentive necessary to reduce line losses, electricity theft, etc.. The avoidance of these costly losses would be considered a 'pass through cost.' A PBR is thus a practical solution. The success of the in-house program's energy efficiency as well as that of other programs in the reduction of line

Contact: Scott.Rouse@Energy-Efficiency.com, 416 402-0525

losses through projects such as phase balancing, energy audits of administration buildings, installation of capacitors, etc. are proven and reproducible.

The time has come to aggressively address transmission and distribution losses and leverage available experiences (for an example see *Appendix A, Source 9: 'EE in the Power Grid'*).

Considering the scarcity of resources, the fact that inefficiencies remain within the regulated generation, transmission and distribution systems represents an indirect but nonetheless crucial barrier.

3.0 Going Forward

Every day newspapers, magazines, and television – both in their content and advertising – are emphasizing the importance of making green improvements, particularly through increasing energy efficiency. ***The 'emerging energy efficiency economy' appears to have arrived*** and includes complementary opportunities such as renewable energy, demand reduction, ground source heat pumps, etc.

As was the experience in New Zealand, ***early 'voluntary' and underfunded energy efficiency programs that are poorly conceived or do not target sustainable savings achieve predictable results: a few kWh reductions that quickly evaporate.*** By contrast, a properly designed program can generate sustainable savings. There are many efficiency examples that have proven success:

- The replacement of incandescent traffic lights with Light Emitting Diode (LED) technology;
- The use of LED technology that uses 1/40th of the kWh on exit signs.
- A proper lighting re-design can reduce a 1.5 watt per square foot configuration by a third to 0.47 watt per square foot (examples of successful projects available upon request).

Multiplying these examples by the number of exit signs, traffic lights, or inefficiently lit rooms that exist in the province demonstrates the savings potential that exists. Furthermore, these demand savings are sustainable.

Such measures, appropriately incented by 'customer' focused programs, will make adoption a 'no-brainer' for customers and potentially lead to significant step improvements. The impact of lighting and HVAC is in the order of a 30% reduction for the commercial sector alone.

New technologies are also around the corner. A review of the 30 years it took Toronto to adopt deep water cooling is an example of potential opportunities that may be available with the right incentives. Already, 40MW has been removed from downtown Toronto during the critical summer season by providing air conditioning. What is the potential if similar investments are made to a new generation plant?"

Gaining particular attention are energy efficiency breakthroughs by reframing opportunities. In a 'Sustainable Sweden' presentation, waste is being re-labeled a resource instead of a problem. In commercial properties, the concept that energy efficiency should be the 'fifth fuel' thought better information. These and other solutions are being pursued across all sectors of the economy, but in this pursuit Ontario should learn from the investments made in the US, Europe, UK and other provinces so that limited resources are allocated in the most effective ways.

The biggest barrier to overcome is putting the 'energy efficiency infrastructure' in place to utilize these emerging opportunities.

The tragedy is that Ontario's competitive position will be in jeopardy unless it remains current with advancements in energy efficiency.

Contact: Scott.Rouse@Energy-Efficiency.com, 416 402-0525

The broad scope of barriers and the limited time meant that ongoing discussion is absolutely necessary.

It was agreed that as a first step the basic question must be answered:

"How do we help Ontario's customers meet their needs at the lowest cost, with the least environmental damage and with a socially responsible solution?"

The answer has become obvious: energy efficient opportunities need to be seized and fully developed across sectors.

The energy efficient economy is evolving, governments, business and ratepayers are looking for practical and cost effective ways to achieve 'green' and to ensure sustainable solutions, such as:

Lighting: *Daylight harvesting, light emitting diodes, and control strategies.*

Heating: *Ground source heat pumps, district heating, and combined heat and power.*

Cooling: *Water cooling, ground source heat pumps, and occupancy controls.*

Safety: *Motion sensors that detect and adjust performance according to occupancy.*

When solutions on both the supply and demand sides are weighed equally against a common set of criteria that measures end results against the status quo, breakthroughs occur:

Specific examples measured against the triple bottom line:

- ***Deep Water Cooling***
  - The highly successful and acclaimed deep lake water-cooling project at the Toronto-Dominion Centre alone provided 8 MW of demand reduction during the critical summer peak in 2006. The significance of the demand response potential, particularly during summer smog days, of downtown Toronto translated to substantial triple bottom line benefits.

- ***Methane Capture from Landfills and Sewage Plants***
  - Europe routinely captures this 'free' energy along with other 'waste' resource recovery opportunities. A recent visitor from Germany confirmed that methane capture from sewage plants is 'standard practice' and was surprised that Ontario was not fully taking advantage of this opportunity.
  - At a Toronto conference called 'Sustainable Sweden' in 2006, there were a number of examples where 'waste recovery' delivered:
    - **Economic Prosperity:** Utilizing energy recovery.
    - **Environmental Performance:** Reduction of greenhouse gasses.
    - **Social Responsibility:** Communities benefit in a variety of ways.

- ***Light Emitting Diodes (LEDs)***
    - **Economic Prosperity:** 90% energy reduction in exit signs and traffic lights; maintenance and 'end of life' issues reduced which increases the benefits.
    - **Environmental Performance:** Reduction of greenhouse gasses.
    - **Social Responsibility:** Safer through increased reliability.

- ***Solar Power 'Direct' (Off Grid) Applications***
    - **Economic Prosperity:** No new supply or infrastructure.
    - **Environmental Performance:** Green energy source taking pressure off the grid.
    - **Social Responsibility:** No disruption of street repair to run power supply.
.

3.1 Interval Meter Customers' Potential

Figure 7 – Costs and Consumption of a Cross Section of Commercial Buildings in Toronto

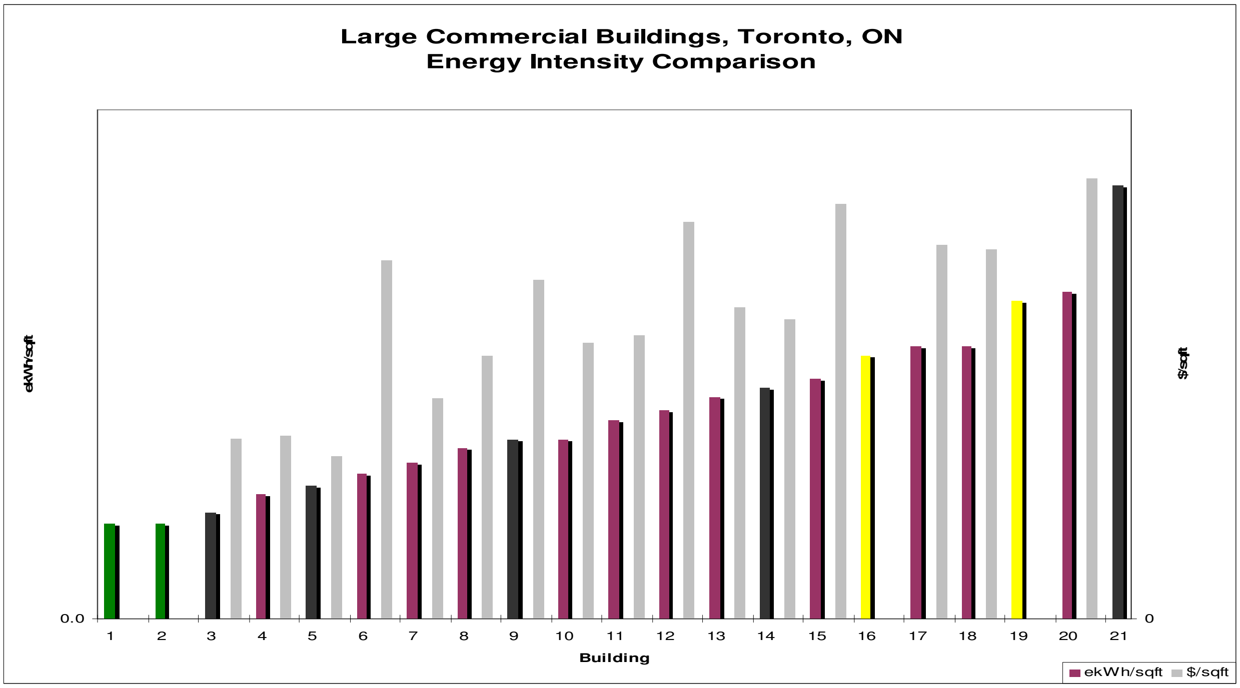


Figure 7 – The above buildings account for 12 million square feet and over $30 million in annual utility costs. © Energy @ Work, 2007

The interval meter customer offers the greatest 'short term' (1 to 5 years) economic potential for energy efficiency.

Dr. Dan Turner, Director, Energy Systems Laboratory, Texas A&M University agrees: In his experience of over 300 commercial audits of commercial facilities the economic energy efficiency opportunity can exceed 25%. The Building Owners and Managers Association International (BOMA), is encouraging its members to consider a 30% reduction target by 2012 (www.boma.org).

Determining the energy efficiency potential for industrial facilities is more challenging because of the range of industries. The 8-15% referenced by the Office of Energy Efficiency has been achieved and serves as an example to others. Dow was recently recognized for their 22% reduction and made a public commitment to achieve an additional 25%. Similarly, there are Canadian examples, including Unilever Canada which won the Canadian 2005 Energy Efficiency Award for their energy efficiency achievements.

Industry is also recognizing that they need to become more active. There have been several recent efforts to build networks and sketch blueprints for industry-wide change in the U.S. These efforts are reflective of a global trend (see *Appendix A, Source 10: 'Business Roundtable CEOs Provide Blueprint for U.S. Energy Future'*) which Ontario would benefit from being a part of.

As other countries and agencies recognize the strategic advantage in aggressively supporting energy efficiency Ontario's competitive position is eroding. For example;

- The International Energy Agency estimates that technological change in manufacturing could reduce energy consumption by up to 26%.

- The US Department of Energy is investing in energy efficiency (see *Appendix A, Source 11: 'DOE Announces Industrial Energy Request for Information (RFI)'*).

- In the UK there is interest in challenging the 'status quo' to ensure all options receive equal consideration (see *Appendix A, Source 12: 'UK Response to Energy Review'*).

Ontario can benefit from these and other studies. The experience is currently available in the province to enable good assessments of what sorts of projects work and what do not. This will enable the step improvement not only in the medium and long terms, but breakthroughs in the short-term.

3.2 Ontario's Challenge – Defining the 'true' value of kW and kWh

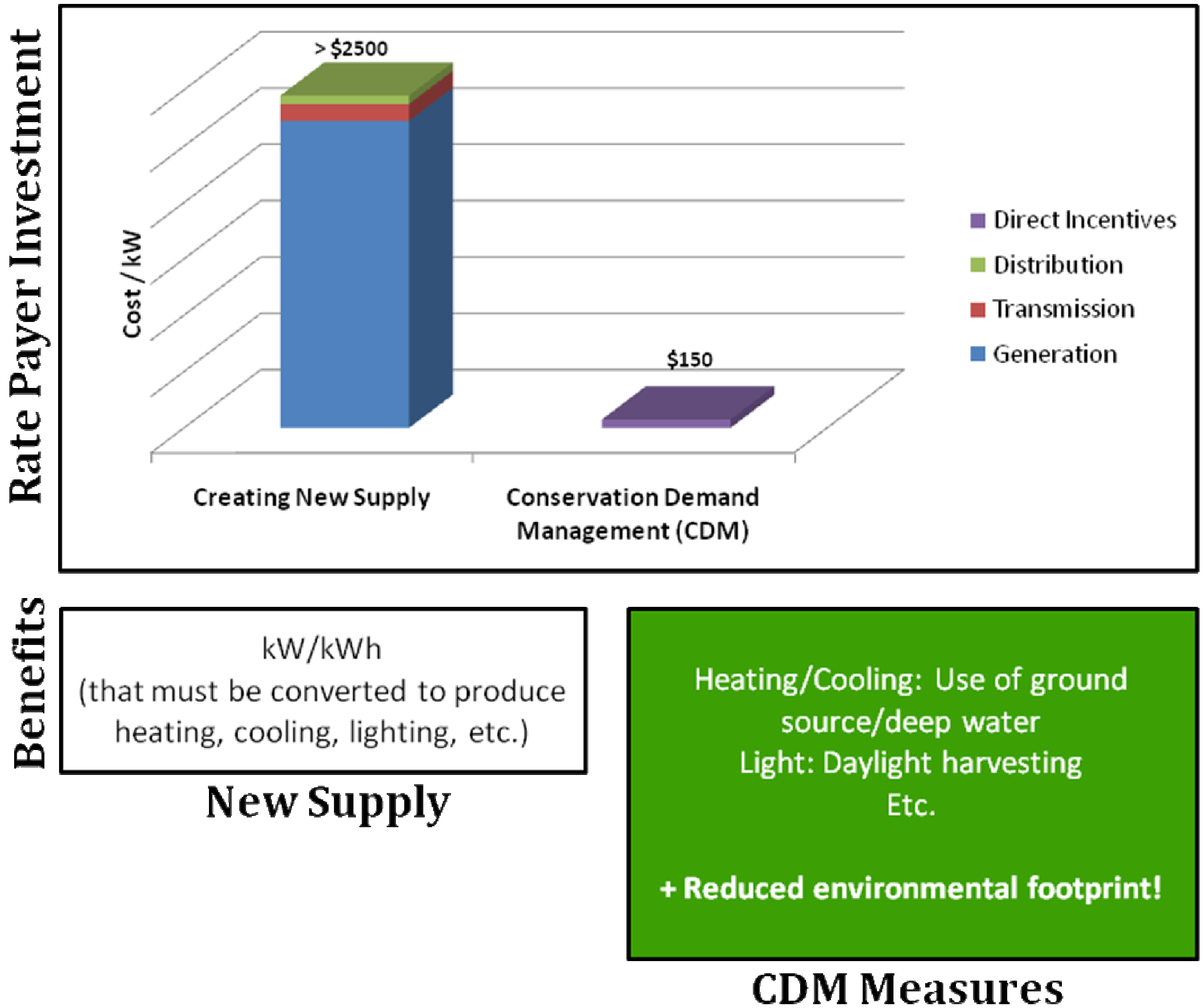


Figure 8 - New Supply vs. Energy Efficiency Solutions
Energy @ Work, © 2007

The economic cost for a kW or kWh is a highly debated subject. The variables, such as the costs of new construction, generation efficiency, fuel cost and delivery go beyond the scope of this report; however, the interval meter customers wanted to make the following points:

- Cost of new generation, transmission and distribution should be measured on an equal basis with conservation and demand management (CDM). For example, deep water cooling provides kW reduction to reduce peak summer requirements as effectively as the construction of a peaking plant. Further, it achieves this reduction at a significantly lower financial cost, with less environmental impact, and with a more positive social impact. There are many similar opportunities that become evident when the fundamental concern is for true customer value.

- The true cost of electricity should be paid by the consumer and not artificially supported. Participants expressed the belief that artificially supporting electricity prices is the primary cause behind the creation of Ontario Hydro's debt. The increase in debt continues as a result of the decision to install temporary generation in 2003.

- CDM measures should be compared 'equally' against the avoided costs of supply. Evaluating the calculated value of achieving various energy efficiency measures, i.e. using the Total Resource Cost (TRC) test does not properly assess the long term benefits. A common method of evaluating cost would **create an equal playing field for supply and demand.**

With regards to the debate on the sustainability of conservation demand management (CDM) versus traditional supply, it is also important to note the following:

- 1 kW saved is worth about 1.1 kW at the point of generation because of avoided transmission and distribution losses.

- Energy efficiency has greater value since generation is typically about 35% efficient. References are available from the In-house energy efficiency program, 1992 to 2002.

- Traditional supply side solutions also face uncertainty around fuel costs, capacity factors, construction overruns, waste management etc. This uncertainty is equal or often greater than that associated with proven CDM solutions.

The debate on the value of a kW and kWh will continue, but consideration that 1 kW saved is actually worth 2.75 kW generated should be used in calculating the value of electricity.

Arriving at the "true value" of electricity will require more work as well as a comprehensive evaluation of criteria. These criteria should include the triple bottom line benefits of economic, environmental, and socially responsibility, from the customer perspective. Using this true value of customer needs increases the credibility of the business case for energy efficiency in providing the optimum solution for Ontario.

4.0 Conclusions

Key points:

1) *There is recognition among interval meter customers that many energy efficiency opportunities are available.*

2) *Interval meter customers have limited resources to contend with multiple challenges in pursuing energy efficiency opportunities.*

3) *Overcoming barriers requires a collaborative approach with, and support from the electricity sector. This collaboration must be bolstered by appropriate investment on all sides that is focused on ensuring that customer concerns are addressed on their terms.*

Generally, better dialogue (in the language of the customer), and an improved energy efficiency infrastructure/investment is required to meet both the micro-level and macro-level barriers that Ontario has inherited from ignoring energy efficiency since deregulation.

An effective energy efficiency infrastructure connects people with the resources and the tools to achieve energy efficiency breakthroughs. It must allow customers to identify common barriers, assist in the development of sustainable solutions, and avoid having to reinvent solutions.

An effective energy efficiency investment rewards a saved 'equivalent' kW or kWh equally with new supply options. What is relevant to consumers is useable equivalent kW or kWh, regardless of whether it comes from energy efficiency measures or from new supply.

By using widely available and documented tools, systems, networks, etc. Ontario can optimize its efforts with confidence. Proven successes in California, Manitoba, and British Columbia demonstrate the solid solutions from energy efficiency, and can be applied in Ontario.

Taking the next steps will require developing principles that form a solid foundation for the growth of energy efficiency in the province:

- Begin with asking the 'right questions' (e.g., are customers achieving the best value);
- Use the triple bottom line criteria to answer these questions in evaluating alternatives;
- Ontario needs benefits such as light, safety, heat, etc. not more electricity kW or kWh;
- Ensure transparent investment in supply and conservation demand management;
- Listen to the customer's needs first!

Ontario has the opportunity to regain the leadership position that it once held in the pursuit of energy efficiency.

Contact: Scott.Rouse@Energy-Efficiency.com, 416 402-0525

Appendix A – Referenced Material

Note: For sources 1, 2, and 3 names have been removed since the situation is true for most utilities, i.e.:

- *Utility owns the meter and restricts 'access' to the meter via their locked cabinet.*
- *Utility imposes 'set' fees to provide pulse outputs that requires payment by certified cheque.*
- *Utility is often not responsive (There are exceptions that prove that pulse outputs can be provided quickly.)*

Sources 1-3: 'Utility Provider Barrier'
Referenced on page 14 in section 2.3.2 The Lack of Awareness

-----Original Message-----
From: Scott Rouse [mailto:scott.rouse@energy-efficiency.com]
Sent: Monday, July 24, 2006 8:50 AM
To: INTERVAL METER CLIENT Request for pulse Outputs
Subject: Status of Real Time Monitoring

UTILITY X will not install pulse outputs from their meter for real time monitoring or even schedule the installation of the pulse outputs on the electric meter (a $1,500 cost) until your cheque is cashed and funds secured in their account. Please note that our request to install pulse outputs as a Conservation Demand Measure was reviewed by 3 people with a negative reply in under 9 min, from the email trail below. Once again, we do not appear to have a choice and will have to wait for the utility.

-----Original Message-----
From: UTILITY X
Sent: Thursday, June 01, 2006 10:39 AM
To: scott.rouse@energy-efficiency.com
Subject: RE: Obtaining Pulse Outputs

Unfortunately at this time all of our CDM funds have been allocated to other projects. I will keep this on file though and if additional funds become available in the future we will review the request at that time. Thank you for your interest. Thanks,
UTILITY X.

-----Original Message-----
From: Scott Rouse [mailto:scott.rouse@energy-efficiency.com]
Sent: Thursday, June 01, 2006 10:00 AM
Subject: UTILITY X: Obtaining Pulse Outputs

Hello UTILITY X, It was good speaking with you today about obtaining a pulse output for Client's main interval meter, information is as follows: Service To: ___
Customer No. ___
Our client has asked for pulse outputs to be installed for real time monitoring of their

main electric meter. As we know, 'we manage what we measure' and the real time monitoring provides real time energy use kWh, kVA and PF with additional features of price alarms, budgeting, performance tracking, etc. I would be pleased to provide a demo.

If possible, we would appreciate the cost to install the pulse outputs be part of UTILITY X conservation and demand management (CDM) activities. This type of investment is certainly consistent with the spirit of the CDM in helping customers manage energy use more effectively. Energy @ Work has invited utilities to be part of our energy management activities for other projects and this has worked very successfully and something we would be pleased to explore. Look forward to hear from you and feel free to give me a call.
Scott Rouse, P.Eng., MBA, CEM, Managing Partner, Energy @ Work 416 -402-0525.

Source 4: 'Irrational Energy Consumers?'
Referenced on page 14 in section 2.3.2 The Lack of Awareness

Sent: Sunday, July 29, 2007 11:34 AM
To: scott.rouse@energy-efficiency.com
Subject: Barriers to Energy Efficiency- article

Irrational energy consumers? Posted by Frank A. Felder July 27, 2007 4:08PM
Studies after studies conclude that energy efficiency is the least expensive way to "produce" the next increment of energy. Payback periods are reported to be a few years or less, begging the question of why isn't more energy efficiency happening?

As a matter of logic, there are three possible answers: The analyses are wrong, people are irrational or both. Not surprisingly, those who favor energy efficiency think that people are irrational.

Before pursuing the irrational argument, let's review some limitations of the analyses that folks commonly conduct. Typically these studies are engineering based. They assume perfect installation, use, and maintenance of the energy efficiency measure. They generally do not account for behavioral changes due to the measure, budget constraints of consumers, and transaction costs.

For example, once I have a more efficient air conditioner installed, I can keep my house at a cooler temperature than before but at the same cost. If the study assumes that I do not change the temperature setting of my unit, then it has overestimated - mis-over estimated as the President might say - the energy savings.

Moreover, consumers and businesses face budget constraints. Even if energy efficiency is cost effective, I may have higher payback opportunities that I pursue first. At some point, I run out of budget before I implement to the energy efficiency measures.

Finally, and in my mind a big issue, are transaction costs. It takes time, and therefore money, to figure out whether an energy efficiency measure is worth it and if so, which of the many options one should use. Consumers and businesses are weary of promises made by vendors, especially because they have little experience or knowledge to assess whether vendors are accurate in their claims.

These three reasons - overstatement by studies, budget constraints, and transaction costs - may seem like nitpicking, but in many cases may add up to consumers not installing energy efficiency measures for perfectly rational reasons. Another point that needs to be discussed is what is meant by the statement that consumers are irrational. Obviously, there are degrees of irrationality, and no one is perfectly rational. Consumers may not be perfectly rational on average, and certainly there are those that stray far from this standard. But it is a big step from saying that folks are not perfectly rational to mandating that they install energy efficiency measures, go to the dentist twice a year, or whatever.

Don't get me wrong. Energy efficiency is underutilized and for the most part cost-effective. It must be a part of a comprehensive approach to reducing greenhouse gases and other air emissions and mitigate raising energy costs. But the way to justify energy efficiency, in my mind, is not through the irrationality-of-consumers argument but due to the negative externalities that are not accounted for in today's energy prices.

Source 5: 'Review of best practices, JRC Report Brussels'
Referenced on page 14 in section 2.3.2 The Lack of Awareness

-----Original Message-----
To: scott.rouse@energy-efficiency.com
Subject: Review of best practices, JRC Report Brussels, Brussels, 13 July 2007

Electricity consumption growing in spite of efficiency drive says EU report

A report from the European Commission's in-house scientific service, the Joint Research Centre (JRC), indicates that overall electricity consumption is growing in the EU. Even if the EU and the Member States have adopted numerous successful measures to curb energy consumption and associated CO emissions, the electricity consumption in the residential sector of the EU-25 grew at a rate comparable to overall GDP (10.8 percent), effectively nullifying overall savings between 1999 and 2004. The report, Electricity Consumption and Efficiency Trends in the Enlarged European Union, highlights the key findings of an in-depth 2006 survey on electricity consumption in buildings in the enlarged EU, and the market share of energy-efficient appliances and equipment. It calculates future potential savings based on currently available technologies.

According to the report, electricity consumption in the tertiary (service) sector increased by 15.8%, and industry consumption by 9.5%. The average consumption for a single household in the EU-25 was 4098 kWh in 2004. This could be reduced by 800 kWh per house per year, or about 20 % less electricity consumption in each household, if replacement of existing appliances and equipment and a full phase out of incandescent lighting were to be actively promoted in all EU Member States.

European citizens are increasingly concerned about the environment. According to a recent Eurobarometer, protecting the environment ranks second only to terrorism among the issues citizens feel are best addressed at EU level. Over recent years, the European Union has adopted numerous successful measures, in the form of labelling, minimum efficiency requirements, voluntary agreements, incentives and saving obligations, to curb energy consumption and associated CO emissions. The EU Greenhouse Gas Emission Trading Scheme is the largest multi-country, multi-sector Greenhouse Gas emission trading scheme world-wide.

In November 2006, the Commission presented an action plan on energy efficiency with the goal of consuming 20% less energy in 2020 than is the case today. The 60 measures included in this action plan address many of the problems identified in today's report.

To view the full report: ies.jrc.ec.europa.eu

Source 6: 'Why Energy Efficiency is a Hard Sell'
Referenced on page 15 in section 2.3.3 Limited Product and Service Availability

Sent: August-20-07 8:44 AM
To: scott.rouse@energy-efficiency.com
Subject: Barriers to Energy Efficiency - Utility Incentive?

Why Energy Efficiency is a Hard Sell
"Most utilities will not support energy efficiency programs without regulatory intervention. Since energy efficiency programs reduce the total electricity sold, and electric rates are set by regulators, without decoupling, energy efficiency measures reduce the utilities profits. A utility helping its customers reduce their usage would be like General Motors encouraging people to carpool so they could buy fewer cars."

Two months ago, I was talking to an experienced entrepreneur who was exploring business models to provide geothermal heat pumps to households. At first blush, it seems like a great idea. Geothermal heat pumps often have payback periods of under five years, which translates into internal rates or return in excess of 20% over the 30 year life of the system. With plenty of room for a business to recoup its cost of capital and leave some money on the table for the consumer, it's amazing that there isn't a company in every jurisdiction already active in the market.

Barriers to Energy Efficiency
When I spoke to the same prospective geothermal heat pump entrepreneur again a month later, he told me he couldn't figure out how to make money on the deal. Nor can I. The economics work best with new construction, but builders have no incentive to save their customers money on their utility bills. In a case study from Delta-Montrose Rural Electric Association (DMEA), a progressive Colorado electric cooperative, they identified purchase cost as the main barrier to adoption. DMEA was able to overcome that by financing the systems for their members (customers) with a payment on their monthly utility bill, something they are in a unique position to do, because they are also the electric utility. Posted by Tom Konrad on August 19, 2007 03:17 PM

Source 7: 'ACEEE EE Savings'
Referenced on page 17 in section 2.3.4 Consumer Preference

-----Original Message-----
To: scott.rouse@energy-efficiency.com
Subject: ACEEE EE Savings

Full set of EE reports, information, links, etc are available from: http://aceee.org
References are available, i.e. Dr. Neil Elliot
Example: Senate and House Energy Bills Provide Large Energy Efficiency Savings and Emissions Reductions Washington, D.C. (July 16, 2007) and
PUCO Approves Duke Energy Ohio Energy Efficiency Programs
July 11, 2007: 04:00 PM EST
CINCINNATI, July 11 /PRNewswire-FirstCall/ -- Customers of Duke Energy Ohio will soon have a variety of new resources available to them to help improve energy efficiency in their homes and businesses, after approval today of a portfolio of programs by the Public Utilities Commission of Ohio. "We look at energy efficiency as the 'fifth fuel' joining coal, natural gas, nuclear and renewables in meeting the future demand for energy," said Sandra Meyer, president of Duke Energy Ohio. "By providing additional incentives and resources, we hope to help customers manage their energy costs wisely."
Programs approved for business customers include:
-- C&I Prescriptive Incentive Program - incentives to commercial and industrial customers to install high-efficiency equipment in applications involving new construction, retrofit and replacement of failed equipment.

Source 8: 'Increased Incentives Will Help Businesses Save Money'
Referenced on page 18 in section 2.3.5 Limited or Uncertain Finances

-----Original Message-----
Sent: Saturday, July 14, 2007 3:44 PM
To: scott.rouse@energy-efficiency.com
Subject: Increased Incentives Will Help Businesses Save Money, 7/13/2007

MADISON, Wis. (July 13, 2007) – Since its inception in 2001, Focus on Energy's Business Programs have helped Wisconsin businesses save more than $85 million in annual energy costs by providing expert advice, technical project support and financial assistance to businesses wanting to cut energy costs by reducing energy use. The state's energy efficiency and renewable energy initiative entered into its new year on July 1, 2007 and with it came increased financial incentives for businesses looking to take advantage of the environmental and economic benefits the implementation of energy efficient projects offers.

Source 9: 'EE in the Power Grid'
Referenced on page 23 in section 2.6 Supply Side Energy Inefficiency – A Barrier for Interval Meter Customers

Sent: Saturday, July 14, 2007 6:36 PM
To: scott.rouse@energy-efficiency.com
Subject: EE in the power grid

http://www.renewableenergyaccess.com/rea/news/reinsider/story?id=49238
July 9, 2007 by Bob Fesmire, ABB Inc.

The concept of energy efficiency has moved in and out of favor with the public over the years, but recently has gained renewed broad-based support. The confluence of economic, environmental and geopolitical concerns around reducing America's exposure to disruptions in the supply of energy has moved efficiency to the fore. As a result, along with renewable energy legislation, a number of initiatives are now underway in the U.S. to improve efficiency in a variety of areas, but much more can and should be done.

Improving transmission capacity is also vital to the integration of renewables like wind and solar which are often located far from the loads they must serve. For that reason, the cause of efficiency in the T&D system is in perfect alignment with that of expanding renewable generation. As renewable energy technologies continue to grow in importance, the potential impact of energy efficiency cannot be overstated. (T&D losses are between 6-8%)

The efficiency of generation varies widely with the technology used. In a traditional coal plant, for example, only about 30-35% of the energy in the coal ends up as electricity on the other end of the generator. So-called "supercritical" coal plants can reach efficiency levels in the mid-40's, and the latest coal technology, known as integrated gasification combined cycle or IGCC, is capable of efficiency levels above 60%. The most efficient gas-fired generators achieve a similar level of efficiency.

Source 10: ***'Business Roundtable CEOs Provide Blueprint for U.S. Energy Future'***
Referenced on page 26 in section 3.1 Interval Meter Customers' Potential

Sent: June-11-07 8:01 PM
To: scott.rouse@energy-efficiency.com

Subject: US CEO Blueprint for US Energy Futures
http://www.businessroundtable.org/pdf/Energy/Business_Roundtable_Energy_Report_06062007.pdf
42 page document
More Diverse, More Domestic, More Efficient: A Vision for America's Energy Future
Business Roundtable CEOs Provide Blueprint for U.S. Energy Future

June 11, 2007 - Business Roundtable, an association of 160 chief executive officers of leading U.S. companies, has unveiled a wide-ranging energy plan calling for a more diversified and domestic-based energy supply mix, **increased energy efficiency** and greater investment in new energy technologies.

The recommendations, available in the plan entitled "More Diverse, More Domestic, More Efficient: A Vision for America's Energy Future," were developed through a consensus-driven process led by Business Roundtable's CEO members representing multiple sectors of the economy, and call for a mix of sound government policies, technological innovation, and proactive, voluntary efforts.

"The production, distribution and overall cost of energy are among the most difficult challenges facing today's business environment," concluded Morris. "And, we believe the business community has a special responsibility to provide leadership on this issue. Our recommendations provide an aggressive-yet-balanced approach."

Source 11: 'DOE Announces Industrial Energy Request for Information (RFI)'
Referenced on page 27 in section 3.1 Interval Meter Customers' Potential

Sent: August-10-07 4:26 PM
To: Scott.Rouse@Energy-Efficiency.com
Subject: DOE Announces Industrial Energy Request for Information (RFI)

The Department of Energy has released a Request For Information (RFI) on reducing industrial energy intensity. Section 106 of the Energy Policy Act of 2005 (EPACT) seeks reduction of industrial energy use by 25% by 2017. Section 106 of EPACT authorizes the Secretary of Energy to enter into voluntary agreements with industry with the goal of reducing energy intensity by not less than 2.5 percent each year during the period o f calendar years 2007 through 2016. The Department of Energy (DOE) is seeking information from industry and industry associations regarding the most beneficial and efficient way to reduce industrial energy intensity in order to implement this goal. The information received will be used by DOE for internal planning and decision making purposes.

Source 12: 'UK Response to Energy Review'
Referenced on page 27 in section 3.1 Interval Meter Customers' Potential

Energy Efficiency in the United Kingdom is challenging traditional thinking along with a movement towards the 'Smart Grid'

----Original Message-----
To: scott.rouse@energy-efficiency.com
Subject: UK Response to Energy Review

"It's now clear that Ministers are asking the wrong questions. Instead of asking how Britain can make its energy system more efficient, this review is only looking at what kind of fuel we use to generate electricity. "The UK has an electricity grid designed seventy years ago that wastes most of the fuel we put into it. What we need is an energy revolution, a grid that lets renewable schemes and energy efficiency measures meet their full potential.

"Energy efficiency is by far the cheapest and simplest way of meeting all our policy goals in this area."

Appendix B – Energy @ Work Prospectus

Energy @ Work is a consulting company that provides independent advice and energy management services to help improve their bottom line from effective energy management.

Examples of projects that are available on-line include:

- ***Bottom Line to Energy Management, independent electricity system operator (IESO)***
  http://www.ieso.ca/imoweb/pubs/bi/em_bottomLine.pdf

- ***Lighting Guide***
  http://www.Energy-Efficiency.com

- ***Power Quality Guide***
  http://www.Energy-Efficiency.com

- ***Case Study for Natural Resources Canada, Confederation Freezers***
  http://www.confederation.energy-efficiency.com

Projects with interval meter customer include new construction, energy audits, energy efficiency projects and assessments to the development of complete corporate energy plans.

Sector support includes industrial, commercial and institutional sectors by providing with services that begin at the meter and end at the utility bill.

Contact: Scott.Rouse@Energy-Efficiency.com, 416 402-0525

Energy @ Work

Energy @ Work's mission is to achieve sustainable and cost effective solutions for our clients.

Energy @ Work works in partnership with you to;

1) Understand Right!
- Obtain Boma Go Green "Plus" Certification
- Deliver Energy Audits / Benchmarking
- Provide 'Real time' utility monitoring

2) Use Right!
- Customize and implement an energy plan
- Access and secure available incentives
- Engineer, design and manage energy measures

3) Buy Right!
- Provide independent review and advice
- Prepare contract documentation
- Ensure on-going monitoring, tracking and verification

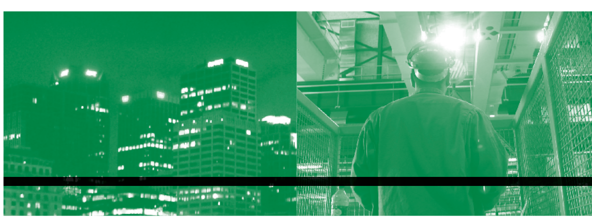
Energy @ Work's framework was recognized by Canada and the U.S. EPA, having won both national energy efficiency awards, and continues to evolve through '**Best in Class**' reviews with energy champions!

Let **Energy @ Work** help you

Contact us
@
Scott.Rouse@Energy-Efficiency.com
Managing Partner

416 402.0525

www.Energy-Efficiency.com



Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 6
Schedule 9
Appendix D
Filed: 2011 Apr 1
(49 pages)

Final Report

Conservation Potential Assessment

Prepared for:
Seattle City Light

October 13, 2006

quantec *Raising the bar in analytics™*

Prepared by:
Ken Seiden, Ph.D.
Collin Elliot
Quantec, LLC

K:\2005 Projects\2005-32 (SCL) Potential Analysis\Report and Presentations\Final CPA Report_10_11_06.doc

Quantec Offices

720 SW Washington, Suite 400
Portland, OR 97205
(503) 228-2992; (503) 228-3696 fax
www.quantecllc.com

1722 14th St., Suite 210
Boulder, CO 80302
(303) 998-0102; (303) 998-1007 fax

28 E. Main St., Suite A
Reedsburg, WI 53959
(608) 524-4844; (608) 524-6361 fax

3445 Grant St.
Eugene, OR 97405
(541) 484-2992; (541) 683-3683 fax

20022 Cove Circle
Huntington Beach, CA 92646
(714) 287-6521

Acknowledgements

This project was a complex undertaking that took over six months to complete. It required the compilation of a large amount of data from multiple sources. We relied heavily on staff in various departments at Seattle City Light for data and analytic support. Key contributors included Debra Tachibana, Deb Das, Dennis Pearson, Glenn Atwood, Michael Little, David Clement, Mary Winslow, Phoebe Warren, and Javad Maadanian. Furthermore, we also want to acknowledge Tom Eckman of the Northwest Power and Conservation Council, who provided assistance on efforts to incorporate non-energy conservation benefits in the analysis. Without the active participation, generous assistance, and timely response to our requests for information from these individuals, we could not have addressed many of the project challenges. We apologize to any whose efforts have gone erroneously unrecognized.

We are indebted to Marya Castillano, former Director of the Conservation Resources Division at Seattle City Light, for her confidence, unwavering support, and patience.

Finally, our enduring gratitude goes to our project manager, Steve Lush, who worked closely with us every step of the way and provided invaluable insight, direction, and decisiveness while allowing us to exercise our independent judgment, and to maintain objectivity.

Table of Contents

1. Executive Summary

This Conservation Potential Assessment (CPA) presents a comprehensive assessment of achievable demand side management (DSM) resources as part of Seattle City Light's (SCL) Integrated Resource Planning (IRP) process. The overall approach in this study distinguishes between two distinct, yet related, definitions of energy efficiency potential that are widely used in utility resource planning: technical and achievable potential. Technical potential assumes that all demand-side resource opportunities may be captured, regardless of their costs or market barriers. Achievable potential, on the other hand, represents that portion of technical that is likely to be available over the planning horizon, given prevailing market barriers that may limit the implementation of demand-side measures.

The study examined energy savings available across the major sectors in SCL's service area:

- Residential – three dwelling segments and 14 end uses
- Commercial – 12 building segments and 24 end uses
- Industrial – six industrial segments and seven end uses.

The CPA analysis considered dozens of individual measures, with hundreds of permutations across segments and construction vintages, distinguishing between discretionary (e.g., shell and lighting retrofit) and lost opportunity (equipment replacement and new construction) resources.

A wide range of measure-specific, economic, and market information was compiled for this study, including primary data (SCL's forecasts, customer characteristics surveys, DSM program achievements) and secondary sources (including the Northwest Power and Conservation Council's Regional Technical Forum, the Energy Information Association, and the California Energy Commission's Database for Energy Efficient Resources).

CPA Findings

For all three sectors, the estimation of achievable potential started with the development of technical potential through the application of Quantec's End Use Forecaster™ model in three separate steps:

a) Develop a baseline forecast,

b) Produce a potential forecast for each end use that incorporates installation of all feasible energy-efficiency measures, and

c) Calculate technical potentials by end-use as the difference between the two forecasts.

Once the estimates of technical potential were complete, a 70% market penetration assumption was incorporated to produce the achievable potential.

Based on the results of this study, cumulative 15-year achievable conservation potentials in SCL's service area are estimated at nearly 229 aMW of electricity, representing more than 18% of the baseline electricity consumption forecast in that year (2020).[1] The breakout of these savings in hypothetical maxima for years five, 10, and 15 are presented below in Table 1.

Table 1. Achievable Conservation by Sector

Segment	aMW Savings		
	5 Years	10 Years	15 Years
Residential	21.6	47.2	71.3
Commercial	37.7	81.3	120.4
Industrial	10.3	23.4	37.1
Total	***69.6***	***151.8***	***228.8***
Total as % of Baseline Forecast	***5.8%***	***12.9%***	***18.1%***

The final CPA task was the aggregation of results into resource blocks for incorporation into SCL's IRP modeling process. Table 2 shows the estimates of achievable potential broken out in $.01 increments based on the levelized cost of the resource. As the data show, around 53% of the achievable potential was available at $.06/kWh or less, which was the threshold used by SCL as an initial economic screen based on a preliminary estimate of the cost of the next available, least-cost supply-side resource. This was driven in large part by potential in the industrial sector, which had more than 95% of the savings available for less than $.06/kWh.

Table 2. Cumulative Achievable Potential by Cost Group

Cost Group	Residential (aMW)	Commercial (aMW)	Industrial (aMW)	Total (aMW)	Cumulative Percent
A. Up to $0.01	2.6	11.7	0.7	14.7	6%
B. $0.01 to $0.02	5.1	32.8	17.9	48.1	21%
C. $0.02 to $0.03	11.2	48.1	34.3	79.1	35%
D. $0.03 to $0.04	13.9	52.4	35.2	101.6	44%
E. $0.04 to $0.05	18.8	58.7	35.5	113.2	49%
F. $0.05 to $0.06	20.3	63.5	36.5	120.5	53%
G. $0.06 to $0.07	26.8	67.4	36.5	130.9	57%
H. $0.07 to $0.08	31.8	70.0	36.5	138.4	60%
I. $0.08 to $0.09	33.2	76.0	36.5	145.8	64%
J. $0.09 to $.10	35.8	78.4	37.1	150.9	66%
K. $.10 and Higher	71.3	120.4	37.1	228.8	100%

Caveats

There was an explicit understanding as this CPA commenced that many of SCL's internal data sources were out-of-date. Consequently, an additional objective of this study was to identify

[1] Since achievable potential estimates represent a percentage of the technical potential estimates, only the results for achievable potential are presented.

where the data were most wanting, and where they might lead to an inaccurate characterization of available resources.

Indeed, Quantec found this to be the case, as much of the data / information we relied upon to develop inputs for the CPA were very dated, and should not be used again in future CPA updates. This is particularly acute in the industrial sector where savings estimates are based on 15 year-old SCL research applied to current and forecasted loads, and in the residential sector where retrofit parameters were developed from the SCL's 1990 Residential Weatherization Study.

The lack of recent data is due, in part, to reductions in spending in basic research at SCL over the last decade. This surely provided customer benefits in terms of reduced bills. Further, SCL conservation programs were consistently meeting annual targets over this period, and there was no state or city requirement to conduct IRPs. The situation has changed markedly in recent years. Expanding IRP requirements, along with the notion that the so-called "low hanging conservation fruit" have been picked, indicate that SCL has to better understand how customers use electricity and make electric equipment purchases in order to rely on future CPA estimates as a real resource.

2. Methodology

This report presents a comprehensive assessment of technical and achievable conservation resources as part of Seattle City Light's (SCL) Integrated Resource Planning (IRP) process. It includes the following conservation resource analytics:

- Development of conservation resource bundles consistent with Global Energy Advisors' IRP model development for SCL
- Incorporation of SCL's existing energy efficiency program achievements
- Appropriate treatment of the relationship(s) between load forecast, existing conservation, and naturally occurring conservation, including both market effects and government-mandated codes and standards.

This chapter presents the overall Conservation Potential Assessment (CPA) methodology. The rest of the CPA report covers the major project tasks:

1. ***Baseline consumption***. The development of an accurate baseline – including the present stock of equipment efficiency characteristics and expected changes in stock equipment efficiencies over the planning horizon due to codes, standards, and naturally occurring conservation – is essential to accurately portray the size of conservation resources.
2. ***Technical and achievable potential***. Our comprehensive conservation resource assessment approach provides a traditional estimation of technical and achievable potential, along with the characterization of conservation achievable potential in resource blocks.

These processes represent the best practices and methods in the utility industry, and use the most recent data available. Moreover, studies such as this require compilation of large amounts of data from multiple sources on existing demand management strategies, technologies, and market dynamics that affect their adoption. They also rely on assumptions concerning the future, particularly changes in codes and standards, energy efficiency technologies, market conditions, and consumer behavior. It is, therefore, inevitable that the findings of this study will have to be periodically revisited to take into account new data and the changing energy market dynamics.

Estimating Technical and Achievable Potential

The overall approach in this study distinguishes between two distinct, yet related, definitions of resource potential that are widely used in utility resource planning: "technical potential" and "achievable potential." Technical potential assumes that all demand-side resource opportunities may be captured regardless of their costs or market barriers. Achievable potential, on the other hand, represents that portion of technical potential that is likely to be available over the planning horizon, given prevailing market barriers that may limit the implementation of demand-side measures.

Technical Potential. The technical potential estimates were comprised of a bottom-up analysis of electric energy savings in SCL's service area. The analysis, which was applied to the residential, commercial, and industrial sectors, assumes 100% market penetration where energy efficiency resources are applicable and measures are not already installed. Quantec's DSM potential analysis tool, End Use Forecaster, was used to estimate technical energy efficiency potential and involved three steps:

Step 1: Develop a baseline forecast that utilizes:

- Calibrated 2004 loads
- Retirement of existing end uses (through equipment decay functions tied to end-use lifetimes)
- Additional customers (e.g., new construction customers)
- Expected improvements in energy efficiency without market intervention
- Federal codes and energy standards that are in effect in 2006
- State of Washington or City of Seattle codes and standards that go beyond state or federal codes.

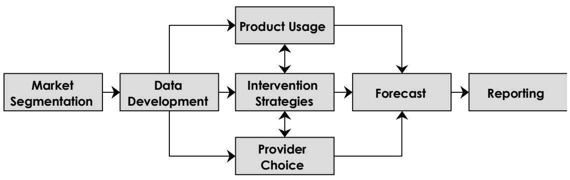
Step 2: Produce a potential forecast for each end use that incorporates installation of all feasible energy efficiency measures.

Step 3: Calculate technical potentials by end use as the difference between the two forecasts.

End Use Forecaster

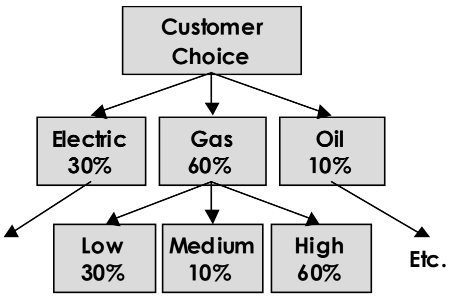
End Use Forecaster is a proprietary end-use forecasting and conservation potential modeling framework developed by Quantec. Seven primary modules form the heart of the End Use Forecaster framework: Market Segmentation, Data Development, Product Usage, Provider Choice, Intervention Strategies, Forecasting, and Reporting. The following figure depicts the relationships between these modules.

Modules and Structure



The usage module tracks the energy consumption by unit (e.g., building type, vintage, end use, fuel type, and equipment efficiency level) and represents annual consumption regardless of the market share of that equipment in the building stock. Put differently, for a customer that has this equipment, this is how much energy it uses per piece of equipment.

Choice Module Nesting



The Customer Choice module focuses on customer equipment decisions by fuel type and efficiency level. As depicted in the *Choice Module Nesting* figure, marginal market shares for replacement end uses, and new construction, are represented by a nested structure of fuel and efficiency choices.

The Intervention Strategies module captures the impacts associated with energy efficiency programs. This module simulates the "what-if" impacts on the usage, market shares, and the resulting demand forecast. Three general types of impacts can be modeled, consistent with conservation planning and program design:

Usage Retrofit in Existing Buildings. These scenarios reduce end use energy usage given the equipment customers already have (e.g., improve the efficiency of existing equipment by installing retrofit efficiency measures or through better O&M procedures).

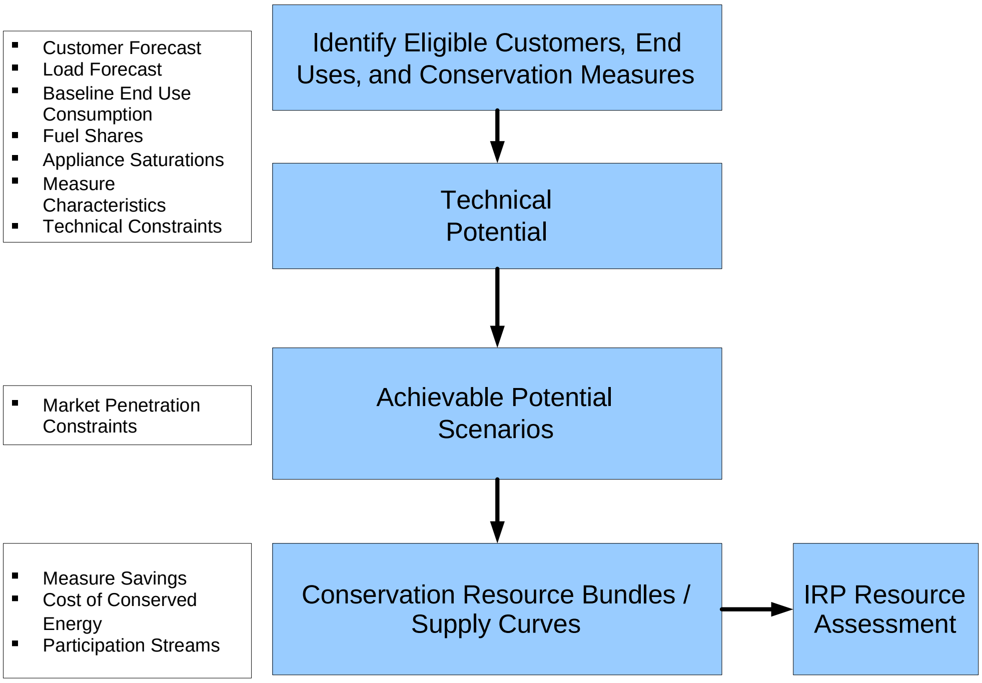
Equipment Replacement in Existing Buildings. These scenarios modify equipment replacement efficiency shares.

New Construction Equipment Shares and Usage. These scenarios modify the equipment for new buildings, and/or their end use energy usage through alternate building shell measures.

The Forecast Module incorporates all the information compiled from the other modules – Usage, Choice, and Intervention Strategies – related to the overall economic growth of the market segment and equipment lifetime (decay) functions to create the final forecast for a given scenario.

The general methodology and analytic techniques in this study conform to standard utility industry practices and methods. The approach begins with the current load forecast, deconstructs it into sector, market segment, and end-use components, and then examines the effect of the range of energy efficiency technologies and strategies on each end use. These impacts are then aggregated to produce energy efficiency potentials at the end use, sector, and system levels. This general methodology is diagrammatically presented in Figure 1 and more detailed information is provided in the section that follows.

Figure 1. Methodological Approach



1) Develop Base Case Forecast: The base case end use forecast was calibrated to SCL's 2004 energy sales, customer forecasts, and appliance and equipment saturations from a variety of sources.[2] This step provides an estimate of future energy consumption in the absence of new energy efficiency programs. It establishes a benchmark against which the impacts of the phase-in technical and achievable energy-efficiency potentials can be assessed. Also taken into account are the effects of equipment standards and naturally occurring efficiency improvements, which emanate from the reduction of usage as low-efficiency equipment is retired.

2) Determine Measure Impacts: This step involved integrating measure-specific data (per unit costs, savings, and measure life) with baseline building stock data (base case fuel saturations, measure applicability factors, current measure saturations) and base case-calibrated energy usage data to produce estimates of levelized costs per unit of conserved energy. More information on measure savings calculations is presented later in this chapter.

3) Estimate Phased-In Technical Potential: Technical potential for energy efficiency was then estimated through the Intervention Strategies module, which effectively overrides the base case energy usage and market equipment efficiency shares. Alternative scenarios were incorporated directly into the relevant Product Usage and Provider Choice forecasts. Phased-in technical

[2] All data sources used in this study are described in the next chapter.

potentials were calculated by subtracting the energy forecast associated with the highest possible penetration of energy efficiency measures from the base case forecast.

As discussed in the End Use Forecaster text box above, Quantec distinguishes between equipment replacement measures, which are modeled based on adjusted market shares of equipment and appliances given their usage, and measures that change equipment usage given equipment efficiency market shares. This distinction is depicted in Figure 2. In this example, the commercial sector is broken down into different business segments, end uses within each segment, fuel types within each end use, and efficiency levels within each end use. This category, shown in the orange boxes below, has two purposes. In the base case, the shares of new construction and replacement of high and medium efficiency heat pumps are set at levels consistent with no further SCL conservation efforts. In the phased-in technical potential case, the share of all new construction and replacement equipment is shifted from the medium box to the high box.

Figure 2. Market Segmentation, End Uses, and Conservation Measures

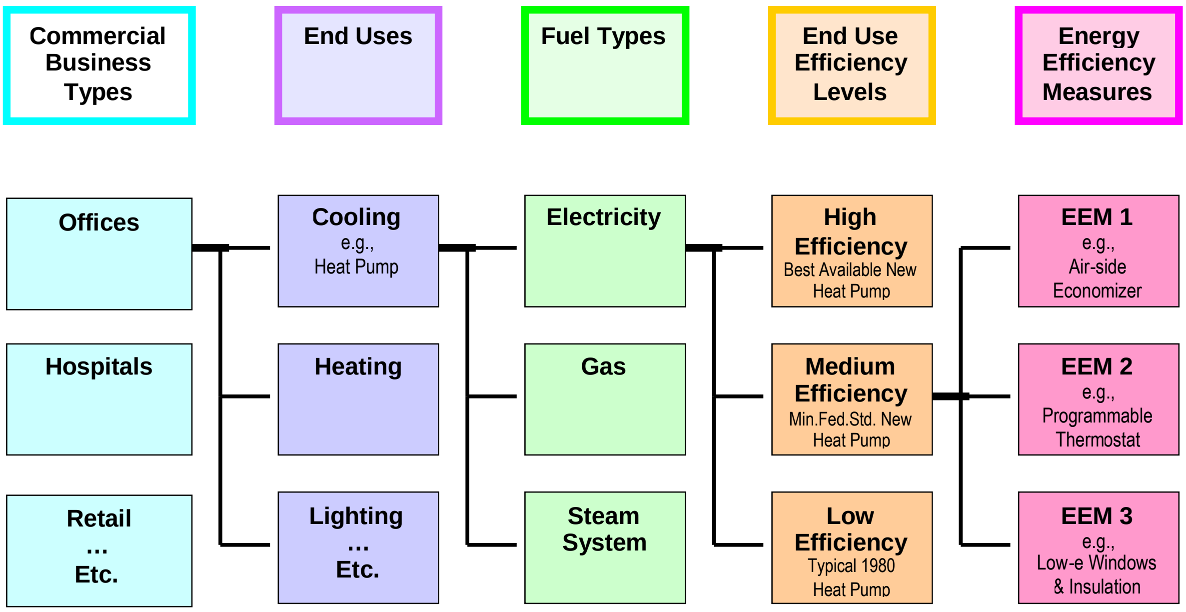


Figure Created by Debra Tachibana, SCL, 2006

Notice that this market share shift is based on a static level of consumption constant for each efficiency level, with revised market shares applying to new homes and the number of existing heat pumps that are replaced upon failure. The heat pump efficiency shift reduces consumption by the relative difference in efficiency ratings. As shown by the pink boxes in Figure 2 above, the model then applies a series of new construction shell measures and existing building retrofit measures that reduce the electric usage of each heat pump regardless of efficiency level.

4) Estimate Achievable Potential and Create Resource Bundles: An important study objective was to make an accurate assessment of achievable energy efficiency potentials. In addition to considering realistic market penetration rates, the achievable conservation potential analyses aggregated the estimates into "blocks" of available energy efficiency resources that were sizable enough to compare to and evaluate against supply options on a balanced and consistent basis.

Based on preliminary estimates of SCL's avoided costs, the achievable energy efficiencies were disaggregated into distinct cost-per-kWh-based resource blocks in 10 mill cost increments as shown in Figure 3. The commercial and industrial price points are identical to this residential sector illustration, and also represent the levelized cost over the life of the resource. They can be viewed as a "contract price" akin to many electric supply resources.

Figure 3. Conservation Resource Block Price Points, Residential Example

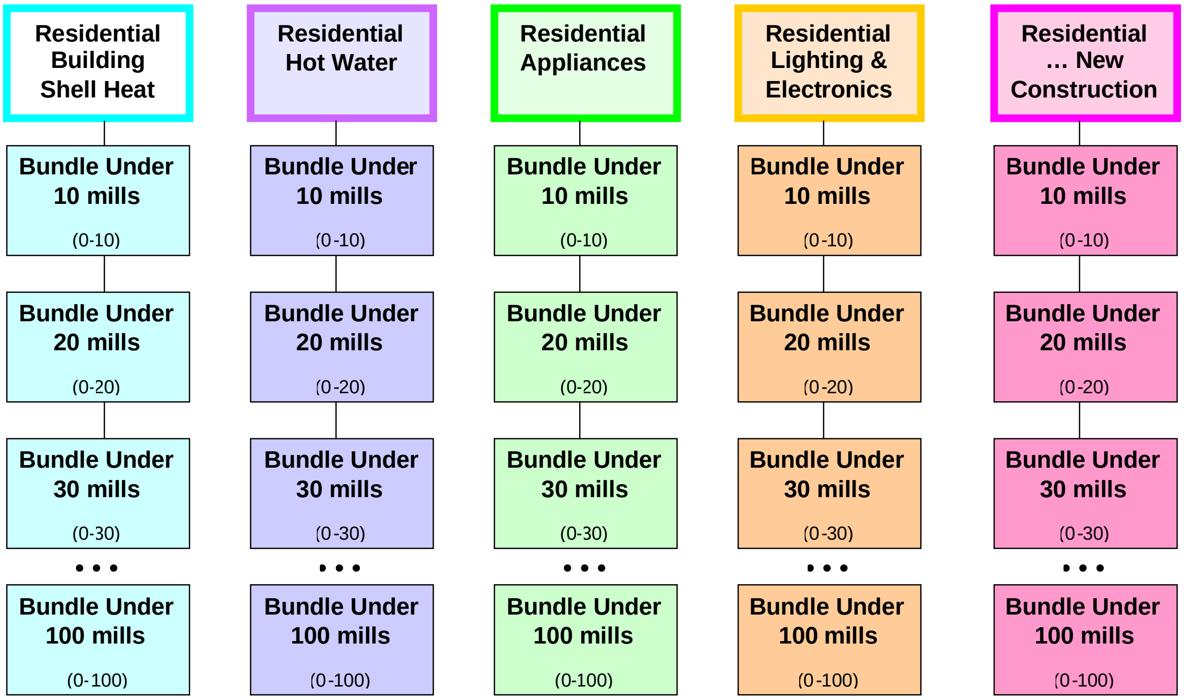


Figure Created by Debra Tachibana, SCL, 2006

The assessment of levelized cost is a means of capturing the economics, and ultimately economic potential, of each measure. Levelized costs are traditionally used by regional planning organizations to provide a broad comparison of energy efficiency resources to supply resources. It is important to recognize that levelized costs themselves do not represent cost-effectiveness criteria, and are not the same as total resource costs. They represent the cost of energy efficiency in terms of a level payment, similar to a mortgage payment. When combined with the size of the resource (kWh saved), the levelized costs effectively represent the "supply curve" of energy efficiency resources. The formula is as follows:

$$LevelizedCost = InstalledCost / \sum_{l=1}^{L} SAVE/(1+DiscountRate)**l$$

where the denominator is the total savings of the measure over its lifetime (l), discounted back to the present. Suppose for example, a measure costs $50, and will save 100 kWh per year over a 10 year life. If the discount rate is 7.5%, the net present amount of the lifetime savings is 686 kWh. We then divide the installed cost of $50 by 686 to yield the levelized cost of $0.073. Each kWh saved over the lifetime of the measure costs 7.3 cents.

After breaking out these groups, four additional steps were required to convert the technical potential estimates into achievable potential blocks for IRP analysis:

1. Add an administrative cost adder of 15% that approximates the program delivery mechanisms and associated costs.
2. Estimate market penetration, which was assumed by SCL to be 70%.
3. Account for line losses at 5.2%.
4. Add appropriate non-energy benefit adders for lighting and water heating measures consistent with NWPC estimates.

Base Case Forecast Calibration

End Use Forecaster-generated annual baseline end use energy consumption was calculated in each market segment as shown in equation (1) as follows:

(1) $$EUSE_{ijf} = \Sigma_e \; ACCTS_i * UPA_i * SAT_{ij} * FSH_{ijf} * ESH_{ijfe} * EUI_{ijfe},$$

where:

- $EUSE_{ijf}$ = total energy consumption for end use j in building type i using fuel f
- $ACCTS_i$ = the number of accounts/customers in segment i
- UPA_i = the units per account in segment i (= average square feet per customer in commercial segments; = 1.0 in residential dwellings)
- SAT_{ij} = the share of customers in segment i with end use j
- FSH_{ijf} = the share of fuel f in end use j in segment i
- ESH_{ijfe} = the market share of efficiency level e in the equipment segment ijf
- EUI_{ijfe} = energy consumption per customer (per square foot for commercial) use by the equipment configuration ijfe

Total consumption in each sector was then determined by summing $EUSE_{ijf}$ across the end uses and customer segments. The key to ensuring an accurate baseline and reasonable estimates of energy efficiency potentials is to calibrate the historical starting year to actual SCL electricity sales in 2004. End Use Forecaster calibration was achieved in two steps:

1. If the initial End Use Forecaster total is less than the SCL historical value, residual energy is attributed to the “other” end use. This value should be greater than or equal to zero, but should not exceed 10% of 2004 electricity sales.

2. When non-calibrated total usage is more than 10% below actual usage (or above actual usage by any amount), the next step is to proportionately increase (reduce) end use energy usage of each end use until the total sector usage in the baseline equals 2004 electricity sales.

Since all energy savings potentials are defined in *percentage terms*, this process has no effect on energy efficiency savings potential estimates. Indeed, this calibration process ensures that resulting energy efficiency potentials are fully consistent with SCL's electricity sales, avoiding any systematic over- or under-estimate of potentials.

Measure Savings

The following data components are necessary to produce levelized costs per unit of energy saved, and the achievable potential resource blocks:

- Basic measure data, including percentage savings, costs, and measure life
- Baseline end use data (annual consumption per customer, number of customers, units per customer (square footage), equipment saturations, fuel shares)
- Measure applicability and share remaining to be completed.

Equation (2) below shows the basic equation for estimating *retrofit* or *new construction shell measure* savings, where the impact is defined as a measure that changes the annual consumption of an end use without affecting the basic end use equipment. The classic example is additional insulation in existing or new buildings. The insulation reduces consumption without changing the basic HVAC equipment in the building.

(2) $SAVE_{ijfm} = EUI_{ijfe} * PCTSAV_{ijfem} * APPFACTOR_{ijfem} * INCFACTOR_{ijfem}$

where:

- $SAVE_{ijfm}$ = annual energy savings for measure m for end use j in building type i using fuel f
- EUI_{ijfe} = calibrated annual end-use energy consumption for the equipment configuration ijfe
- $PCTSAV_{ijfem}$ = is the percentage savings of measure m relative to the base usage for the equipment configuration ijfe, and takes into account interactions among measures such as lighting and HVAC calibrated annual end use energy consumption
- $APPFACTOR_{ijfem}$ = is the fraction of the floor space or households that is applicable to install measure m. For non-competing measures, which are primarily non-lighting, this estimate is generally close to 100%, with lesser amounts due to engineering limitations (for example, the share of buildings with enough room in the wall cavities to install additional insulation). For competing measures within an end use, such as various types of lighting retrofits, this factor is used to represent the share of the end use associated with the measure.

- $INCFACTOR_{ijfem}$ = is the fraction of the applicable floor space or households that has not yet been converted to measure m.

As discussed previously, pure "equipment" measures in existing and new construction are modeled by adjusting market shares relative to the baseline.[3] Since the baseline forecast includes the impacts of federal codes and standards and the small penetration of high efficiency equipment that occurs without market intervention, it incorporates most "naturally-occurring" conservation as commonly defined by the demand-side management analysis community.

Measure Stacking and Interaction Effects

A well-known issue associated with determining retrofit energy efficiency potentials is measure stacking. Stacking effects occur when more than one measure (such as wall, ceiling, and floor insulation) are applied to a single end use. To incorporate stacking effects, it is necessary to establish a rolling reduced baseline as each new measure is added. This is shown in equations (3) through (5), where measures 1, 2, and 3 are applied to end use life:

(3) $SAVE_{ijf1} = EUI_{ij\,fe} * PCTSAV_{ijfe1} * APPFACTOR_{ijfe1} * INCFACTOR_{ijfe1}$

(4) $SAVE_{ijf2} = (EUI_{ijfe} - SAVE_{ijf1}) * PCTSAV_{ijfe2} * APPFACTOR_{ijfe2} * INCFACTOR_{ijfe2}$

(5) $SAVE_{ijf3} = (EUI_{ijfe} - SAVE_{ijf1} - SAVE_{ijf2}) * PCTSAV_{ijfe3} * APPFACTOR_{ijfe3} * INCFACTOR_{ijfe3}$

The stacking order for SCL is determined by the stand alone, levelized cost of each measure affecting the end use.

A similar result occurs in End Use Forecaster between retrofit and replacement measures impacting the same end use. Consider the example shown in Table 3 – the base case annual usage for this central heat pump is 8,000 kWh. Two measure packages are applied: a retrofit package consisting of insulation measures and a replacement high-efficiency heat pump. Note that the timing of these measure packages is likely to differ, with the heat pump replacement occurring when the customer's unit fails.

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3 Energy usage differences across efficiency levels for each end use are also determined in the baseline, consistent with the percentage of reduction in equipment energy consumption from moving up the equipment efficiency "ladder."

Table 3. Retrofit and Replacement Interaction Effects Example

Category	kWh	Percent Savings
Base case usage	8,000	
Non-interactive savings		
Building shell improvements	1,600	20%
High-efficiency heat pump	1,200	15%
Total savings	2,800	35%
Interactive savings		
Building shell improvements	1,600	20%
Usage after shell improvements	6,400	
High-efficiency heat pump	960	15% of 6,400 kWh
Total savings	***2,560***	***32% of 8,000 kWh***

If savings are estimated without these interaction effects, each measure package is treated independently with savings estimated relative to the base case. The 20% savings in building shell improvements are added to the 15% savings from the high efficiency heat pump to yield total savings, but this overstates the potential.

Interactive impacts are determined in a manner similar to retrofit measure stacking, with the order determined by the respective timing of the replacement and retrofit activities over the resource planning horizon.

Non-Energy Benefits

The incorporation of non-energy benefits (NEBs) into Seattle City Light's (SCL) conservation potential assessment (CPA) followed the approach used by the Northwest Power and Conservation Council (NPCC). Although NEBs include a wide variety of system benefits, for this CPA we focused on benefits that are quantifiable and where there is common consensus about their value. Consistent with these criteria, the analysis was limited to the following categories:

- Detergent, water, and sewer savings associated with residential clothes washers
- Water and sewer savings associated with residential dish washers
- O&M savings for residential CFLs
- O&M savings for commercial lighting.

The values for these benefits were derived from data available on the NPCC's Regional Technical Forum's (RTF) Web site. The first step was to map the RTF measures to their counterparts from the CPA. For the residential measures, this process was straightforward, with clearly recognizable counterparts in the RTF data for all of the CPA measures. For commercial lighting, the vast number of permutations in terms of segments, baseline technologies, lamp lengths, and fixture counts in both the RTF data and the CPA measures meant that there was no possible way to perform a one-to-one mapping of the NEBs with the specific CPA measures.

Instead, average NEBs for a subset of technology configurations were calculated for use in the analysis.

Once the measures were mapped, the values for the NEBs were used to determine net measure costs. For the residential measures, this involved taking the present value of the stream of benefits over the measure's lifetime and subtracting them from the installation cost. The net measure cost was then used in the subsequent calculation of the measure's levelized costs. For the commercial lighting measures, the RTF data already represented the levelized value of the benefit in $/kWh, and were removed directly from the calculated levelized cost as shown in Table 4. The table shows the NEBs as a percent of the total measure cost; the relative magnitude of the NEBs can be substantial.

Table 4. Non-Energy Benefits (NEB) as Percent of Total Measure Cost

NEB Category	NEB Value as Percent of Measure Cost	Notes
Detergent and water and sewer savings associated with residential clothes washers	90%	Detergent savings alone amount to more than $17/year, according to RTF data
Water and sewer savings associated with residential dish washers	5%	Council data specific to Seattle
O&M savings for residential CFLs	16%	Varies by average daily usage.
O&M savings for commercial lighting	80%	Figure based only on those measures where valid O&M savings were identified.

3. Data Sources and Gap Analysis

The full assessment of energy efficiency resource potentials required compilation of a large database of measure-specific technical, economic, and market data from a large number of existing primary and secondary sources. The main sources of data used in this study included, but were not limited to:

1. ***Seattle City Light***: 2005 load forecasts, economic assumptions, historical energy efficiency and load management program activities, 2000 Residential Customer Characteristics Survey (RCCS), 1995 industrial conservation potential study, and the Commercial Building Stock Assessment (CBSA). The CBSA is a study of the Northwest's commercial building characteristics sponsored jointly by the Bonneville Power Administration, the Northwest Energy Efficiency Alliance, and SCL. A complete list of data elements provided by SCE is shown in Table 5.

Table 5. SCL Data Sources

SCL Data Source	Key Variables	Use in This Study
2005 Load Forecasts: Commercial, Residential and Industrial	Energy and Peak Forecasts, Customer Counts, Employment and Population Forecasts	Base Case Calibration, Energy efficiency Potential Share of Forecast, Per Customer Use for Calibration, New Construction Forecast
Annual Conservation Accomplishments Reports, 1990-2005	Program Participation, Conservation Measures Installed Between 1990 and 2004	Incomplete Factors
2000 Residential Customer Characteristics Survey (RCCS)	Dwelling Characteristics, Equipment Saturations, and Fuel Shares	Dwelling Type Breakouts, Square Footage per Dwelling, Applicability Factors, Incomplete Factors, Forecast Calibration
2003 Commercial Building Stock Assessment (CBSA)	Building Characteristics, Equipment Saturations, and Fuel Shares	Building Type Breakouts, Square Footage per Dwelling, Applicability Factors, Incomplete Factors, Forecast Calibration
1995 Industrial Conservation Potential Study	Equipment Usage, Measure Characteristics	Industrial End Use / Process Consumption Estimates, Measure Characteristics (savings, cost, life)
1990 Residential Weatherization Study	Residential Retrofit Parameters	Saturation of weatherization measures (incomplete factors), building stock characteristics

2. ***Pacific Northwest Energy Studies***: Several Northwest entities provided data critical to this study, including the Northwest Power and Conservation Council (NPCC), the Regional Technical Forum (RTF), the Northwest Energy Efficiency Alliance (the Alliance), and Puget Sound Energy (PSE). This information included technical information on measure savings, costs, lives and non-energy benefits, hourly end use load shapes, and commercial building and energy characteristics. Details are provided in Table 6.

Table 6. Pacific Northwest Data Sources

Pacific Northwest Data Source	Key Variables	Use in This Study
NPCC 2004 Power Plan	Measure Data, Energy efficiency Potential Estimates	Measure Savings, Costs, Lives, and Non-Energy Benefits; Cross-Check of SCL Potential Estimates
NPCC Hourly Electric Load Model (HELM)	Hourly Load Shapes	Hourly End-Use Load Shapes for Residential, Commercial, and Industrial Sectors
RTF Web Site	Measure Data	Measure Savings, Costs and Lives, estimates of non-energy benefits
PSE 2005 Least Cost Plan	Measure Data, Energy Efficiency Potential Estimates	Measure Savings, Costs and Lives; Cross-Check of SCL Potential Estimates

3. ***California Energy Commission***: This study relied heavily on information available through the 2005 Database of Energy Efficiency Resources (DEER). These data included information on energy efficiency measure costs and savings, measure applicability factors, and technical feasibility factors.
4. ***Equipment Vendors***: Cost data for various measures were compiled from the original sources and, where necessary, updated based on the most recent information available from regional equipment suppliers.
5. ***Ancillary Sources***: Other data sources consisted primarily of available information from past energy efficiency market studies, energy efficiency potential studies and evaluations of energy-efficiency programs in the Northwest and elsewhere in the country. The primary source for information on the industrial section was the U.S. Department of Energy, Energy Information Administration Office of Industrial Technologies.

Gap Analysis

The previous chapter described the systematic approach taken to calibrate the end use forecast to actual sales in the base year. In practice, however, nearly all the assessments require a number of informal steps to get the end use forecasts within a range where it is then reasonable to apply the standardized approach to calibration. These steps are based on assessing the quality of the various inputs to the forecast, and making the necessary adjustments where it is reasonable to do so. The idea is to anchor the study in as much reliable data as possible, and restrict uncertainty to isolated areas. When a large number of data sources, or just some of the key inputs, are less reliable than is desired, both the level of uncertainty and where it lies become difficult to ascertain.

With this in mind, this study served as a review process, based on experience and collaboration with City Light staff, to identify the key issues concerning quality and age of the key data sources. Through this review process Quantec and SCL identified certain data that, while used in this effort due to study resource and time limitations, should not be relied upon in the future given SCL's commitment to accurately identifying cost-effective conservation resources. In particular, the follow primary data collection activities are warranted either prior to, or as part of SCL's 2008 IRP and accompanying CPA:

- Update industrial sector data
- Update residential sector data
- Update commercial sector data
- Assess potential market penetration of conservation program offerings.

Update Industrial Sector Data

Due to its frequently intractable nature, the industrial sector often receives short shrift in potential assessments. This oversight is not due to researcher negligence, but is a decision made based on full consideration of the costs and benefits of conducting the necessary research to gather quality data. In the case of SCL, the industrial sector is sufficiently distinct and large enough that basic research is justified. Moreover, SCL has been successful in capturing the available potential from its top industrial customers (largest 200 or so), but there are at least one thousand industrial customers that SCL needs to know more about.

Unfortunately, SCL last conducted a major industrial customer base assessment in 1995 in a study using data from the early 1990s. At 15 years of age, the data are essentially unreliable for obtaining a baseline or projecting conservation potential. Current SCL industrial billing data are based on customers paying industrial rates (e.g., rate codes 35 and 39). This amounts to around 200 customers. However, according to SCL customer data, the number classified as industrial using the two-digit SIC code is approximately 1,200. This means that approximately 80% of the "true" industrial sector customers are not counted by SCL in the forecast or potential estimates. In the absence of up-to-date three- or four-digit SIC codes by customer, which are not utilized by SCL, there is no way to actually count actual customers or true industrial load at this time. In summary, industrial data collection is not only necessary to obtain actionable estimates of conservation resource potential, it is indispensable to accurately forecast future industrial loads.

Update Residential Sector Data

SCL's most recent residential customer assessment was a Customer Characteristics Survey (RCCS) conducted six years ago. At one time, the organization performed a RCCS biennially, but that practice stopped in the mid-1990s. More importantly, SCL has not collected in-field housing characteristics data since 2000. As with the industrial sector, reliance on old primary and secondary data in this CPA creates uncertainty about the conservation potential estimates accuracy.

Accurate estimates of residential conservation potential in future IRPs require regular basic RCCS information updates: appliance holdings and ages, fuel shares where a competing fuel is available to the customer, efficiency shares for new and replaced equipment, and trends in these and other key variables. Additionally, field work will be necessary to resolve the uncertainty surrounding the envelope characteristics of the existing housing stock. For example, how much insulation is out there? What are the physical constraints relating to adding insulation? How much more can be done? These data are needed across the lighting, HVAC, and water/

heating/plumbing end-uses. Given the distinct nature of SCL's service territory, where renovation and the construction of mixed-use multifamily are the dominant areas of activity, the need to gather data to accurately reflect the market is yet more critical.

Update Commercial Sector Market Data

From a market data standpoint, the commercial sector is in the best shape. SCL participated in the 2002 Commercial Building Stock Assessment (CBSA). Yet the field data collected by CBSA represent some of the largest buildings in the city. There is little data available to gauge the modeling assumption accuracy for small commercial customers (under 25,000 square feet)[4].

Key information requirements for small commercial customers will require on-site data collection efforts:

- Firmographic information (hours of operation, building type, etc.)
- Existing facility information (square footage, building construction, etc.)
- Energy-using equipment information (efficiency levels, age, kW capacity, etc.)
- Implemented energy efficiency strategies
- Opportunities to improve energy efficiency and reduce peak demand

Assess potential market penetration of conservation program offerings

In the Pacific Northwest, the achievable penetration rate has been traditionally set at 85% of technical potential for cost-effective measures. This figure is based on the results of BPA's successful direct-install program in Hood River the mid-1980s. The NPCC has used the 85% estimate in all subsequent Power Plans. SCL modifies this figure to a flat rate of 70% across all programs and services consistent with program results until a couple of years ago, and we employed the 70% per SCL staff instructions in this CPA.

The NPCC/SCL practice of setting a future market penetration "goal" based on past experience may, however, overstate future achievable conservation potential. A variety of factors affect the market penetration of conservation measures, including which markets and customers are targeted (e.g., large vs. small customers), inherent market barriers resulting from the customers' tendency to avoid paperwork and higher first costs, and SCL program marketing strategies and delivery mechanisms. This is why some programs, even with full incremental cost incentives, can have a wide range of penetration rates, and seldom achieve full market saturation. The available industry information suggests that, although incentive levels do play a significant role in determining program success, other non-financial factors may play an equal, if not more important, role.

To reduce market penetration uncertainty, we recommend that SCL conduct primary market research. This research can take the form of customer interviews, focus groups, or surveys

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[4] This is not an explicit reference to customers in SCL's small commercial rate class, although there is likely a strong correspondence between the two.

exploring energy attitudes, behaviors, intentions, and ultimately, likely participation in various SCL program offerings. In cases where trade allies are the ultimate decision-maker or heavily influence the decision-maker, it would be better to conduct this research directly with them.

Quantec has also successfully implemented a cost-effective approach, called the Delphi Method, to obtain penetration rates. The notion behind this methodology is that well-informed individuals, calling on their insights and experience, are better equipped to predict the future than purely theoretical approaches or empirical approaches without relevant historical or market research data. These experts are well-informed staff, trade allies, external advisors, and customers. The process works as follows:

1. Delphi participants are sent market penetration related questions via email. Program concepts describe possible program implementation strategies and associated incentives.
2. Respondents send their market penetration estimates back. We then calculate key market penetration statistics for each program concept: median, minimum, maximum, etc.
3. To maintain anonymity, we send "blind" results back to each individual, asking whether they want to change their estimates. The process continues for an iteration or two until the estimates converge.

Gap Analysis Summary

The reductions in spending in basic research at SCL over the last decade surely provided customer benefits in terms of reduced bills. Further, SCL conservation programs were consistently meeting annual targets, and there was no state or city requirement to conduct IRPs.

The situation has changed markedly in recent years. Expanding IRP requirements, along with the notion that the so-called "low hanging conservation fruit" has been picked, indicate that SCL has to better understand how customers use electricity and make electric equipment purchases in order to rely on CPA estimates as a real resource. This data gap analysis identifies several areas where data collection is critical to maintain the necessary confidence in future CPA resource estimates, and we urge SCL to proceed to collect these data in advance of its next planning cycle.

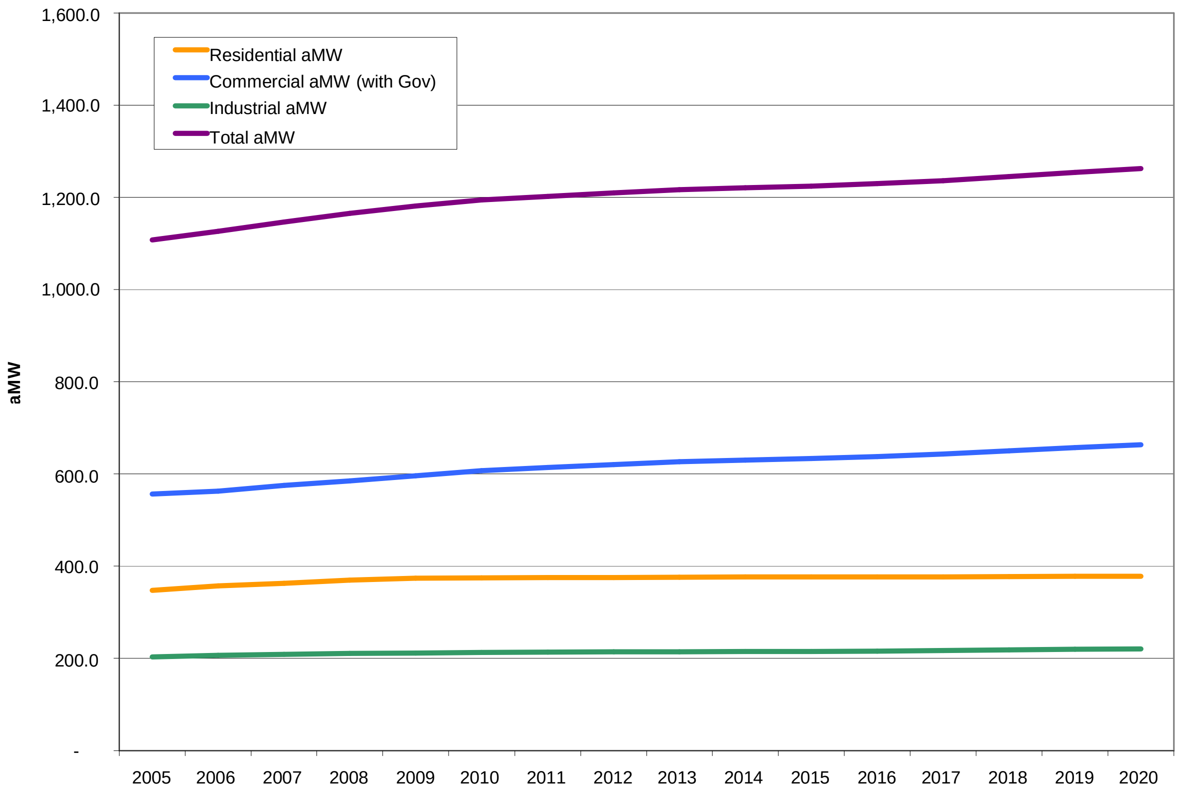
4. Baseline Energy Consumption

This chapter describes the segmentation design used to generate the baseline forecast and subsequent energy efficiency potential results, and presents the results of the baseline energy consumption forecast. The development of an appropriate and accurate baseline is essential to robust economic analysis of conservation resources and program design. The first step in characterizing the baseline was to appropriately partition SCL's customers by:

- Customer segments: residential, commercial, and industrial; and sub-segments by dwelling, building, and industry type
- Building vintage: existing and new construction
- End uses: those applicable for each customer segment.

As described in Chapter 2, the End Use Forecaster baseline is calibrated to SCL's official forecasts for each sector. These forecasts are shown in Figure 4.

Figure 4. SCL Energy Forecast



Residential Sector

The residential sector was divided into three segments and 14 end uses, as shown in Table 7 below. The segments chosen were based on their consistency with classifications available in SCL's most recent residential study, which had critical data on appliance and end use saturations and fuel shares. The end uses were broken out at the level necessary to assess the various measures of interest.

Table 7. Residential Segments and End Uses

Residential Segments	Electric End Uses
Single Family	Central_Heat
Multifamily 2- 4 Units	Room_Heat
Multifamily 5+ Units	Heat_Pump
	Central_AC
	Room_AC
	Lighting_Bulbs
	Lighting_Fixtures
	Water_Heat
	Refrigerator
	Freezer
	Cooking
	Dryer
	Plug_Load
	Other

Figure 5 shows base year (2004) energy consumption for each building type in the segmentation design. Given the higher usage per home in single family, the distribution of baseline usage by home type is consistent with the proportions of each home type in the residential study data used for the analysis.

Figure 5. Residential Base Year Consumption by Building Type

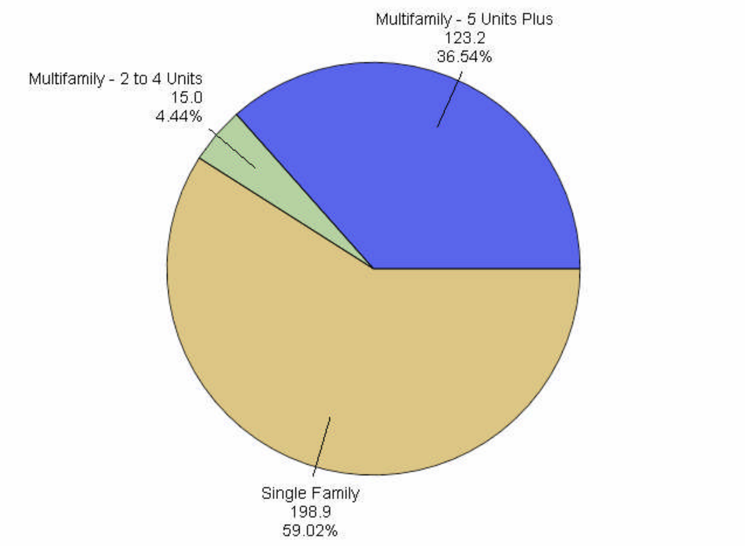
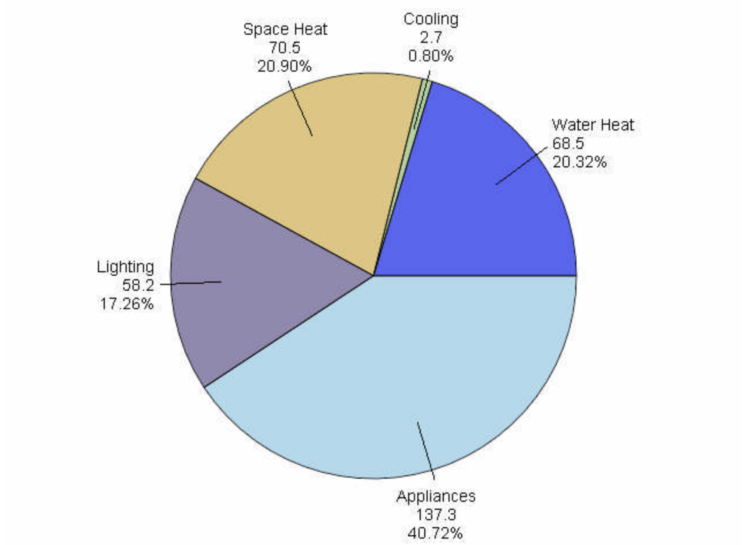


Figure 6 shows base year sales by end use. These breakouts take into account different fuel shares for the different end uses, with a substantial amount of gas heating and water heating reducing the overall share associated with those end uses. The low cooling load is due to the available residential data, which showed a very low saturation of room and central air conditioning in Seattle City Light's service territory. Anecdotal evidence suggests that these saturations are increasing, and this is one area where we anticipate that SCL efforts to eliminate data gaps will change the results presented here.

Figure 6. Residential Base Year Consumption by End Use



Commercial Sector

The commercial sector was divided into 13 segments and 24 end uses, as shown in Table 8 below. Following the detailed breakout available in the CBSA study, fluorescent lighting is disaggregated by number of bulbs, length of each bulb in feet, and diameter of each bulb in eighths of an inch. For example, Lighting_4L4T12 represents a 4 bulb fixture, 4 feet long, with an older, inefficient 12-eigths diameter.

Table 8. Commercial Segments and End Uses

Commercial Segments	Electric End Uses
Dry_Goods_Retail	Space_Heat_ASHP
Grocery	Space_Heat_WSHP
Office	Space_Heat_Boiler
Restaurant	Space_Heat_Furnace
Warehouse	Space_Heat_RadiantBase
Hospital	Cooling_Chillers
Hotel_Motel	Cooling_DX
School	Cooling_HeatPump
University	Ventilation
Other	Lighting_4L4T12
Data_Centers	Lighting_3L4T12
Biotech	Lighting_2L4T12
MF_Common	Lighting_2L8T12
	Lighting_4L4T8
	Lighting_3L4T8
	Lighting_2L4T8
	Lighting_INC75W
	Lighting_INC150W
	Lighting_MF_Common
	Water_Heat
	Refrigeration
	Cooking
	Plug_Load
	Other

Figure 7 shows base year energy consumption for each building type in the segmentation design. Nearly half of the baseline consumption is associated with the office segment, with the other segments accounting for the remaining energy usage in roughly equal proportions.

Figure 7. Commercial Base Year Consumption by Building Type

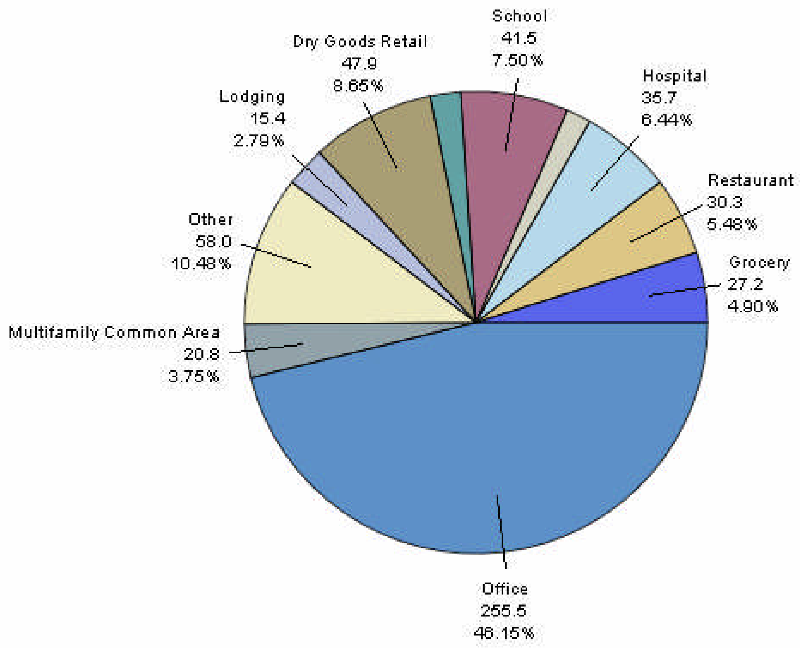
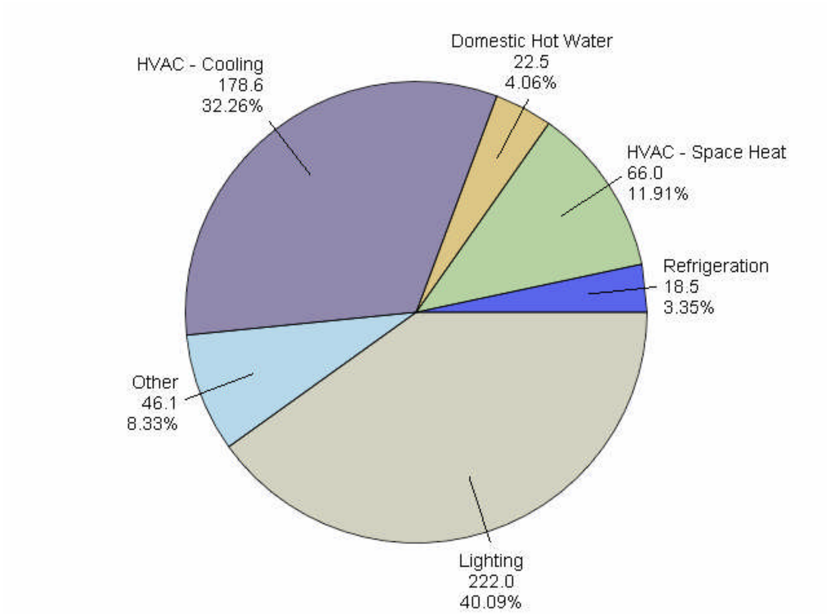


Figure 8 shows commercial base year sales by end use. The dominance of the office segment in the baseline consumption also explains the dominance of lighting and HVAC in the distribution by end use.

Figure 8. Commercial Base Year Consumption by End Use



Industrial Sector

The industrial sector was divided into six segments and seven end uses, as shown in Table 9 below. The segments and end uses were dictated by both the need to be consistent with previous assessment for this sector and the availability of key data inputs. The distribution of industrial base year energy consumption by segment and end use are shown in Figure 9 and Figure 10.

Table 9. Industrial Segments and End Uses

Industrial Segments	Electric End Uses
Food	Lighting
Stone_Clay_Glass	HVAC_Other
Metals	Air_Compressor
Aerospace	Motors
Ship	Process_Heat
Other	Refrigeration
	Welding

Figure 9. Industrial Base Year Consumption by Industry Type

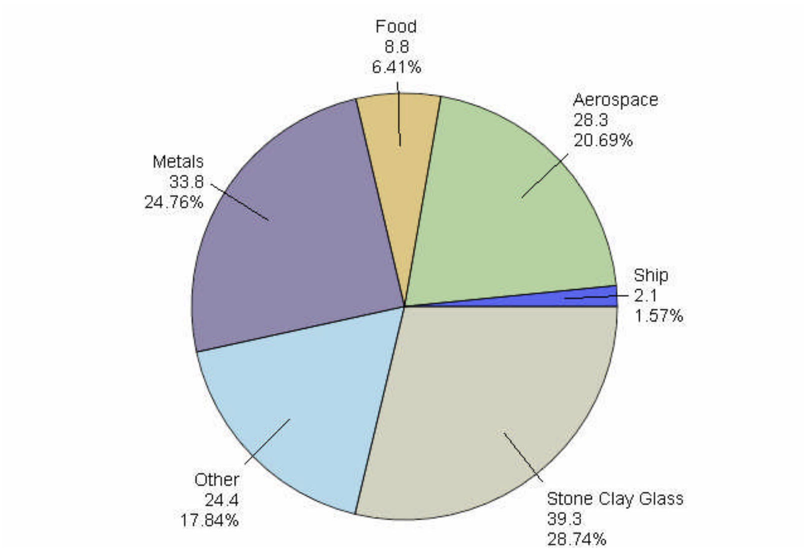
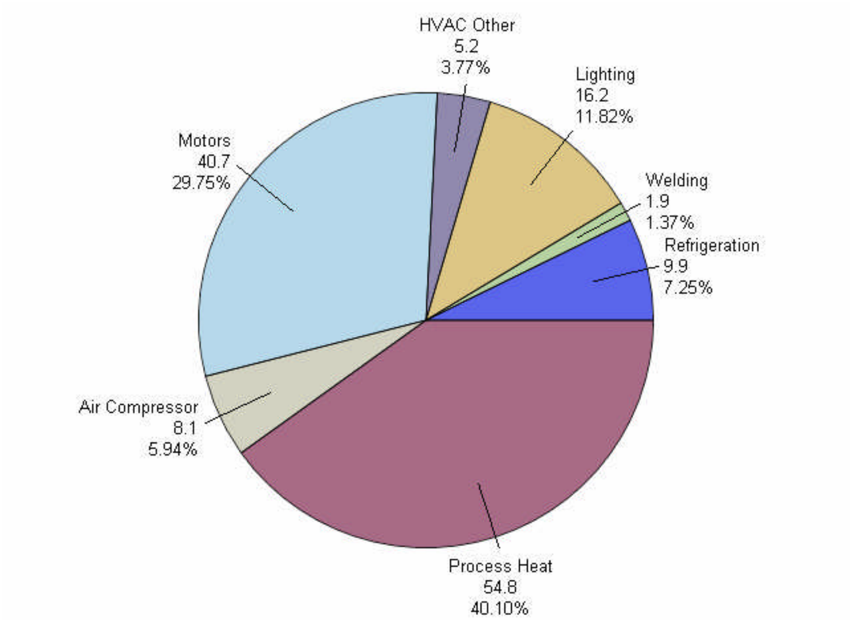


Figure 10. Industrial Base Year Consumption by End Use



5. Achievable Conservation Potential

As described in the *Methodology* chapter, the overall approach in this study distinguishes between two distinct, yet related, definitions of resource potential widely used in utility resource planning: “technical potential” and “achievable potential.” Technical energy efficiency potential, which assumes that all demand-side resource opportunities may be captured regardless of their costs or market barriers, was estimated using End Use Forecaster in three steps:

1. Development a baseline forecast (presented in the previous Chapter)
2. Creation of a potential forecast for each end use that incorporates installation of all feasible energy-efficiency measures
3. Calculation of technical potentials by end-use as the difference between the two forecasts.

Achievable potential, on the other hand, represents that portion of technical potential that is likely to be available over the planning horizon given prevailing market barriers that may limit the implementation of demand-side measures. SCL deemed that the market penetration rate across all sectors, segments, vintages, end-uses, and measures should be 70% for 2006 IRP purposes. Because of the simplicity of this approach, the results are shown for the achievable potential only, which is the subject of most interest.

Based on the results of this study, cumulative 15-year achievable conservation potentials in SCL’s service area are estimated at nearly 229 aMW of electricity, representing more than 18% of the baseline electricity consumption forecast in that year (2020). Table 10 shows these hypothetical maxima by sector for years five, 10, and 15 of the planning horizon.

Table 10. Achievable Conservation Potential by Sector

Segment	aMW Savings		
	5 Years	10 Years	15 Years
Residential	21.6	47.2	71.3
Commercial	37.7	81.3	120.4
Industrial	10.3	23.4	37.1
Total	***69.6***	***151.8***	***228.8***
Total as % of Baseline Forecast	***5.8%***	***12.9%***	***18.1%***

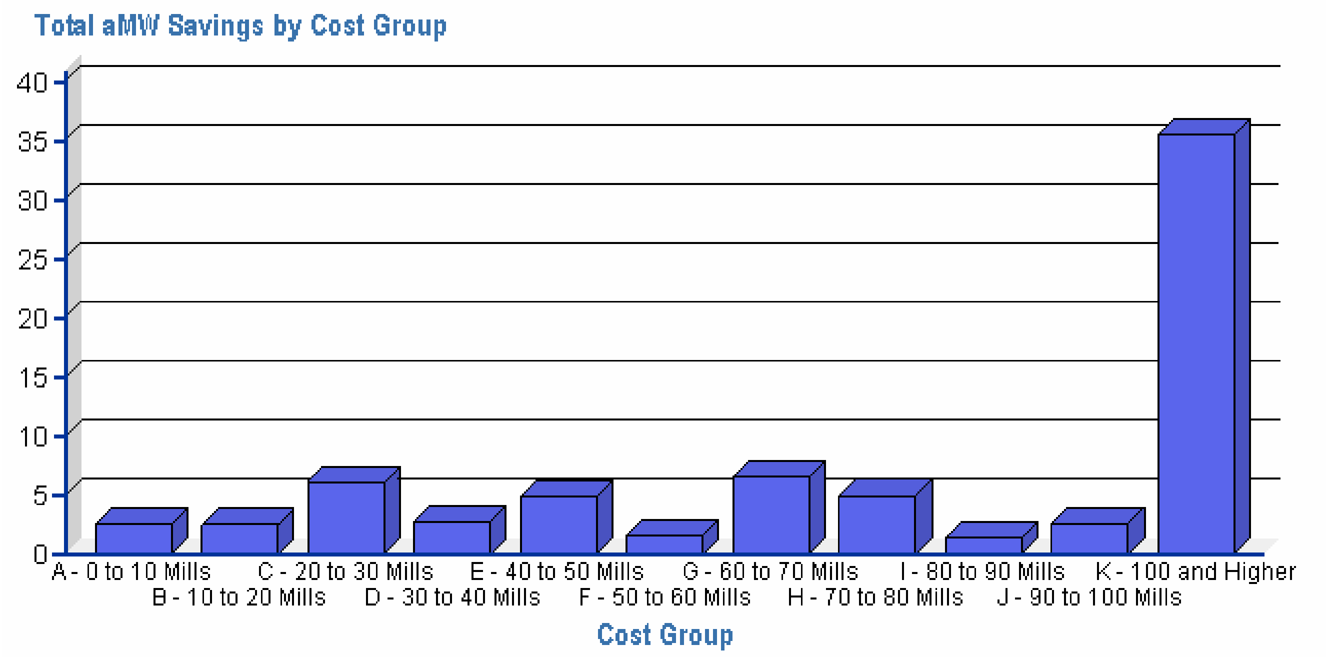
Residential Achievable Potential Results

Electricity energy efficiency achievable potential in the residential sector is estimated to be approximately 71.3 aMW in the 15th year of the planning horizon. The breakout of these savings by cost group and resource type is presented in Table 11. These savings represent approximately 19% savings relative to the base case (378 aMW) and 70% of technical potential. A full 20% of this potential (14 aMW) can be achieved at a cost of less than $.04 per kWh (Table 11 and Figure 11).

Table 11. Distribution of Residential Sector Achievable Potential by Cost Category

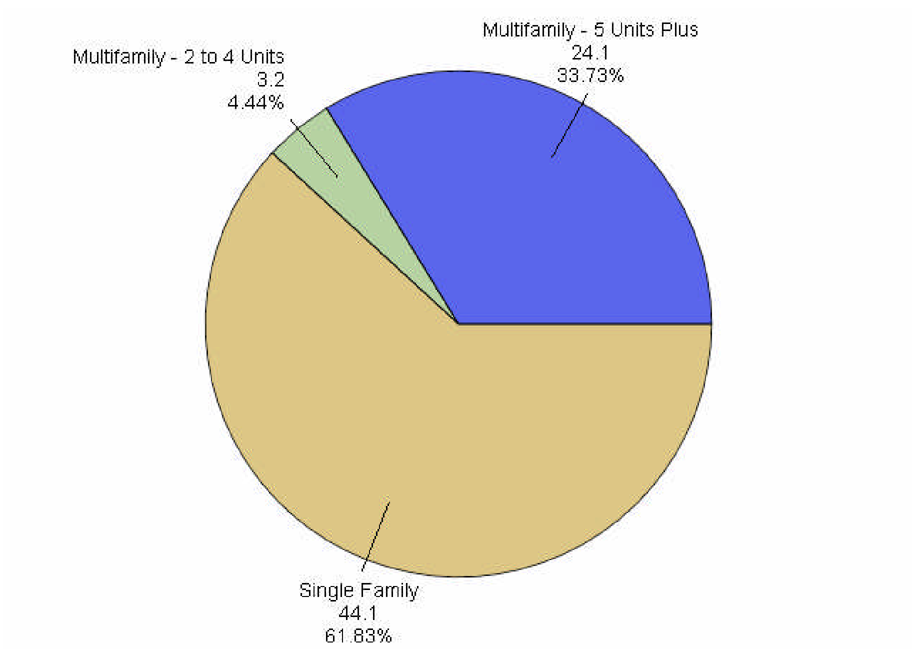
	Total aMW			Percent of Total by Cost Group		
	Equipment Replacement	New Construction	Retrofit	Equipment Replacement	New Construction	Retrofit
A - 0 to 10 Mills	-	0.1	2.5	0.0%	3.0%	3.9%
B - 10 to 20 Mills	-	-	2.5	0.0%	0.5%	3.9%
C - 20 to 30 Mills	-	0.7	5.4	0.0%	20.0%	8.6%
D - 30 to 40 Mills	-	-	2.8	0.0%	0.0%	4.4%
E - 40 to 50 Mills	-	-	4.8	0.0%	1.0%	7.6%
F - 50 to 60 Mills	-	-	1.5	0.0%	0.3%	2.4%
G - 60 to 70 Mills	1.9	0.1	4.5	40.8%	1.7%	7.1%
H - 70 to 80 Mills	0.5	0.1	4.4	9.9%	3.6%	6.9%
I - 80 to 90 Mills	0.7	0.2	0.5	14.8%	5.2%	0.9%
J - 90 to 100 Mills	-	-	2.6	0.0%	0.7%	4.1%
K - 100 and Higher	1.6	2.3	31.6	34.5%	63.9%	50.2%
Total	***4.8***	***3.5***	***63.1***	***100.0%***	***100.0%***	***100.0%***

Figure 11. Distribution of Residential Sector Achievable Potential by Cost Category



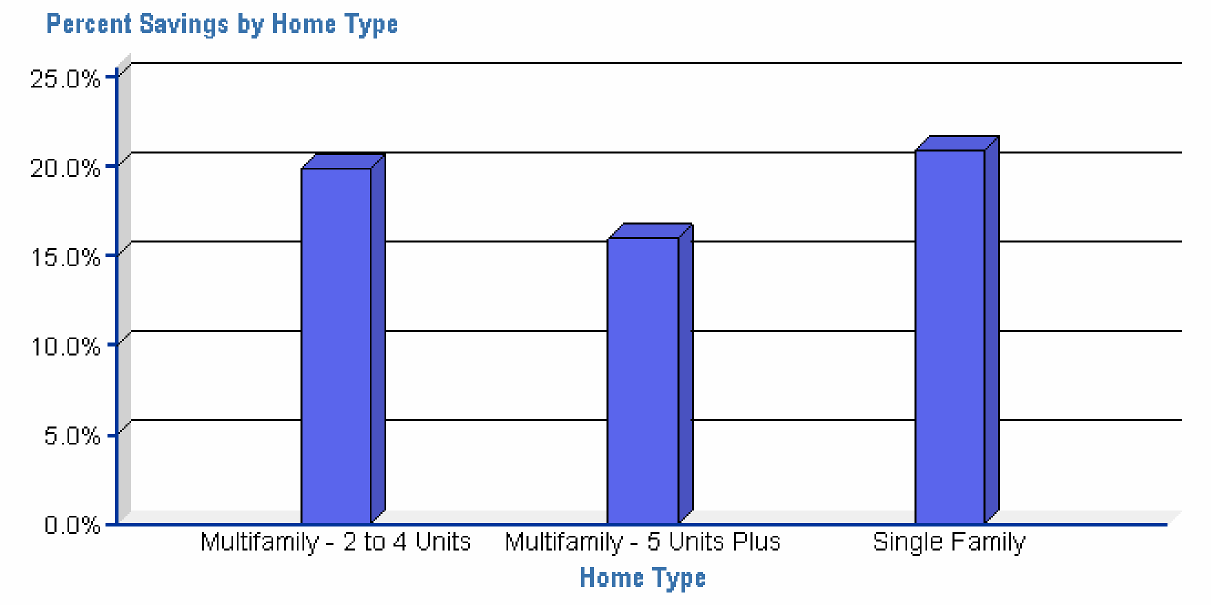
Single-family dwellings account for the largest share of achievable potential (62%) in the residential sector, followed by large multifamily dwellings, which account for approximately 34% of all residential achievable potential (Figure 12).

Figure 12. Distribution of Achievable Potential by Dwelling Type



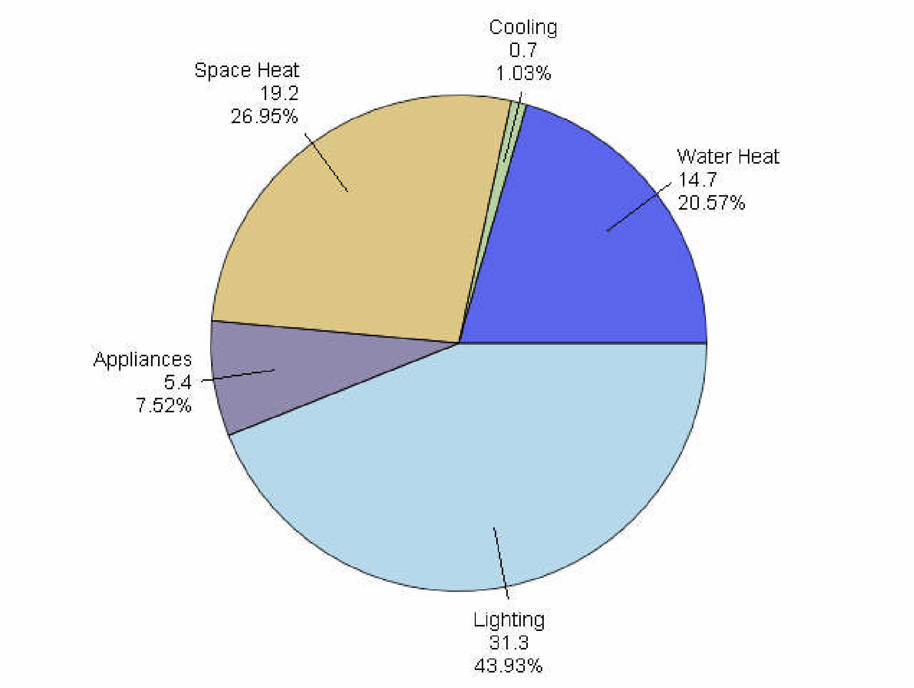
As shown in Figure 13, achievable potential within single family and small multifamily dwellings represents approximately 20% savings with respect to the total consumption in those dwellings. Large multifamily achievable potential represents about 16% of total consumption.

Figure 13. Achievable Potential as Percent Savings by Home Type



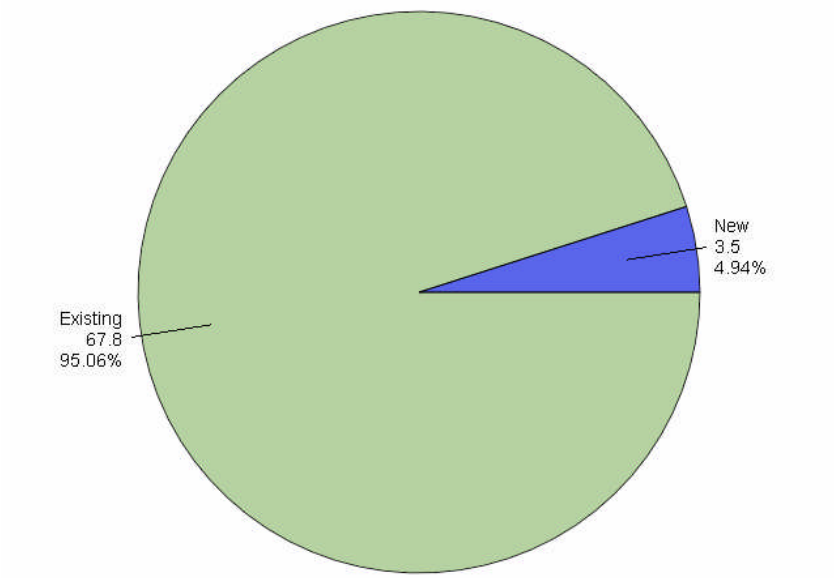
As shown in Figure 14, expected savings in lighting is the largest component of achievable potential in the residential sector, accounting for almost 44% of the total achievable potential across all end uses. Electric space heating and water heating account for nearly all of the remaining potential, with other end uses (refrigerators, freezers, etc.) accounting for less than 10% of the total achievable potential.

Figure 14. Distribution of Achievable Potential by End Use



Achievable potential in existing construction accounts for approximately 95% of total achievable potential, while the remaining 5% of achievable potential is attributed to new construction (Figure 15).

Figure 15. Distribution of Achievable Potential by Construction Type



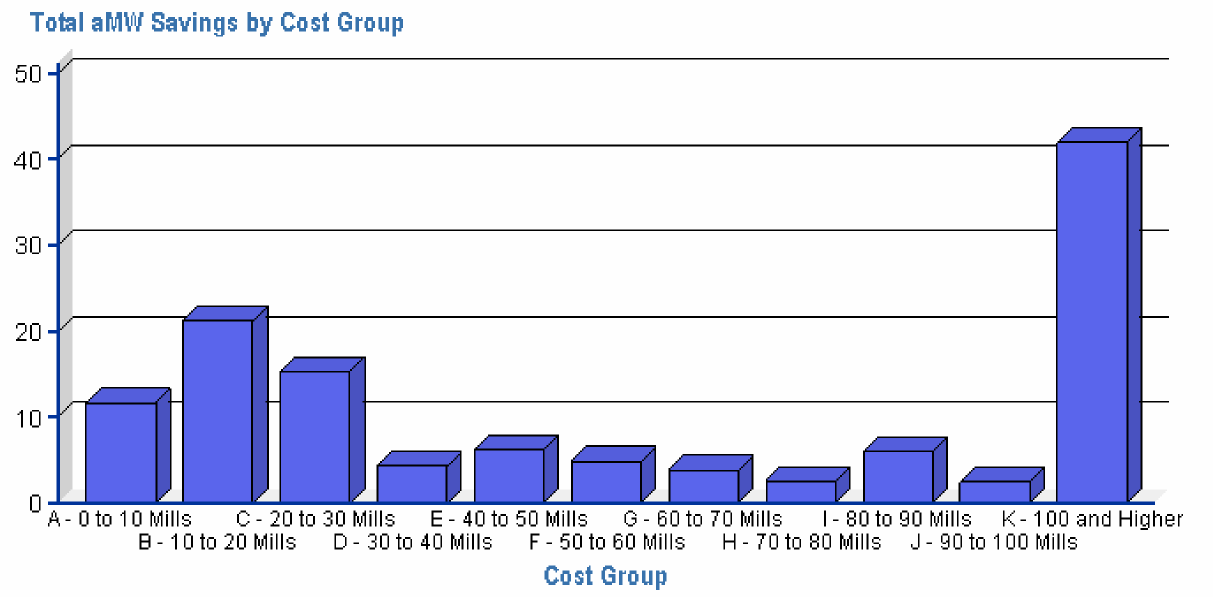
Commercial Achievable Potential Results

Electricity energy efficiency achievable potential in the commercial sector is estimated to be approximately 120 aMW in the 15th year of the planning horizon, which is approximately 18.2% savings relative to the base case (663 aMW) and 70% of technical potential. Around 44% of this potential (53 aMW) can be achieved at a cost of less than $.04 per kWh (Table 12 and Figure 16).

Table 12. Distribution of Commercial Sector Achievable Potential by Cost Category

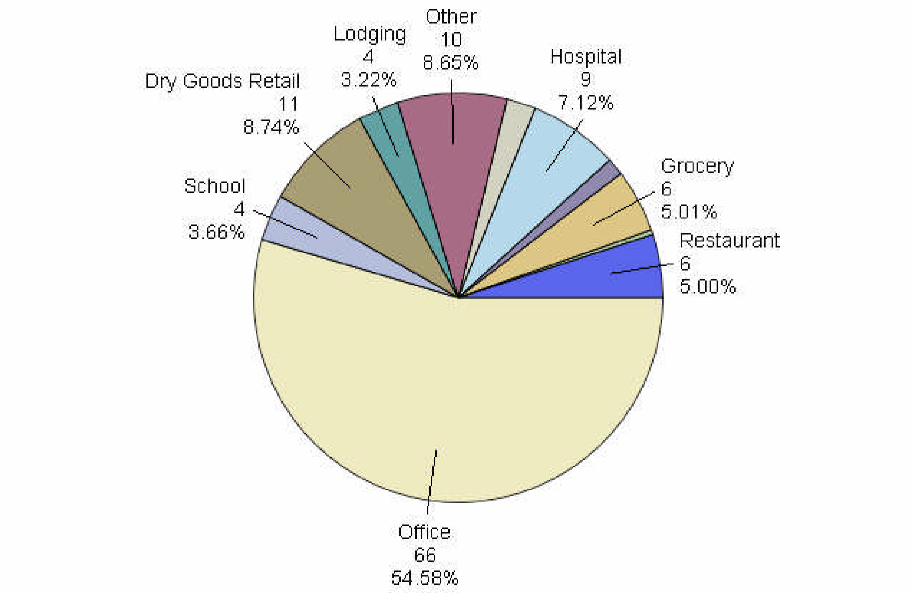
	Total aMW			Percent of Total by Cost Group		
	Equipment Replacement	New Construction	Retrofit	Equipment Replacement	New Construction	Retrofit
A - 0 to 10 Mills	0.9	1.1	9.6	0.0	6.4%	11.7%
B - 10 to 20 Mills	2.6	3.5	15.1	12.3%	20.2%	18.4%
C - 20 to 30 Mills	10.1	2.3	3.0	48.0%	13.1%	3.6%
D - 30 to 40 Mills	1.2	0.5	2.6	5.8%	2.9%	3.1%
E - 40 to 50 Mills	1.5	1.3	3.4	7.3%	7.7%	4.1%
F - 50 to 60 Mills	1.2	0.5	3.2	5.6%	3.0%	3.9%
G - 60 to 70 Mills	-	0.6	3.3	0.0%	3.4%	4.0%
H - 70 to 80 Mills	0.1	0.4	2.1	0.6%	2.2%	2.5%
I - 80 to 90 Mills	0.1	0.7	5.2	0.3%	4.3%	6.3%
J - 90 to 100 Mills	-	0.3	2.2	0.0%	1.7%	2.6%
K - 100 and Higher	3.3	6.1	32.6	15.6%	35.2%	39.7%
Total	*21.0*	*17.2*	*82.2*	*100.0%*	*100.0%*	*100.0%*

Figure 16. Distribution of Commercial Sector Achievable Potential by Cost Category



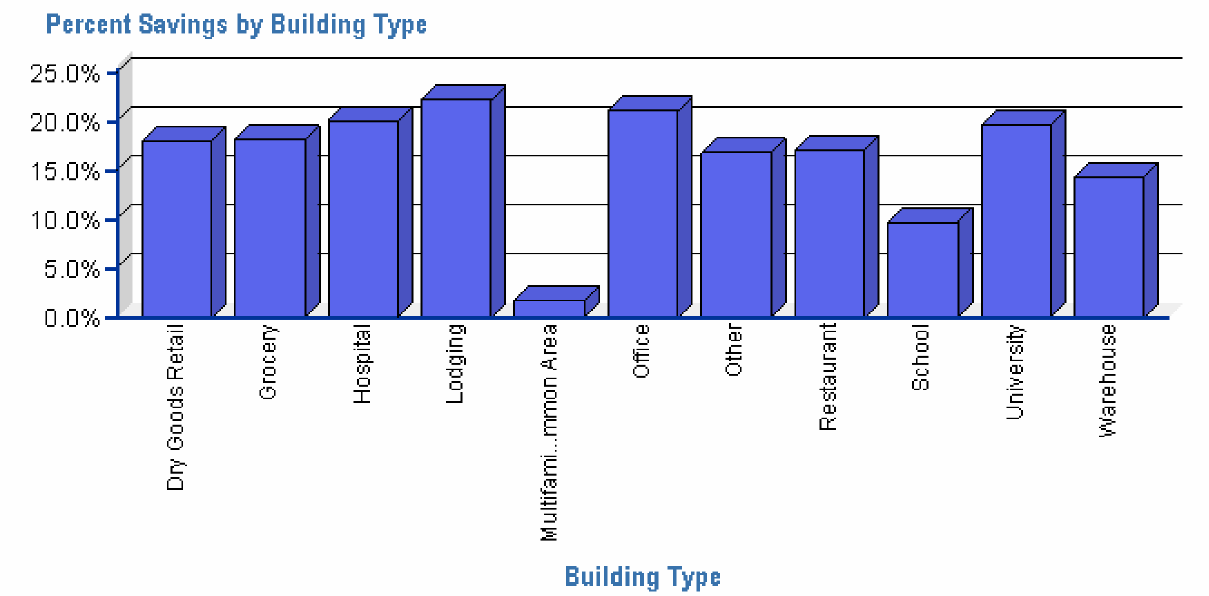
The office segment accounts for the largest share of achievable potential (55%) in the commercial sector, with no other segment accounting for more than 10% of the total achievable potential (Figure 17).

Figure 17. Distribution of Achievable Potential by Building Type



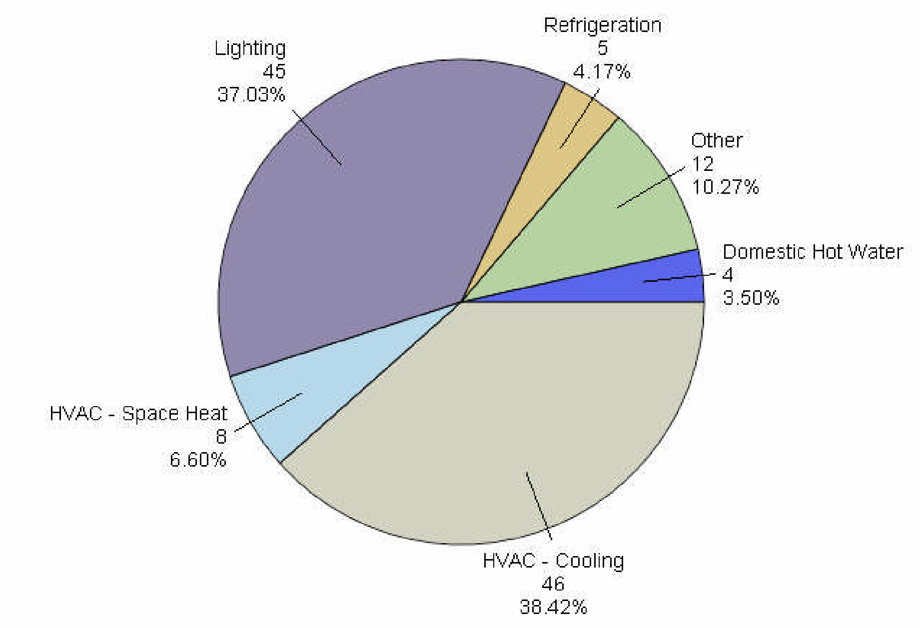
As a percentage of total consumption, achievable potential is highest within the lodging and office segments, with both at more than 20%. As shown in Figure 18, the lowest savings are with the school segment and multifamily common areas, which consists of lighting only.

Figure 18. Achievable Potential as Percent of Total Usage by Building Type



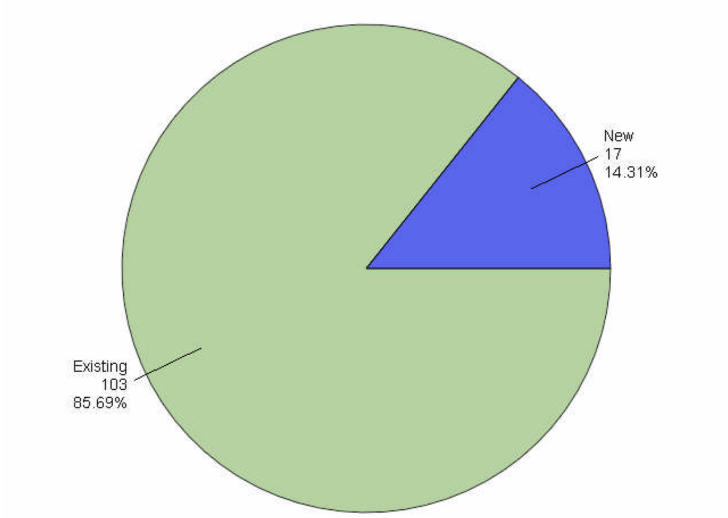
As shown in Figure 19, expected savings in HVAC is the largest component of achievable electricity energy efficiency potential in the commercial sector, accounting for 38% of the total achievable potential. Lighting is a close second with 37%.

Figure 19. Distribution of Achievable Potential by End Use



Achievable potential in existing construction accounts for approximately 86% of total achievable potential, while the remaining 14% of achievable potential is attributed to new construction (Figure 20).

Figure 20. Distribution of Achievable Potential by Construction Type



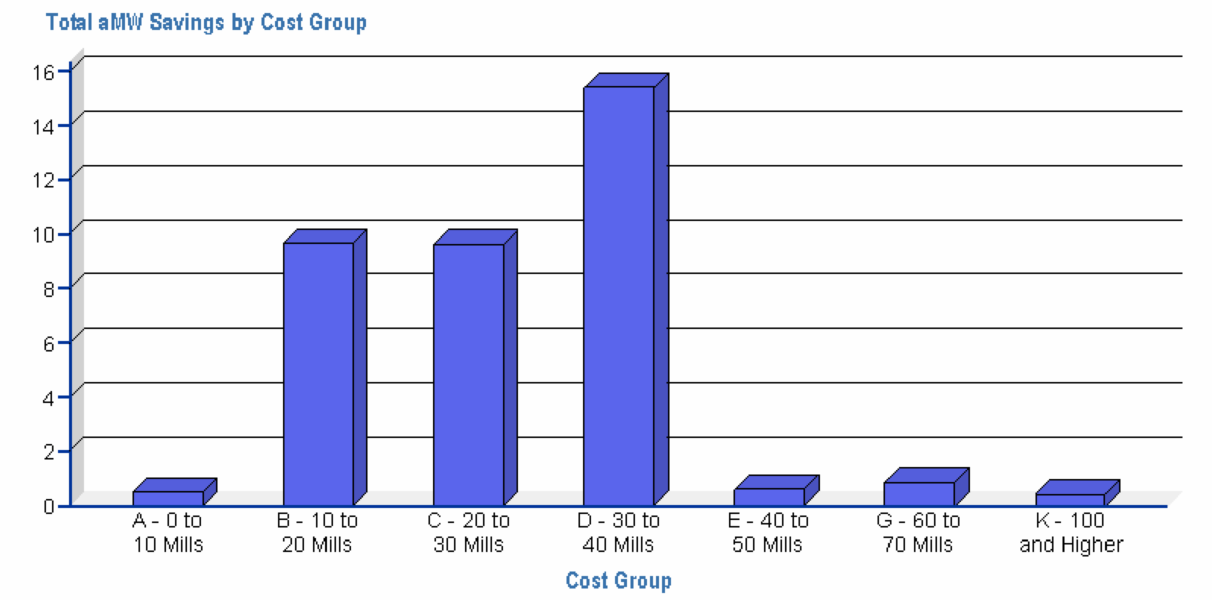
Industrial Achievable Potential Results

Electricity energy efficiency achievable potential in the industrial sector is estimated to be approximately 37 aMW in the 15th year of the planning. This represents approximately 17% savings relative to the base case (220 aMW) and 70% of technical potential. 95% of this potential (35 aMW) can be achieved at a cost of less than $.04 per kWh (Table 13 and Figure 21).

Table 13. Distribution of Industrial Sector Achievable Potential by Cost Category

	Retrofit Total MWh	Retrofit Percent of Total by Cost Group
A - 0 to 10 Mills	0.5	1.3%
B - 10 to 20 Mills	9.7	26.1%
C - 20 to 30 Mills	9.6	26.0%
D - 30 to 40 Mills	15.4	41.6%
E - 40 to 50 Mills	0.6	1.6%
G - 60 to 70 Mills	0.9	2.3%
K - 100 and Higher	0.4	1.1%
Total	**37.1**	**100.0%**

Figure 21. Distribution of Industrial Sector Achievable Potential by Cost Category



Industries in stone, clay, and glass accounted for over 39% of the achievable potential in the industrial sector (Figure 22), and were also the segment with the highest percentage of potential in terms of base consumption (Figure 23). The metals category had the second highest achievable potential at nearly 27%, followed by the general other category and aerospace with 18% and 12%, respectively.

Figure 22. Distribution of Achievable Potential by Segment

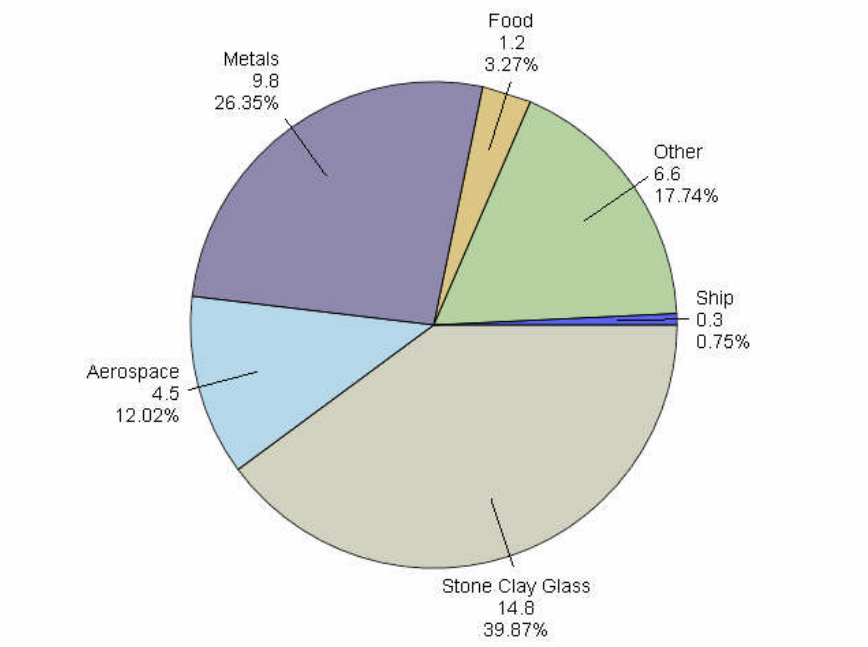
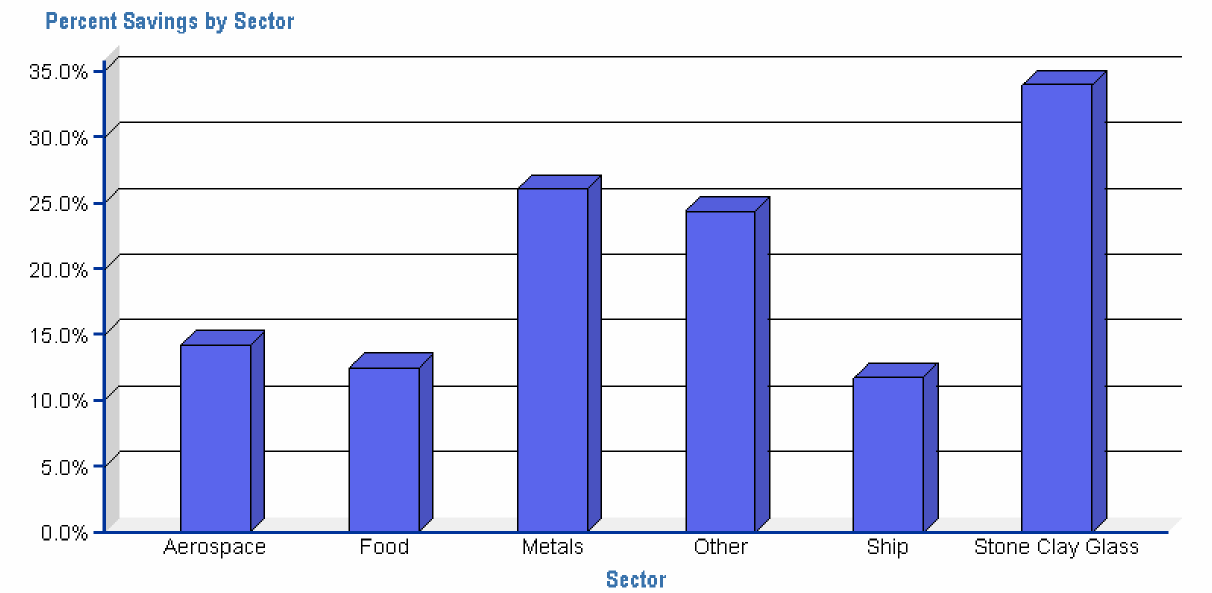
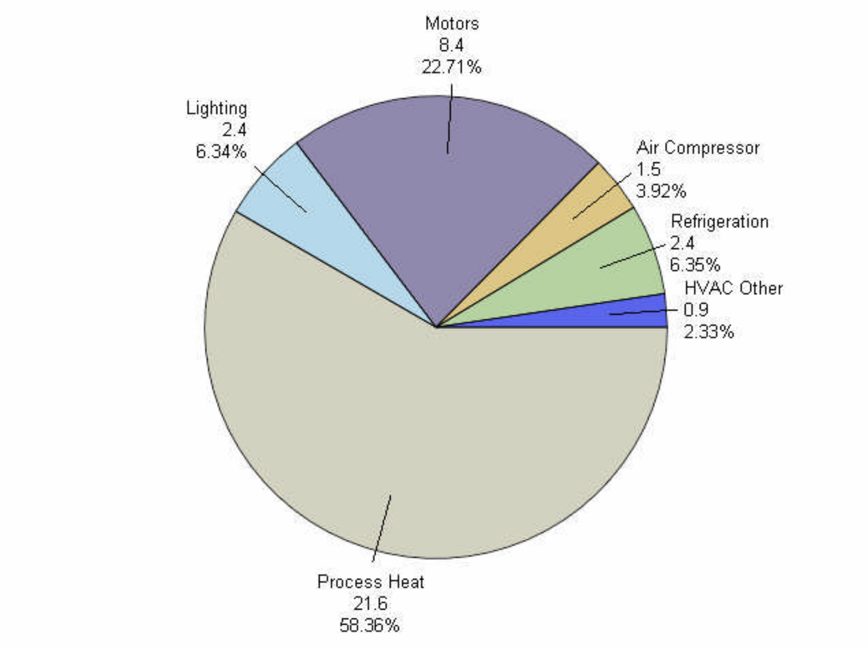


Figure 23. Achievable Potential as Percent of Total Usage by Industry



With respect to end uses, process heat accounted for 58.36% of the achievable potential (Figure 24), followed by motors at nearly 23%. Lighting, HVAC, and refrigeration all contributed less than 10% each.

Figure 24. Distribution of Achievable Potential by End Use

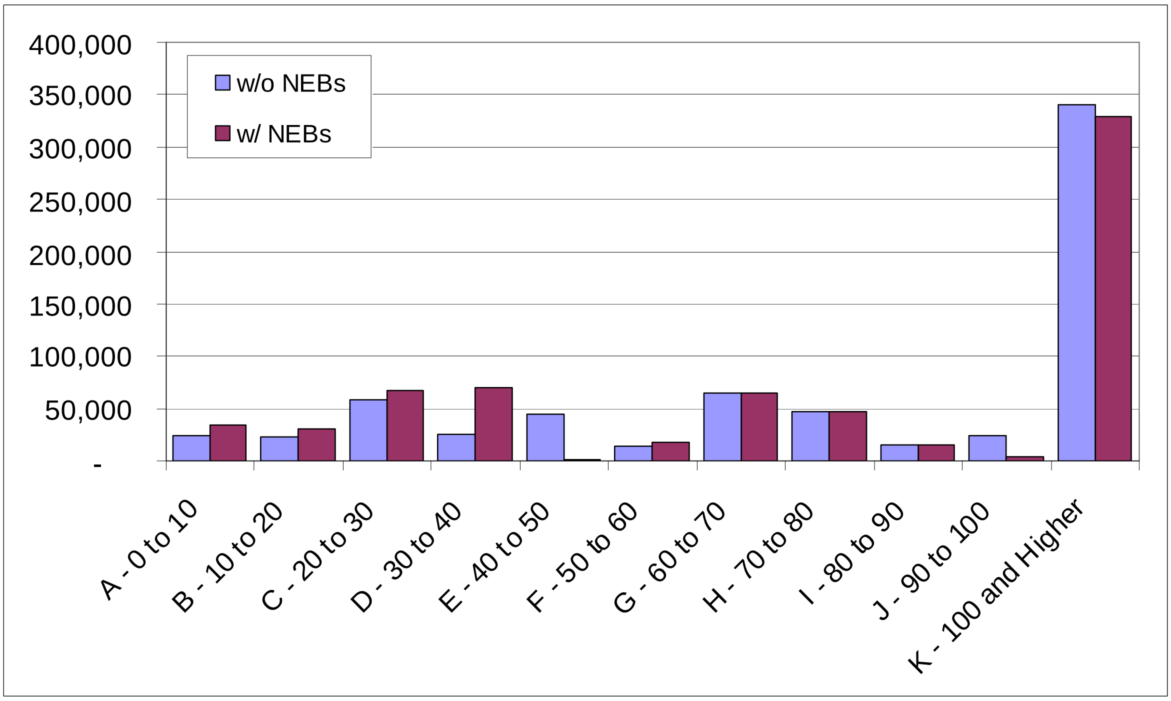


Impact of Non-Energy Benefits (NEBs)

The addition of NEBs had no effect on the absolute value of achievable potential, but rather had two effects on the relative cost-effectiveness among the mill bundles. First, there was a shifting of potential among the mill bundles, with potential moving from the higher to lower cost bundles. Second, within the bundles, there was a change in the average levelized cost where the NEB lowered the cost of a measure, but not enough to move it into a different mill bundle. Note that the results in this section of the report refer to the data that were provided for use in the IRP modeling efforts. As such, they are presented in terms of megawatt hours and levelized dollars per MWh. Furthermore, the potential is shown for year 20, consistent with the forecast horizon used for planning.

The end results of the analysis will come down to how the bundles with NEBs compare when used in the IRP modeling. However, there are ways to see what the effect of the analysis had on the makeup of the bundles. For the residential results, there were clear shifts of potential from one mill group to another. For example, in Figure 25, the total potential in the 90 to 100 mill group was reduced from more than 24,000 MWh to just over 3,500 with the addition of NEBs. Likewise, the MWh potential in the 30 to 40 mill group increased from around 25,500 to over 69,600.

Figure 25. Residential MWh Potential in Year 20 by Mill Bundle, with and without NEBs



For commercial achievable potential, the shifts are smaller and hard to perceive in a graphical representation. Instead, the effects of NEBs are shown in Table 14, where the average levelized cost in dollars per MWh is shown with and without NEBs for the different mill groups. The 40 to 50 mill group, for example, was reduced in average cost from $45.50 to $41.10 per MWh.

Table 14. Commercial Potential Bundle Costs, with and without NEBs

Mill Group	$/MWh w/o NEBs	$/MWh w/ NEBs
A - 0 to 10	$7.1	$6.0
B - 10 to 20	$13.3	$12.8
C - 20 to 30	$23.5	$22.8
D - 30 to 40	$34.8	$31.1
E - 40 to 50	$45.5	$41.1
F - 50 to 60	$53.3	$50.1
G - 60 to 70	$66.4	$66.4
H - 70 to 80	$73.2	$69.7
I - 80 to 90	$87.9	$87.9
J -90 to 100	$96.7	$96.7
K - 100 and Higher	**$ 439.6**	**$ 439.6**

Appendix A: Detailed Data Tables

Conservation measure details are provided as Excel tables on the enclosed CD.

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 6
Schedule 9
Appendix E
Filed: 2011 Apr 1
(83 pages)

Toronto Hydro peakSAVER Load Management

Analysis of Load Data and Load Reduction Impact

from

GoodCents

to

Toronto Hydro

December 2007

2970 Rosebud Road
Loganville, GA 30052
Tel: 1.800.653.3445

Table of Contents

Executive Summary

Load Reduction Program Design

Toronto Hydro contracted with GoodCents to collect and analyze end-use load research data from a sample of peakSAVER load management program participants. The main goal of the study is to provide an analysis and report of air conditioning and water heating load control impacts for Toronto Hydro's peakSAVER program.

GoodCents gathered whole house usage data from 200 peakSAVER customers during the period of August 2006 through September 2006 and May 2007 through September 2007.

The amount of load reduction during the peak hours (2 pm to 6 pm) of the summer months at various maximum daily temperature ranges is developed and presented in this report.

Load Reduction Program Impact

Overall, June 2007 was a warm month for Toronto Hydro's service territory; five days reached temperatures above 32 degrees in Toronto. July was a cooler month with only 3 days reaching the 32-degree and above range in Toronto. August, similar to June, was warm with six days reaching temperatures above 32 degrees. The highest temperature recorded in the summer of 2007 was 34.8 degrees in Toronto. Temperatures over 28 degrees Celsius are favorable for control in the Ontario, Canada regions. Toronto Hydro controlled on four days with temperatures between 28 and 30 degrees Celsius, one day with temperatures between 30 and 32 degrees, five days with temperatures between 32 and 34 degrees, and two days with temperatures over 34 degrees.

As many as fifteen customers participating in the peakSAVER M&V study have water heaters under control. In addition, Toronto Hydro controlled water heaters on eleven days this summer for a four-hour period. Control was primarily initiated between 2 pm and 6 pm. However, one day Toronto Hydro initiated control from 11 am to 3 pm. Water heater control is 100% enabling the reduction to be 100% of the typical energy usage for that time period. Regression analysis was completed to determine load control estimates for summer water heating. The highest water heater load reduction Toronto Hydro can expect in the late afternoon will occur in hour 16 with 0.638 kW of reduction. Currently, the peakSAVER program has 449 customers with water heaters under control. Toronto Hydro can expect a total water heater population load reduction of 286 kW in hour 16 of the afternoon.

Toronto Hydro initiated air conditioning control on twelve days this summer, two of which recorded maximum temperatures over 34 degrees Celsius. Using the outside temperature, the average connected load of the population's air conditioning units, and the customers' thermostat settings we were able to develop twelve regression models, one for each strata and each hour of control for the residential population. Using the outside temperature and the average connected load of the population's air conditioning units we were able to develop twelve regression models, one for each strata and each hour of control for the commercial population. AC load control estimates were then developed from the twelve residential regression models and the twelve commercial regression models.

On a moderately warm summer day, Toronto Hydro can expect a residential load reduction of 0.69 kW during the second hour of control for each participating customer. A total residential population reduction of 23 MW can be expected on a moderately warm summer day in Toronto. This estimate is based on the current residential peakSAVER population of 32,634 customers with AC control. On an extreme summer day, Toronto Hydro can expect a residential load reduction of 0.99 kW per customer and a total residential population load reduction of 32 MW from AC load control alone.

On a moderately warm summer day, Toronto Hydro can expect a commercial load reduction of 2.86 kW during the second hour of control for each participating business. A total commercial population reduction of almost 5 MW can be expected on a moderately warm summer day in Toronto. This estimate is based on the current small commercial peakSAVER population of 1,554 customers with AC control. On an extreme summer day, Toronto Hydro can expect a commercial load reduction of 3.39 kW per customer and a total commercial population load reduction of 6 MW from AC load control alone.

In past studies, we have analyzed the effect of AC control on customer comfort. This data shows that moderate thermostat setback strategies used during the peakSAVER program should not lead to large temperature or relative humidity increases in the home, nor should any customer discomfort occur.

The statistical relative accuracy on residential load reduction estimates achieved in 2007 was well within the benchmark +/- 10% at 90% confidence and indicates current sample sizes are sufficient. We recommend that Toronto Hydro rotate the residential sample every 2 to 3 years to assure the sample is representative of the population.

Introduction

Toronto Hydro contracted with GoodCents for analysis and reporting of load control impacts for an air conditioning thermostatic cycling control experiment. The primary purpose of this study is to provide an analysis and report of air-conditioning and water heating load control impacts for Toronto Hydro's peakSAVER load management program.

GoodCents acquired whole house interval metered data on 200 homes and small businesses for two summer months in 2006 and five summer months in 2007. The population consists of 153 residential customers and 47 small commercial customers. This report will analyze air conditioning load reduction during summer afternoon peak periods from 2006 and 2007 at various temperature ranges for both residential and small customers, as well as water heater load reduction during summer afternoon peak periods.

We will compare load impacts by outside temperature and hour of thermostatic control for the sample and develop load reduction estimates by comparing and modeling like temperatures on control and non-control days.

Sample Design

Upon installation of the peakSAVER equipment, GoodCents collected air conditioner (AC) load information from each customer's air conditioning unit. The AC load can then be divided by 1000 to represent the connected load, or maximum kW the air conditioning unit can use in one hour. A frequency analysis of each participant's connected load in kW is performed as the first step of the sample design. The frequency is then used to compute the necessary parameters for a Dahlenius-Hodges (D-H) analysis to determine optimal stratum breakpoints.

The Dahlenius-Hodges analysis is commonly used for general populations because it makes no restrictive assumptions about the population distribution. Given a fixed sample size and a fixed number of strata, the D-H method provides a quick means of determining strata boundaries that approximately minimizes the coefficient of variation. Applying the D-H method requires the assumptions that the finite population correction can be ignored, the underlying population distribution is continuous, and the probability density of the interested variable is constant with the strata. For a given sample size, minimization is dependant on five discrete variables: the number of strata, the sample allocations within the strata, the population variance within the strata, the population size within the strata, and the strata boundary breakpoints. The sample design process will be completed for the residential population, as well as the commercial population.

Frequency Analysis of Connected Load for Residential Customers

GoodCents used the D-H analysis to yield 3 strata. Our experience in load research sample design leads us to believe that a 3 strata design is the best design to optimally place sample points at minimum cost with minimal or no loss in accuracy as opposed to designs with larger than 3 strata.

A frequency analysis was first performed to determine the number of customers for each recorded connected load. Table F-1 on the following page shows the connected load (FreqkW) and the frequency and percentage of customers with that particular connected load.

Table F-1

Toronto Hydro FREQUENCY ANALYSIS Installed to date
The FREQ Procedure

Toronto Hydro Residential Installed Customers

FREQKWH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0.5	927	5.83	927	5.83
1	9	0.06	936	5.88
1.5	30	0.19	966	6.07
2	1676	10.54	2642	16.61
2.5	4956	31.16	7598	47.77
3	4277	26.89	11875	74.66
3.5	2325	14.62	14200	89.27
4	778	4.89	14978	94.17
4.5	422	2.65	15400	96.82
5	180	1.13	15580	97.95
5.5	127	0.80	15707	98.75
6	62	0.39	15769	99.14
6.5	56	0.35	15825	99.49
7	31	0.19	15856	99.69
7.5	14	0.09	15870	99.77
8	9	0.06	15879	99.83
8.5	6	0.04	15885	99.87
9	4	0.03	15889	99.89
9.5	3	0.02	15892	99.91
10	1	0.01	15893	99.92
10.5	2	0.01	15895	99.93
11	2	0.01	15897	99.94
12	1	0.01	15898	99.95
12.5	1	0.01	15899	99.96
14	1	0.01	15900	99.96
15.5	2	0.01	15902	99.97
16	1	0.01	15903	99.98
17	1	0.01	15904	99.99
19.5	1	0.01	15905	99.99
21	1	0.01	15906	100.00

To produce 3 strata using the D-H analysis, the final CDHI value of 252.584 (see last bold red entry in Table F-2 on the next page) is divided by 3 to yield breaks at 84.195 and 168.389. We find the CDHI values closest to these to be 84.722 and 165.061. These lines are highlighted below in bold red print. These values correspond to kW values of 2.5 and 3.5. Therefore, our 3 residential strata are 0-2.5 kW, 2.51-3.5 kW, and above 3.5 kW.

Table F-2

Toronto Hydro FREQUENCY ANALYSIS- Installed to date

Obs	FREQKWH	COUNT	PERCENT	SQCNT	DI	D1	UI	SQUI	DHI	CCOUNT	CPERCENT	CSQCNT	CDHI
1	0.5	927	5.8280	30.4467	0.5	.	.	.	.	927	5.8280	30.447	.

2	1.0	9	0.0566	3.0000	0.5	1	0.5	0.70711	2.1213	936	5.8846	33.447	2.121
3	1.5	30	0.1886	5.4772	0.5	1	0.5	0.70711	3.8730	966	6.0732	38.924	5.994
4	2.0	1676	10.5369	40.9390	0.5	1	0.5	0.70711	28.9482	2642	16.6101	79.863	34.943
5	2.5	4956	31.1581	70.3989	0.5	1	0.5	0.70711	49.7795	7598	47.7681	150.262	84.722
6	3.0	4277	26.8892	65.3988	0.5	1	0.5	0.70711	46.2439	11875	74.6574	215.661	130.966
7	3.5	2325	14.6171	48.2183	0.5	1	0.5	0.70711	34.0955	14200	89.2745	263.879	165.061
8	4.0	778	4.8912	27.8927	0.5	1	0.5	0.70711	19.7231	14978	94.1657	291.771	184.785
9	4.5	422	2.6531	20.5426	0.5	1	0.5	0.70711	14.5258	15400	96.8188	312.314	199.310
10	5.0	180	1.1316	13.4164	0.5	1	0.5	0.70711	9.4868	15580	97.9505	325.730	208.797
11	5.5	127	0.7984	11.2694	0.5	1	0.5	0.70711	7.9687	15707	98.7489	337.000	216.766
12	6.0	62	0.3898	7.8740	0.5	1	0.5	0.70711	5.5678	15769	99.1387	344.874	222.334
13	6.5	56	0.3521	7.4833	0.5	1	0.5	0.70711	5.2915	15825	99.4908	352.357	227.625
14	7.0	31	0.1949	5.5678	0.5	1	0.5	0.70711	3.9370	15856	99.6857	357.925	231.562
15	7.5	14	0.0880	3.7417	0.5	1	0.5	0.70711	2.6458	15870	99.7737	361.667	234.208
16	8.0	9	0.0566	3.0000	0.5	1	0.5	0.70711	2.1213	15879	99.8303	364.667	236.329
17	8.5	6	0.0377	2.4495	0.5	1	0.5	0.70711	1.7321	15885	99.8680	367.116	238.061
18	9.0	4	0.0251	2.0000	0.5	1	0.5	0.70711	1.4142	15889	99.8931	369.116	239.475
19	9.5	3	0.0189	1.7321	0.5	1	0.5	0.70711	1.2247	15892	99.9120	370.848	240.700
20	10.0	1	0.0063	1.0000	0.5	1	0.5	0.70711	0.7071	15893	99.9183	371.848	241.407
21	10.5	2	0.0126	1.4142	0.5	1	0.5	0.70711	1.0000	15895	99.9308	373.262	242.407
22	11.0	2	0.0126	1.4142	0.5	1	0.5	0.70711	1.0000	15897	99.9434	374.677	243.407
23	12.0	1	0.0063	1.0000	1.0	1	1.0	1.00000	1.0000	15898	99.9497	375.677	244.407
24	12.5	1	0.0063	1.0000	0.5	1	0.5	0.70711	0.7071	15899	99.9560	376.677	245.114
25	14.0	1	0.0063	1.0000	1.5	1	1.5	1.22474	1.2247	15900	99.9623	377.677	246.339
26	15.5	2	0.0126	1.4142	1.5	1	1.5	1.22474	1.7321	15902	99.9749	379.091	248.071
27	16.0	1	0.0063	1.0000	0.5	1	0.5	0.70711	0.7071	15903	99.9811	380.091	248.778
28	17.0	1	0.0063	1.0000	1.0	1	1.0	1.00000	1.0000	15904	99.9874	381.091	249.778
29	19.5	1	0.0063	1.0000	2.5	1	2.5	1.58114	1.5811	15905	99.994	382.091	251.359
30	21.0	1	0.0063	1.0000	1.5	1	1.5	1.22474	1.2247	15906	100.000	383.091	252.584

Frequency Analysis of Connected Load for Commercial Customers

GoodCents used the D-H analysis to yield 3 strata. Our experience in load research sample design leads us to believe that a 3 strata design is the best design to optimally place sample points at minimum cost with minimal or no loss in accuracy as opposed to designs with larger than 3 strata.

A frequency analysis was first performed to determine the number of customers for each recorded connected load. Table F-3 on the following page shows the connected load (FreqkW) and the frequency and percentage of customers with that particular connected load.

Table F-3

Toronto Hydro FREQUENCY ANALYSIS- Installed to date
The FREQ Procedure

Toronto Hydro Commercial Installed Customers

FREQKWH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
0.5	55	6.95	55	6.95
1	19	2.40	74	9.36
1.5	18	2.28	92	11.63
2	35	4.42	127	16.06
2.5	60	7.59	187	23.64

3	73	9.23	260	32.87
3.5	89	11.25	349	44.12
4	76	9.61	425	53.73
4.5	45	5.69	470	59.42
5	31	3.92	501	63.34
5.5	28	3.54	529	66.88
6	24	3.03	553	69.91
6.5	31	3.92	584	73.83
7	26	3.29	610	77.12
7.5	22	2.78	632	79.90
8	10	1.26	642	81.16
8.5	15	1.90	657	83.06
9	10	1.26	667	84.32
9.5	14	1.77	681	86.09
10	10	1.26	691	87.36
10.5	9	1.14	700	88.50
11	4	0.51	704	89.00
11.5	7	0.88	711	89.89
12	10	1.26	721	91.15
12.5	9	1.14	730	92.29
13	2	0.25	732	92.54
13.5	2	0.25	734	92.79
14.5	4	0.51	738	93.30
15	2	0.25	740	93.55
15.5	7	0.88	747	94.44
16	2	0.25	749	94.69
16.5	5	0.63	754	95.32
17	4	0.51	758	95.83
17.5	3	0.38	761	96.21
18	1	0.13	762	96.33
18.5	2	0.25	764	96.59
19	2	0.25	766	96.84
19.5	3	0.38	769	97.22
20	3	0.38	772	97.60
20.5	1	0.13	773	97.72
21.5	3	0.38	776	98.10
22	1	0.13	777	98.23
23	2	0.25	779	98.48

Toronto Hydro FREQUENCY ANALYSIS- Installed to date Continued
The FREQ Procedure

Toronto Hydro Commercial Installed Customers

FREQKWH	Frequency	Percent	Cumulative Frequency	Cumulative Percent
24.5	1	0.13	780	98.61
25	1	0.13	781	98.74
27	1	0.13	782	98.86
27.5	1	0.13	783	98.99
30.5	1	0.13	784	99.12
31.5	1	0.13	785	99.24
32.5	1	0.13	786	99.37
34	1	0.13	787	99.49
34.5	1	0.13	788	99.62
37.5	1	0.13	789	99.75
39.5	1	0.13	790	99.87
41.5	1	0.13	791	100.00

To produce 3 strata using the D-H analysis, the final CDHI value of 119.307 (see last bold red entry in Table F-4 on the next page) is divided by 3 to yield breaks at 39.769 and

79.538. We find the CDHI values closest to these to be 39.3629 and 78.8638. These lines are highlighted below in bold red print. These values correspond to kW values of 4.5 and 11.5. Therefore, our 3 commercial strata are 0-4.5 kW, 4.51-11.5 kW, and above 11.5 kW.

Table F-4

Toronto Hydro FREQUENCY ANALYSIS- Installed to date

Obs	FREQKWH	COUNT	PERCENT	SQCNT	DI	D1	UI	SQUI	DHI	CCOUNT	CPERCENT	CSQCNT	CDHI
1	0.5	55	6.9532	7.41620	0.5	.	.	.	.	55	6.9532	7.416	.
2	1.0	19	2.4020	4.35890	0.5	1	0.5	0.70711	3.08221	74	9.3552	11.775	3.0822
3	1.5	18	2.2756	4.24264	0.5	1	0.5	0.70711	3.00000	92	11.6308	16.018	6.0822
4	2.0	35	4.4248	5.91608	0.5	1	0.5	0.70711	4.18330	127	16.0556	21.934	10.2655
5	2.5	60	7.5853	7.74597	0.5	1	0.5	0.70711	5.47723	187	23.6410	29.680	15.7427
6	3.0	73	9.2288	8.54400	0.5	1	0.5	0.70711	6.04152	260	32.8698	38.224	21.7843
7	3.5	89	11.2516	9.43398	0.5	1	0.5	0.70711	6.67083	349	44.1214	47.658	28.4551
8	4.0	76	9.6081	8.71780	0.5	1	0.5	0.70711	6.16441	425	53.7295	56.376	34.6195
9	**4.5**	**45**	**5.6890**	**6.70820**	**0.5**	**1**	**0.5**	**0.70711**	**4.74342**	**470**	**59.4185**	**63.084**	**39.3629**
10	5.0	31	3.9191	5.56776	0.5	1	0.5	0.70711	3.93700	501	63.3375	68.652	43.2999
11	5.5	28	3.5398	5.29150	0.5	1	0.5	0.70711	3.74166	529	66.8774	73.943	47.0416
12	6.0	24	3.0341	4.89898	0.5	1	0.5	0.70711	3.46410	553	69.9115	78.842	50.5057
13	6.5	31	3.9191	5.56776	0.5	1	0.5	0.70711	3.93700	584	73.8306	84.410	54.4427
14	7.0	26	3.2870	5.09902	0.5	1	0.5	0.70711	3.60555	610	77.1176	89.509	58.0482
15	7.5	22	2.7813	4.69042	0.5	1	0.5	0.70711	3.31662	632	79.8989	94.199	61.3649
16	8.0	10	1.2642	3.16228	0.5	1	0.5	0.70711	2.23607	642	81.1631	97.361	63.6009
17	8.5	15	1.8963	3.87298	0.5	1	0.5	0.70711	2.73861	657	83.0594	101.234	66.3395

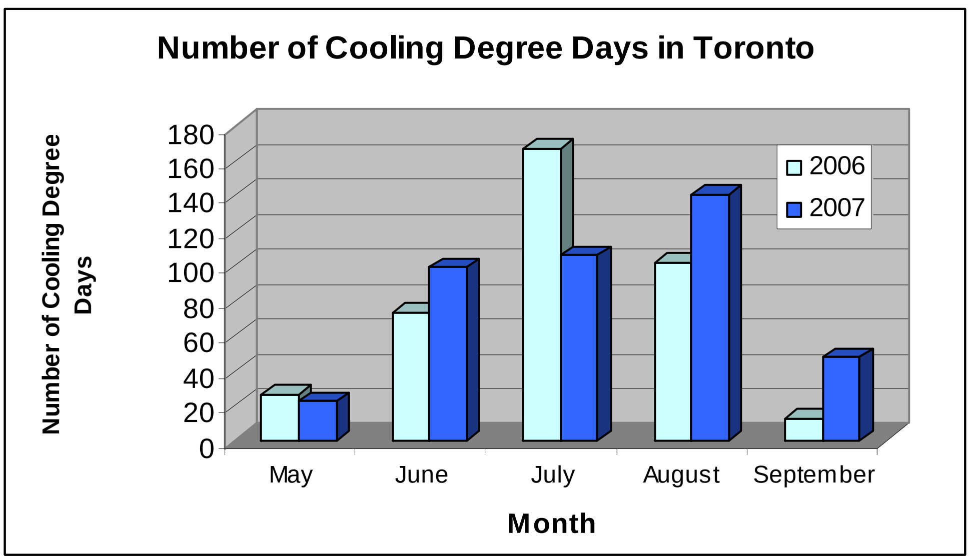
Toronto Hydro FREQUENCY ANALYSIS- Installed to date

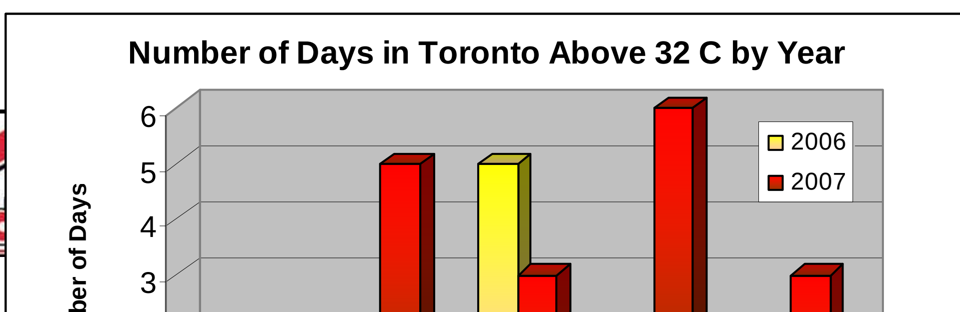
Obs	FREQKWH	COUNT	PERCENT	SQCNT	DI	D1	UI	SQUI	DHI	CCOUNT	CPERCENT	CSQCNT	CDHI
18	9.0	10	1.2642	3.16228	0.5	1	0.5	0.70711	2.23607	667	84.3236	104.397	68.5756
19	9.5	14	1.7699	3.74166	0.5	1	0.5	0.70711	2.64575	681	86.0936	108.138	71.2214
20	10.0	10	1.2642	3.16228	0.5	1	0.5	0.70711	2.23607	691	87.3578	111.301	73.4574
21	10.5	9	1.1378	3.00000	0.5	1	0.5	0.70711	2.12132	700	88.4956	114.301	75.5787
22	11.0	4	0.5057	2.00000	0.5	1	0.5	0.70711	1.41421	704	89.0013	116.301	76.9930
23	**11.5**	**7**	**0.8850**	**2.64575**	**0.5**	**1**	**0.5**	**0.70711**	**1.87083**	**711**	**89.8862**	**118.946**	**78.8638**
24	12.0	10	1.2642	3.16228	0.5	1	0.5	0.70711	2.23607	721	91.1504	122.109	81.0999
25	12.5	9	1.1378	3.00000	0.5	1	0.5	0.70711	2.12132	730	92.2882	125.109	83.2212
26	13.0	2	0.2528	1.41421	0.5	1	0.5	0.70711	1.00000	732	92.5411	126.523	84.2212
27	13.5	2	0.2528	1.41421	0.5	1	0.5	0.70711	1.00000	734	92.7939	127.937	85.2212
28	14.5	4	0.5057	2.00000	1.0	1	1.0	1.00000	2.00000	738	93.2996	129.937	87.2212
29	15.0	2	0.25284	1.41421	0.5	1	0.5	0.70711	1.00000	740	93.552	131.351	88.221
30	15.5	7	0.88496	2.64575	0.5	1	0.5	0.70711	1.87083	747	94.437	133.997	90.092
31	16.0	2	0.25284	1.41421	0.5	1	0.5	0.70711	1.00000	749	94.690	135.411	91.092
32	16.5	5	0.63211	2.23607	0.5	1	0.5	0.70711	1.58114	754	95.322	137.647	92.673
33	17.0	4	0.50569	2.00000	0.5	1	0.5	0.70711	1.41421	758	95.828	139.647	94.087
34	17.5	3	0.37927	1.73205	0.5	1	0.5	0.70711	1.22474	761	96.207	141.379	95.312
35	18.0	1	0.12642	1.00000	0.5	1	0.5	0.70711	0.70711	762	96.334	142.379	96.019
36	18.5	2	0.25284	1.41421	0.5	1	0.5	0.70711	1.00000	764	96.587	143.794	97.019
37	19.0	2	0.25284	1.41421	0.5	1	0.5	0.70711	1.00000	766	96.839	145.208	98.019
38	19.5	3	0.37927	1.73205	0.5	1	0.5	0.70711	1.22474	769	97.219	146.940	99.244
39	20.0	3	0.37927	1.73205	0.5	1	0.5	0.70711	1.22474	772	97.598	148.672	100.469
40	20.5	1	0.12642	1.00000	0.5	1	0.5	0.70711	0.70711	773	97.724	149.672	101.176
41	21.5	3	0.37927	1.73205	1.0	1	1.0	1.00000	1.73205	776	98.104	151.404	102.908
42	22.0	1	0.12642	1.00000	0.5	1	0.5	0.70711	0.70711	777	98.230	152.404	103.615
43	23.0	2	0.25284	1.41421	1.0	1	1.0	1.00000	1.41421	779	98.483	153.818	105.029
44	24.5	1	0.12642	1.00000	1.5	1	1.5	1.22474	1.22474	780	98.609	154.818	106.254
45	25.0	1	0.12642	1.00000	0.5	1	0.5	0.70711	0.70711	781	98.736	155.818	106.961
46	27.0	1	0.12642	1.00000	2.0	1	2.0	1.41421	1.41421	782	98.862	156.818	108.375

47	27.5	1	0.12642	1.00000	0.5	1	0.5	0.70711	0.70711	783	98.989	157.818	109.082
48	30.5	1	0.12642	1.00000	3.0	1	3.0	1.73205	1.73205	784	99.115	158.818	110.814
49	31.5	1	0.12642	1.00000	1.0	1	1.0	1.00000	1.00000	785	99.241	159.818	111.814
50	32.5	1	0.12642	1.00000	1.0	1	1.0	1.00000	1.00000	786	99.368	160.818	112.814
51	34.0	1	0.12642	1.00000	1.5	1	1.5	1.22474	1.22474	787	99.494	161.818	114.039
52	34.5	1	0.12642	1.00000	0.5	1	0.5	0.70711	0.70711	788	99.621	162.818	114.746
53	37.5	1	0.12642	1.00000	3.0	1	3.0	1.73205	1.73205	789	99.747	163.818	116.478
54	39.5	1	0.12642	1.00000	2.0	1	2.0	1.41421	1.41421	790	99.874	164.818	117.893
55	41.5	1	0.12642	1.00000	2.0	1	2.0	1.41421	1.41421	791	100.000	165.818	119.307

Weather Review

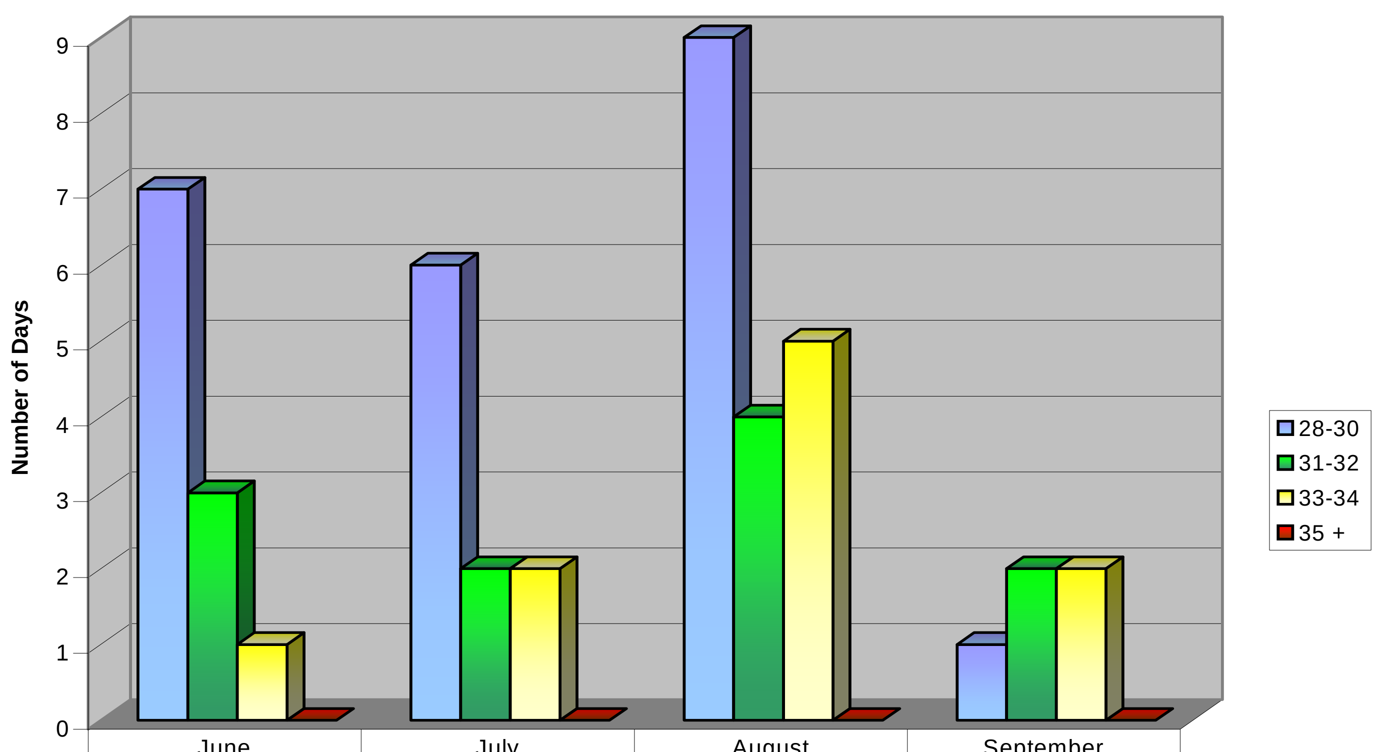
The variation of weather and climate has a great impact on the effectiveness of any weather sensitive load control program. Toronto Hydro's service territory is primary centered in Toronto. Toronto had a warmer than average year in 2007, with six days in August reaching temperatures above 32 degrees Celsius. Below are two comparison graphs; the first graph shows the number of cooling degree days recorded in the summer of 2006 compared to the number of cooling degrees recorded in the summer of 2007. In addition, the second graphs shows the number of days that reached 32 degrees Celsius and higher recorded in Toronto for the summers of 2006 and 2007.





A further analysis of 2007 summer weather in Toronto shows that the majority of maximum temperatures reached were in the range of 28 degrees to 32 degrees Celsius. You can see from the graph below that June, July, and August were fairly warm months. August recorded temperatures ranging from 28 to 30 on nine days and temperatures ranging from 33 to 34 on five days.

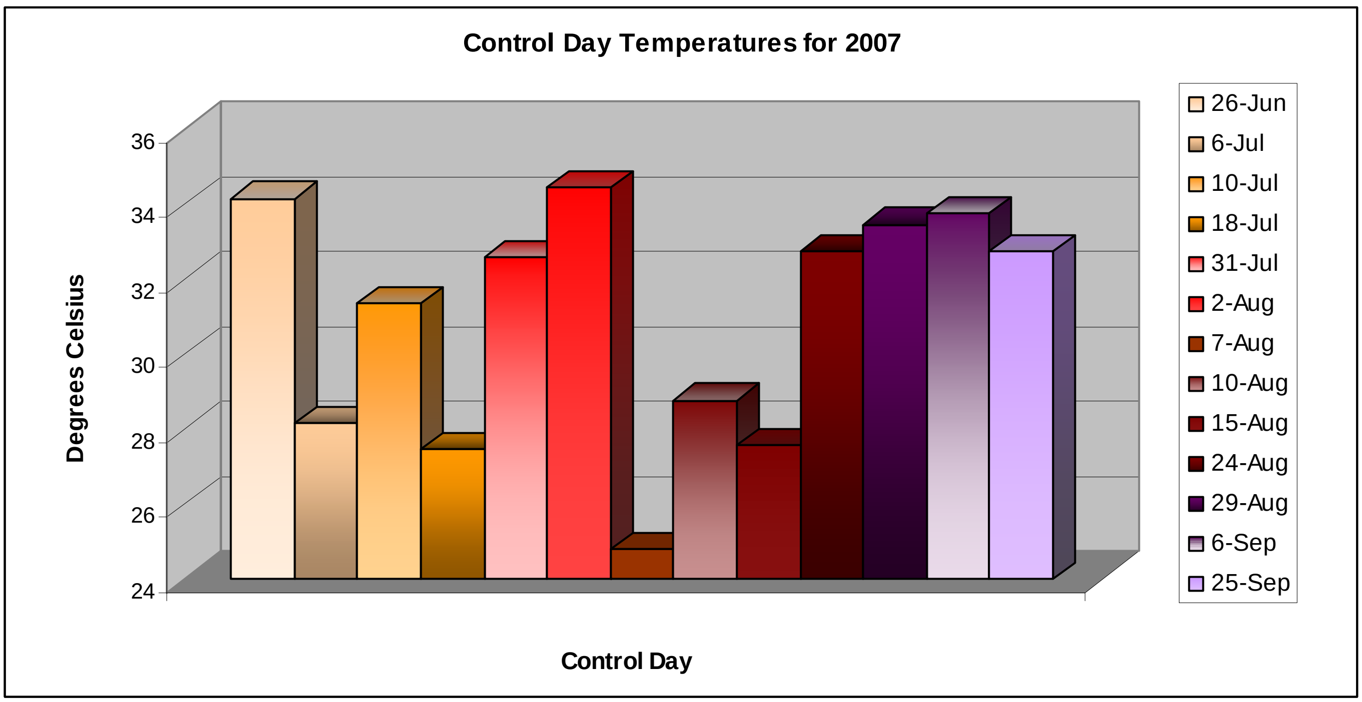
Number of Days With Max Temperatures Ranging from 28-35 Degrees C
Toronto 2007



	June	July	August	September
28-30	7	6	9	1
31-32	3	2	4	2
33-34	1	2	5	2
35 +	0	0	0	0

Month

Temperatures over 28 degrees Celsius are favorable for control in Ontario, Canada. From the graph below it is apparent that the majority of our control days more than met that requirement. Temperatures in Toronto reached as high as 34 degrees for two control days.



Impact Analysis

Summer Water Heating

Toronto Hydro has fifteen residential customers participating in the peakSAVER M&V study with water heaters under control. In addition, Toronto Hydro controlled water heaters on eleven days during the summer of 2007. The water heater control period for the summer of 2007 was from 3 to 6 pm on most days. However, one day this summer, July 6, Toronto Hydro controlled water heaters from 11 am to 3 pm. Water heater control is 100% during the hour, allowing the load reduction to be 100% of the typical energy usage for that time period. We did not collect any connected load information on the water heaters, preventing us from determining any specific energy usage values.

An analysis of water heater load reduction was developed using regression analysis. Water heater usage was modeled as a function of a control variable indicating whether load control was in effect or not. Since water heater control is 100%, the control term coefficients are the actual water heater load control estimates.

Two regression analyses were completed, one for the early afternoon control period and another for the late afternoon control period. There were ten days with the late afternoon control period, therefore the regression model is based on more data and has less variance. The control term coefficients for each hour of the late afternoon water heater control period are significant to the 99th percentile. There was only one day with the early afternoon control period. Therefore, the model is based on less data, has a higher variance, and is not as statistically valid. The control term coefficients for each hour of the early afternoon water heater control period are only significant to the 82nd percentile.

The highest water heater load reduction of 0.822 kW occurs in the early afternoon, in hour 12. However, this estimate is not as statistically valid as the late afternoon estimates. The highest water heater load reduction for the late afternoon control period is 0.63751 kW, which occurs in hour 16. The full regression output for both control periods are shown on the following pages. In addition, the hourly load control estimates for each control period are following the regression output.

Regression Output for the Late Afternoon Water Heater Control Period

Toronto Hydro kwh - controlmax3 maxacdb3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	407
Number of Observations Used	382
Number of Observations with Missing Values	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1058.69867	264.67467	149.53	<.0001
Error	377	667.31251	1.77006		
Corrected Total	381	1726.01118			

Root MSE	1.33044	R-Square	0.6134
Dependent Mean	2.47775	Adj R-Sq	0.6093
Coeff Var	53.69539		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.74491	0.11672	6.38	<.0001
controlmax3	1	-0.00008459	0.00008751	-0.97	0.3344
maxacdb3	1	-0.00003867	0.00004478	-0.86	0.3883
whcontrol	1	-0.49851	0.23180	-2.15	0.0321
kwhr13	1	0.78093	0.03343	23.36	<.0001

Toronto Hydro kwh - controlmax3 maxacdb3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	407
Number of Observations Used	382
Number of Observations with Missing Values	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	908.19758	227.04940	116.53	<.0001
Error	377	734.58011	1.94849		
Corrected Total	381	1642.77769			

Root MSE	1.39588	R-Square	0.5528
Dependent Mean	2.49464	Adj R-Sq	0.5481
Coeff Var	55.95521		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.92110	0.11972	7.69	<.0001
controlmax3	1	-0.00009593	0.00009565	-1.00	0.3165
maxacdb3	1	-0.00004407	0.00004680	-0.94	0.3470
whcontrol	1	-0.63751	0.27636	-2.31	0.0216
kwhr13	1	0.72085	0.03499	20.60	<.0001

Toronto Hydro kwh - controlmax3 maxacdb3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=17

The REG Procedure
Model: MODEL1

Dependent Variable: kwh

Number of Observations Read	407
Number of Observations Used	382
Number of Observations with Missing Values	25

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	882.98640	220.74660	106.37	<.0001
Error	377	782.37241	2.07526		
Corrected Total	381	1665.35881			

Root MSE	1.44058	R-Square	0.5302
Dependent Mean	2.54289	Adj R-Sq	0.5252
Coeff Var	56.65109		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.93429	0.12355	7.56	<.0001
controlmax3	1	-0.00006099	0.00009871	-0.62	0.5371
maxacdb3	1	-0.00000755	0.00004830	-0.16	0.8759
whcontrol	1	-0.59381	0.28521	-2.08	0.0380
kwhr13	1	0.70906	0.03611	19.64	<.0001

Toronto Hydro kwh - controlmax3 maxacdb3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	408
Number of Observations Used	382
Number of Observations with Missing Values	26

Analysis of Variance

Sum of Mean

Source	DF	Squares	Square	F Value	Pr > F
Model	4	843.58645	210.89661	97.54	<.0001
Error	377	815.12860	2.16214		
Corrected Total	381	1658.71506			

Root MSE	1.47042	R-Square	0.5086
Dependent Mean	2.62307	Adj R-Sq	0.5034
Coeff Var	56.05732		

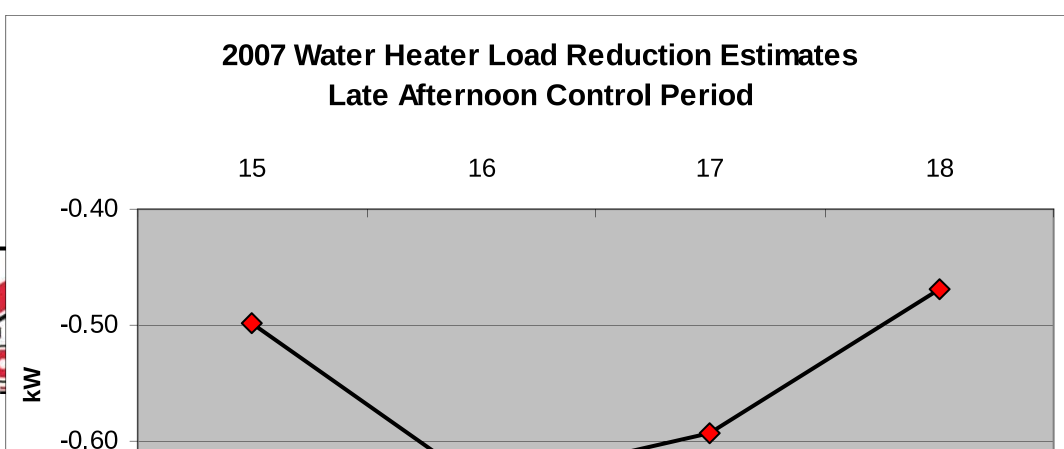
Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.02560	0.12611	8.13	<.0001
controlmax3	1	-0.00008798	0.00010076	-0.87	0.3831
maxacdb3	1	0.00000477	0.00004930	0.10	0.9230
whcontrol	1	-0.46909	0.29112	-1.61	0.1079
kwhr13	1	0.69395	0.03686	18.83	<.0001

The hourly load reduction estimates for the late afternoon water heater control period are shown below.

2007 Water Heater Load Control Estimates
Late Afternoon Control

Hour	kWh
15	-0.4985
16	-0.6375
17	-0.5938
18	-0.4691



The peakSAVER program currently has 449 water heaters under control. Based on the load control estimates provided above, we were able to estimate a total population load reduction for water heater control in the late afternoon control period.

2007 peakSAVER Population
Water Heater Load Control Estimates
449 Controlled Water Heaters

Hour	kWh
15	-223.8310
16	-286.2420
17	-266.6207
18	-210.6214

Regression Output for the Early Afternoon Water Heater Control Period

This model should be used with caution, t-statistics are not valid at 90% confidence for three of four strata.

```
Toronto Hydro kwh - whcontrol kwhr11 Regressions for 27 to 37 Degrees
hr=12

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read         406
Number of Observations Used         406


                             Analysis of Variance

                                    Sum of           Mean
Source                    DF       Squares         Square    F Value    Pr > F

Model                      2    1017.53458      508.76729     315.08    <.0001
Error                    403     650.74138        1.61474
Corrected Total          405    1668.27596
```

Root MSE	1.27073	R-Square	0.6099
Dependent Mean	2.40211	Adj R-Sq	0.6080
Coeff Var	52.90037		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.60898	0.09741	6.25	<.0001
whcontrol	1	-0.82202	0.35837	-2.29	0.0223
kwhr11	1	0.80068	0.03213	24.92	<.0001

Toronto Hydro kwh - whcontrol kwhr11 Regressions for 27 to 37 Degrees
hr=13

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read 406
Number of Observations Used 406

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	982.56971	491.28486	200.00	<.0001
Error	403	989.92433	2.45639		
Corrected Total	405	1972.49404			

Root MSE	1.56729	R-Square	0.4981
Dependent Mean	2.59568	Adj R-Sq	0.4956
Coeff Var	60.38053		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.82258	0.12015	6.85	<.0001
whcontrol	1	-0.60432	0.44201	-1.37	0.1723
kwhr11	1	0.78880	0.03963	19.90	<.0001

Toronto Hydro kwh - whcontrol kwhr11 Regressions for 27 to 37 Degrees
hr=14

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	406
Number of Observations Used	406

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	781.57062	390.78531	124.82	<.0001
Error	403	1261.73233	3.13085		
Corrected Total	405	2043.30295			

Root MSE	1.76942	R-Square	0.3825
Dependent Mean	2.66115	Adj R-Sq	0.3794
Coeff Var	66.49095		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.08804	0.13564	8.02	<.0001
whcontrol	1	-0.69226	0.49902	-1.39	0.1661
kwhr11	1	0.70203	0.04474	15.69	<.0001

Toronto Hydro kwh - whcontrol kwhr11 Regressions for 27 to 37 Degrees
hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	407
Number of Observations Used	406
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	718.75635	359.37818	102.08	<.0001
Error	403	1418.80035	3.52060		
Corrected Total	405	2137.55671			

Root MSE	1.87633	R-Square	0.3363
Dependent Mean	2.69736	Adj R-Sq	0.3330
Coeff Var	69.56147		

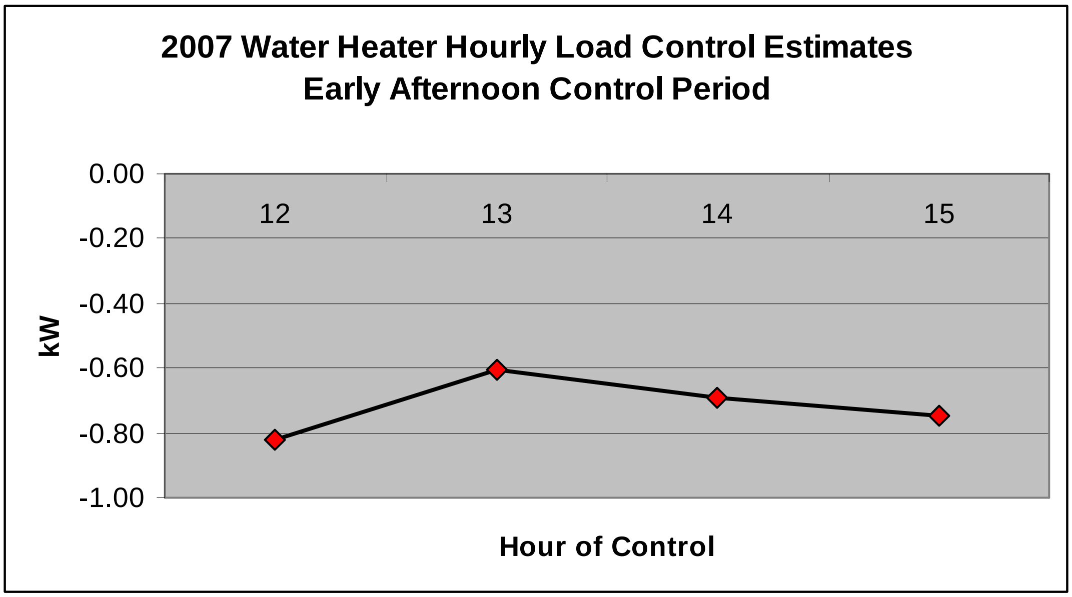
Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.34215	0.15082	8.90	<.0001
whcontrol	1	-0.74577	0.24704	-3.02	0.0027
kwhr11	1	0.65297	0.04752	13.74	<.0001

The hourly load reduction estimates for the early afternoon water heater control period are shown below. Again, these estimates should be used with caution.

2007 Water Heater Load Control Estimates
Early Afternoon Control

Hour	kWh
12	-0.8220
13	-0.6043
14	-0.6923
15	-0.7458



The peakSAVER program currently has 449 water heaters under control. Based on the load control estimates provided above, we were able to estimate a total population load reduction for water heater control during the early afternoon control period.

2007 peakSAVER Population
Early Afternoon Water Heater Load Control Estimates
449 Controlled Water Heaters

Hour	kWh
12	-369.0870
13	-271.3397
14	-310.8247
15	-334.8507

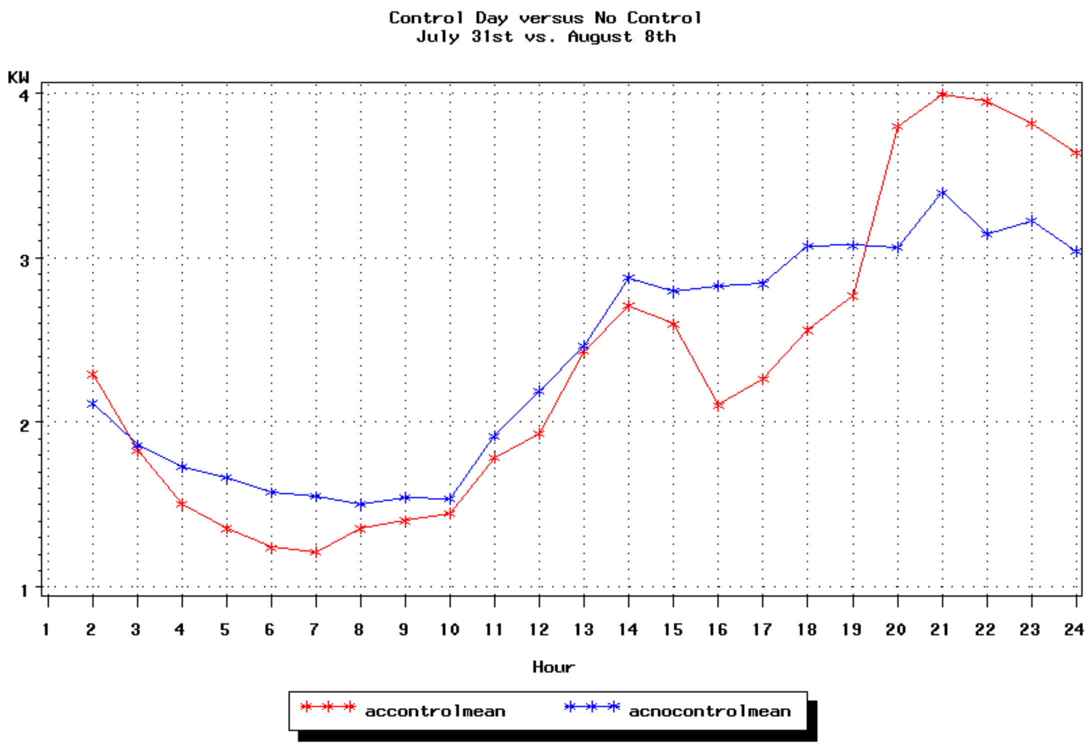
Air Conditioning

There are a number of factors that determine air conditioning demand. Some of these factors include AC size (tons, kW), time of day, outside temperature, and thermostat settings. GoodCents conducted a brief survey at the time peakSAVER installation, allowing nameplate information and thermostat settings to be collected for most customers. Both air conditioning connected load information and thermostat settings will prove to be helpful in determining load reduction estimates.

The biggest factor affecting AC demand is the outside air temperature. Our methodology to estimate the AC load reduction due to cycling is to compare like maximum temperature days with control versus those days without control.

The graph below shows a control day and non-control with very similar load shapes for the whole house load. The control day shown in the following graph is July 31st, which reached a maximum temperature of 32.6 degrees Celsius. The non-control day in the following graph is August 8th, which reached a maximum high temperature of 31.7 degrees Celsius. The graph shows the whole house load and indicates a reduction of almost 0.7 kWh in the first hour of control.

Analysis for Mean AC Usage



We have many more non-control days than control days. A statistical approach is needed, taking into account outside temperatures on all non-control and control days, as well as the connected load of all air conditioners in the sample. Multiple regression analysis is the tool best suited for this problem.

Regression Analysis of Air Conditioner Load Reduction

The output below shows the number of control (1) and no-control (0) hours by the maximum daily temperature for the load data collected during the summer months (August-September) of 2006 and (May – September) 2007 for all residential and commercial customers.

Table of AC control by maximum outdoor temperature

The FREQ Procedure

Table of control by tempr

control	Frequency / Percent / Row Pct / Col Pct	27	28	29	30	31	32	33	34	35	37	Total
0	Frequency	41773	45971	33452	15392	23716	5251	3418	18389	790	2231	494900
	Percent	8.36	9.21	6.70	3.08	4.75	1.05	0.68	3.68	0.16	0.45	99.10
	Row Pct	8.44	9.29	6.76	3.11	4.79	1.06	0.69	3.72	0.16	0.45	
	Col Pct	100.00	96.26	99.48	100.00	97.13	100.00	89.62	94.26	83.51	100.00	
1	Frequency	0	1786	176	0	700	0	396	1120	156	0	4502
	Percent	0.00	0.36	0.04	0.00	0.14	0.00	0.08	0.22	0.03	0.00	0.90
	Row Pct	0.00	39.67	3.91	0.00	15.55	0.00	8.80	24.88	3.47	0.00	
	Col Pct	0.00	3.74	0.52	0.00	2.87	0.00	10.38	5.74	16.49	0.00	
Total		41773	47757	33628	15392	24416	5251	3814	19509	946	2231	499402
		8.36	9.56	6.73	3.08	4.89	1.05	0.76	3.91	0.19	0.45	100.00

There were twelve control days this summer, allowing 4,502 hours of control day data to be collected. Between 2006 and 2007, 494,900 hours of non-control day data was collected. Our warmest control day reached a maximum temperature of 35 degrees Celsius.

After two summers of data collection, most maximum temperatures have data for control hours as well as data for non-control hours, making a discrete regression analysis for several maximum temperatures possible. There are a few maximum temperatures in which we do not have control data. We are not able to conduct a discrete regression analysis for these few maximum temperatures. For example, the maximum temperature of 35 degrees has data for 156 control hours and data for 790 non-control hours. Therefore, it is possible to develop a discrete regression for the effects of load control at 35 degrees. However, it is not possible to do this for 37 degrees, since there were no control hours at 37 degrees.

It was decided to develop a model per strata over the overall maximum temperature range of control from 27 degrees to 37 degrees. This will enable us to have a model estimate of load reduction at temperatures with no control hours. A regression analysis was conducted for both the residential customers and the commercial customers, giving us two final models.

Residential Regression Analysis and Load Control Estimates

A variety of models were developed for the residential load control estimates and the model with the best statistical results was chosen. The model chosen assumes AC use is determined by the outside temperature cubed, multiplied by the maximum summer kWh usage. The model was developed by strata, which were developed by the total population AC compressor size in kW used in the sample design process. The three strata are 0 – 2.5 kW, 2.51 – 3.5 kW, and above 3.5 kW. The model is given below.

ACLoad (Hour t, Site J) = A + B1*controlmax3 (ACMaxkWh (Site J)) * (0 = no control in hour t, 1 = control in hour t) * (Max Outdoor Temperature)**3

+ B2 * max3 (ACMaxkWh (Site J)) * (Max Outdoor Temperature)**3

+ B3 * whcontrol: Control indicator variable for customers with water heaters (0 = no control, 1 = control in hour t)

+ B4 * aclag: Hour 13 ACLoad (Site J)).

Where A is the regression intercept and B1, B2, B3, and B4 are regression coefficients determined during the modeling process. The B1 coefficient is the load reduction estimate for a 1 kW AC at hour t and a given temperature. A total of 12 regressions were estimated for the residential population. These are cross-sectional models and are estimated with all data from all sites for each strata and hour of control.

The regression output for strata 1 for the overall temperature range of 27 to 37 degrees Celsius and control hours 15 to 18 is shown on the following page. The complete residential regression output for all strata is given in the appendix.

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1288
Number of Observations Used	1287
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2051.53191	512.88298	626.34	<.0001
Error	1282	1049.78021	0.81886		
Corrected Total	1286	3101.31212			

Root MSE	0.90491	R-Square	0.6615
Dependent Mean	1.93839	Adj R-Sq	0.6604
Coeff Var	46.68360		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.05289	0.06390	-0.83	0.4080
maxacdb3	1	0.00000363	3.753416E-7	9.67	<.0001
controlmax3	1	-0.00000214	3.011403E-7	-7.10	<.0001
whcontrol	1	-0.27608	0.26648	-1.04	0.3004
kwhr13	1	0.74690	0.02093	35.68	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1288
Number of Observations Used	1287

Number of Observations with Missing Values 1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1853.47581	463.36895	444.40	<.0001
Error	1282	1336.71593	1.04268		
Corrected Total	1286	3190.19174			

Root MSE	1.02112	R-Square	0.5810
Dependent Mean	2.02754	Adj R-Sq	0.5797
Coeff Var	50.36245		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.08473	0.07238	1.17	0.2420
maxacdb3	1	0.00000393	4.251056E-7	9.26	<.0001
controlmax3	1	-0.00000272	3.515003E-7	-7.74	<.0001
whcontrol	1	-0.29195	0.32936	-0.89	0.3756
kwhr13	1	0.69393	0.02361	29.39	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read 1288
Number of Observations Used 1287
Number of Observations with Missing Values 1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1703.85839	425.96460	349.38	<.0001
Error	1282	1562.99628	1.21919		

Corrected Total	1286	3266.85467	

Root MSE	1.10417	R-Square	0.5216
Dependent Mean	2.14874	Adj R-Sq	0.5201
Coeff Var	51.38669		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.28509	0.07826	3.64	0.0003
maxacdb3	1	0.00000378	4.596806E-7	8.23	<.0001
controlmax3	1	-0.00000267	3.800889E-7	-7.02	<.0001
whcontrol	1	-0.18135	0.35615	-0.51	0.6107
kwhr13	1	0.66555	0.02553	26.07	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1289
Number of Observations Used	1287
Number of Observations with Missing Values	2

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1504.28190	376.07048	278.25	<.0001
Error	1282	1732.67259	1.35154		
Corrected Total	1286	3236.95449			

Root MSE	1.16256	R-Square	0.4647
Dependent Mean	2.26853	Adj R-Sq	0.4631
Coeff Var	51.24723		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.59239	0.08240	7.19	<.0001
maxacdb3	1	0.00000279	4.83989E-7	5.76	<.0001
controlmax3	1	-0.00000187	4.001883E-7	-4.68	<.0001
whcontrol	1	-0.34105	0.37498	-0.91	0.3632
kwhr13	1	0.65450	0.02688	24.35	<.0001

The load reduction regression coefficients for each strata and hour are shown in the table below. <u>All regression coefficients are significant at the 99th percentile and all other statistical measures (F test for significance of the regression and adjusted R square) are acceptable.</u>

Table R-1

Toronto Hydro Residential Energy Hourly AC Load Model

Strata	Hour	Dependent Variable	Intercept	MaxACdb3	ControlMax3	WH Control	AC Lag	R Square	Adjusted R Square
1	15	kwh	-0.052890	0.000004	-0.000002	-0.276080	0.746900	0.661500	0.660450
1	16	kwh	0.084730	0.000004	-0.000003	-0.291950	0.693930	0.580990	0.579680
1	17	kwh	0.285090	0.000004	-0.000003	-0.181350	0.665550	0.521560	0.520070
1	18	kwh	0.592390	0.000003	-0.000002	-0.341050	0.654500	0.464720	0.463050
2	15	kwh	0.121250	0.000003	-0.000003	-0.218970	0.736220	0.671020	0.670200
2	16	kwh	0.090430	0.000005	-0.000003	-0.421880	0.643190	0.598120	0.597120
2	17	kwh	0.118380	0.000006	-0.000003	-0.668900	0.579750	0.554890	0.553780
2	18	kwh	0.233200	0.000006	-0.000003	-0.463950	0.548960	0.506920	0.505690
3	15	kwh	0.230320	0.000002	-0.000002	-0.008010	0.818110	0.737730	0.737190
3	16	kwh	0.268790	0.000003	-0.000002	-0.213010	0.768690	0.681980	0.681330
3	17	kwh	0.412100	0.000003	-0.000002	-0.294270	0.735420	0.640750	0.640010
3	18	kwh	0.417450	0.000004	-0.000002	-0.403810	0.687420	0.598280	0.597450

The following chart shows the average AC size (connected load) and average maximum summer hourly kWh by strata.

Table R-2

Toronto Hydro Residential Energy
Mean AC Size and Thermostat Setting by Strata

Strata	AC Size kW/Hr	Max Summer kWh
1	1.92	7.06
2	2.9	7.18
3	4.43	9.54

Calculation of Residential Load Reduction

The load reduction for a given strata, hour, and maximum daily temperature are developed using the appropriate control coefficient (controlmax3) from Table R-1 for the strata, hour selected, and temperature range selected. The control coefficient for the selected strata, hour, and temperature range is multiplied by the difference between outside temperature and inside thermostat setting cubed and multiplied by the average AC connected load for that strata and hour. The average connected load and strata information is shown in Table R-2 on the previous page.

A sample calculation for strata 3 for hour 17 for a temperature of 35 degrees Celsius is shown below using the data from Tables R-1 and R-2.

Control Coefficient (controlmax3) = -0.000002178

Outside Temperature = 35 Degrees Celsius

Average Summer Maximum kWh = 9.54 kW

Control Estimate = -0.000002178 * (35) * (35) * (35) * (9.54)
= -0.8909 kW

In order to develop the total load reduction at hour 17, we must calculated the reduction for strata 1 and strata 2 and then apply sample weights to each strata. The weights are calculated from the total population stratification and are shown in the table below.

Table R-3

Toronto Hydro Residential Energy Strata Counts and Weights

Strata	AC Size kW	Number of Customers	Weight
1	0 - 2.5	598	0.3137
2	2.51 - 3.5	602	0.3158
3	> 3.5	706	0.3704
Total		1906	1.0000

The strata 3 result calculated above is then weighted by the strata 3 weight of 0.3704 and summed with the weighted control estimates for strata 1 and strata 2 for hour 17 and 35 degrees Celsius to develop the overall weighted population estimate of control for a 35 degree maximum temperature day for the hour ending in 17:00. This is shown below.

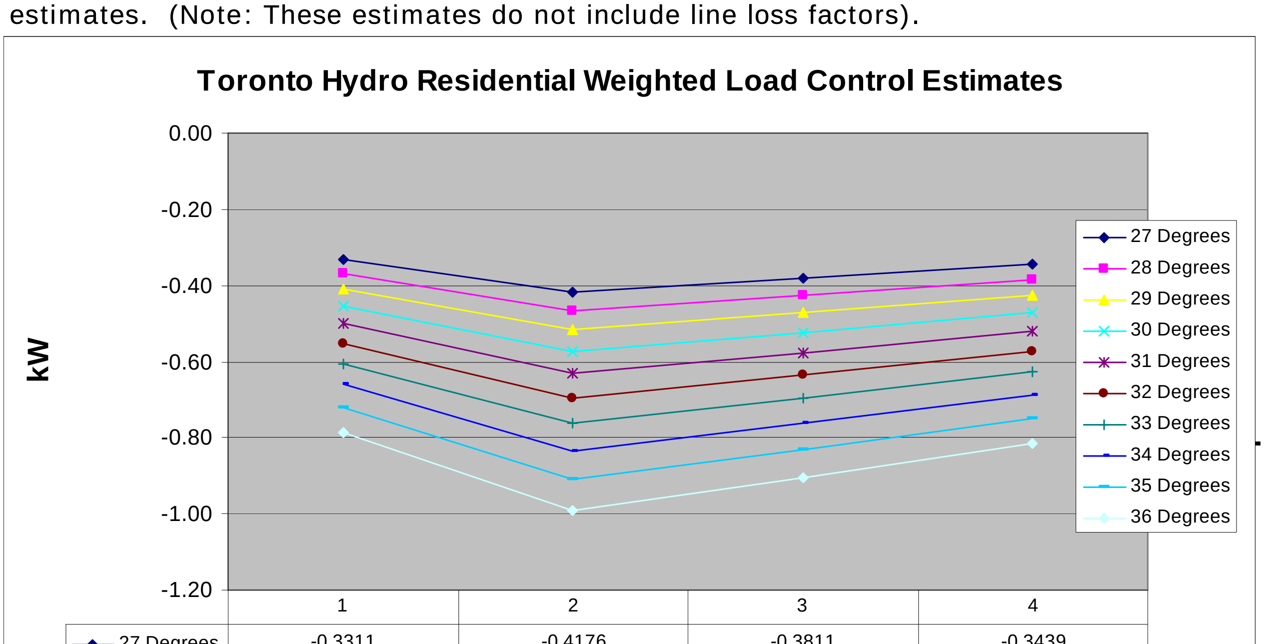
Strata 1 Weighted Control Estimate = -0.80741* 0.3137 = -0.2533 kW

Strata 2 Weighted Control Estimate = -0.78180 * 0.3158 = -0.2469 kW

Strata 3 Weighted Control Estimate = -0.89041 * 0.3704 = -0.3298 kW

Population Weighted Residential Average Control Estimate for Hour 17, Maximum Daily Temperature 35 Degrees = -0.83 kW at the Customer's Meter.

The following chart was developed for the weighted average residential load control estimates. (Note: These estimates do not include line loss factors).



peakSAVER Residential Population Total Air Conditioner Control Estimates

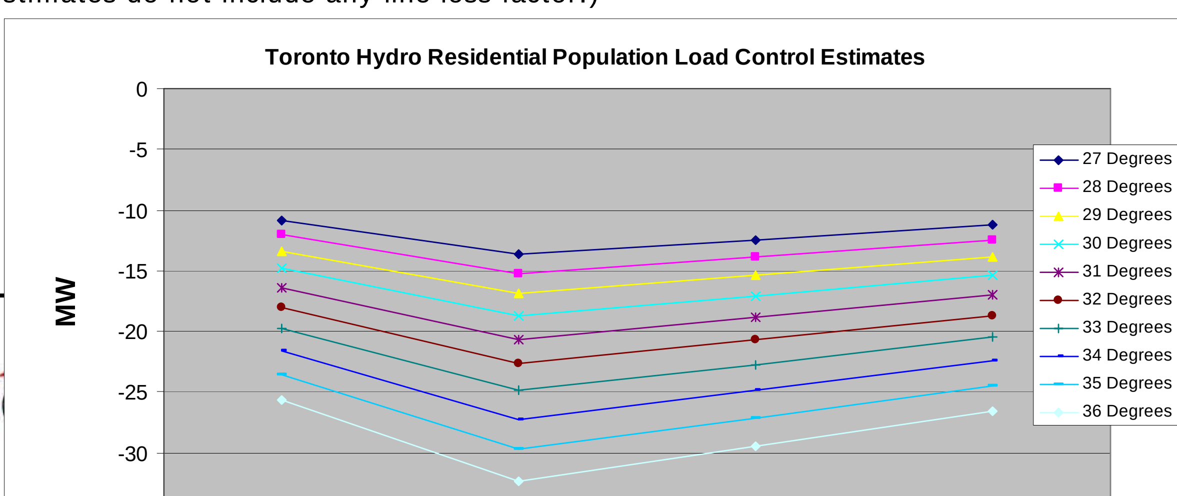
Toronto Hydro has 32,634 residential customers participating with the peakSAVER program. Several of these customers have multiple air conditioners and therefore load control devices. In fact, there are 33,437 residential load control devices installed in the Toronto Hydro peakSAVER program. If we multiply the controlled customer population by the weighted average control reduction at a given hour and temperature, we will obtain the total kW reduction with the peakSAVER program.

In the example on page 34 we found that:

Population Weighted Residential Average Control Estimate for Hour 17, Maximum Daily Temperature 35 Degrees = -0. 83 kW at the Customer's Meter.

Total Population Weighted Residential Average Control Estimate for hour 17, Maximum Daily Temperature 35 Degrees = -0.83 * 32,634 = 27,086 kW

We can now develop a chart of expected load reduction for the current peakSAVER program population based on the whole house data. This chart is shown below. (Note: These estimates do not include any line loss factor.)



Small Commercial Regression Analysis and Load Control Estimates

A variety of models were developed for the commercial load control estimates and the model with the best statistical results was chosen. The model chosen assumes AC use is determined by the outside temperature cubed, multiplied by the size of the AC compressor in kW. The model was developed by strata, which were developed by the total population AC compressor size in kW used in the sample design process. The three strata are 0 – 4.5 kW, 4.51 – 11.5 kW, and 11.51 kW and above. Unfortunately, we did not have sufficient thermostat setting data for the commercial customers to include in the regression analysis and model development. The model is given below.

ACLoad (Hour t, Site J) = A + B1 * controlmax3 (ACMaxkWs (Site J)) * (0 = no control in hour t, 1 = control in hour t) * Max Outdoor Temperature**3

+ B2 * maxacdb2 (ACMaxkWs (Site J)) * Max Outdoor Temperature**3

+ B3 * aclag: Hour 13 ACLoad (Site J)).

Where A is the regression intercept and B1, B2, and B3 are regression coefficients determined during the modeling process. The B1 coefficient is the load reduction estimate for a 1 kW AC at hour t and a given temperature. A total of 12 regressions were estimated for the residential population. These are cross-sectional models and are estimated with all data from all sites for each strata and hour of control.

The regression output for strata 2 for the overall temperature range of 27 to 37 degrees Celsius and control hours 15 to 18 is shown on the following page. The complete small commercial regression output for all strata is given in the appendix.

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	192723	64241	658.33	<.0001
Error	238	23224	97.58191		
Corrected Total	241	215947			

Root MSE	9.87836	R-Square	0.8925
Dependent Mean	17.40037	Adj R-Sq	0.8911
Coeff Var	56.77094		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.90507	2.06890	-0.92	0.3581
maxacdb3	1	0.00002124	0.00001080	1.97	0.0503
controlmax3	1	-0.00002145	0.00000962	-2.23	0.0267
kwhr13	1	0.87416	0.01972	44.32	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	179443	59814	646.07	<.0001
Error	238	22034	92.58109		
Corrected Total	241	201477			

Root MSE	9.62191	R-Square	0.8906
Dependent Mean	17.02601	Adj R-Sq	0.8893
Coeff Var	56.51298		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.67996	2.01581	-0.83	0.4055
maxacdb3	1	0.00002126	0.00001057	2.01	0.0454
controlmax3	1	-0.00002970	0.00001031	-2.88	0.0043
kwhr13	1	0.84265	0.01920	43.89	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	180654	60218	631.23	<.0001
Error	238	22705	95.39836		
Corrected Total	241	203359			

Root MSE	9.76721	R-Square	0.8884
Dependent Mean	16.33403	Adj R-Sq	0.8869
Coeff Var	59.79667		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-2.31062	2.04625	-1.13	0.2600
maxacdb3	1	0.00002035	0.00001073	1.90	0.0592
controlmax3	1	-0.00002726	0.00001047	-2.60	0.0098
kwhr13	1	0.84571	0.01949	43.40	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	175596	58532	594.85	<.0001
Error	238	23419	98.39734		
Corrected Total	241	199015			

Root MSE	9.91954	R-Square	0.8823
Dependent Mean	15.65982	Adj R-Sq	0.8808
Coeff Var	63.34392		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.93687	2.07817	-0.93	0.3523
maxacdb3	1	0.00001626	0.00001090	1.49	0.1370
controlmax3	1	-0.00003202	0.00001063	-3.01	0.0029
kwhr13	1	0.83401	0.01979	42.14	<.0001

The load reduction regression coefficients for each strata and hour are shown in the table below. Two hours for strata 1 indicate a positive control coefficient. This is because the control coefficient is not statistically significant. However, all regression coefficients for strata 2 and strata 3 are significant at the 99th percentile. All other statistical measures (F test for significance of the regression and adjusted R square) are acceptable.

Table R-4

Toronto Hydro Commercial Energy Load Control Coefficients

Strata	Hour	Dependent Variable	Intercept	MaxACdb3	ControlMax3	AC Lag	R Square	Adjusted R Square
1	15	kwh	0.19688	0.000000583	-0.000003709	0.88616	0.82841	0.8275
1	16	kwh	0.34295	0.000000893	0.000000225	0.80961	0.76768	0.76644
1	17	kwh	0.45096	0.000000509	0.000001311	0.73621	0.67178	0.67003
1	18	kwh	0.29423	0.000006249	-0.000001928	0.5374	0.50763	0.50501
2	15	kwh	-1.90507	0.000021244	-0.000021454	0.87416	0.89245	0.8911
2	16	kwh	-1.67996	0.000021263	-0.000029699	0.84265	0.89064	0.88926
2	17	kwh	-2.31062	0.000020349	-0.000027257	0.84571	0.88835	0.88694
2	18	kwh	-1.93687	0.000016264	-0.00003202	0.83401	0.88233	0.88084
3	15	kwh	-1.30913	0.000002419	-0.000003478	0.97443	0.96308	0.96224
3	16	kwh	-2.14847	0.00000321	-0.000005328	0.99885	0.95866	0.95772
3	17	kwh	-2.63982	0.000003718	-0.000005478	0.98059	0.94818	0.94701
3	18	kwh	-2.83947	0.00000348	-0.000005043	0.96855	0.94606	0.94485

The following chart shows the average AC size (connected load) by strata.

Table R-5

Toronto Hydro Commercial Energy
Mean AC Size by Strata

Strata	AC Size kW/Hr
1	2.6
2	7.0
3	18.0

Calculation of Commercial Load Reduction

The load reduction for a given strata, hour, and maximum daily temperature are developed using the appropriate control coefficient (controlmax3) from Table R-4 for the strata, hour selected, and temperature range selected. The control coefficient for the selected strata, hour, and temperature range is multiplied by the temperature cubed and multiplied by the average AC connected load for that strata and hour. The average connected load and strata information is shown in Table R-5 on the previous page.

A sample calculation for strata 3 for hour 17 for a temperature of 35 degrees Celsius is shown below using the data from Tables R-4 and R-5.

Control Coefficient (controlmax3) = -0.000005478

Outside Temperature = 35 Degrees Celsius

Average Connected AC kW = 18.0

Control Estimate = -0.000005478 * (35) * (35) * (35) * (18.0)
= -4.2276 kW

In order to develop the total load reduction at hour 17, we must calculate the reduction for strata 1 and strata 2 and then apply sample weights to each strata. The weights are calculated from the total population stratification and are shown in the table below.

Table R-6

Toronto Hydro Commercial Energy
Strata Counts and Weights

Strata	AC Size kW	Number of Customers	Weight
1	0 - 4.5	470	0.5942
2	4.51 - 11.5	241	0.3047
3	> 11.5	80	0.1011
Total		791	1.00

The strata 3 result calculated above is then weighted by the strata 3 weight of 0.1011 and summed with the weighted control estimates for strata 1 and strata 2 for hour 17 and 35 degrees Celsius to develop the overall weighted population estimate of control for a 35 degree maximum temperature day for the hour ending in 17:00. This is shown below.

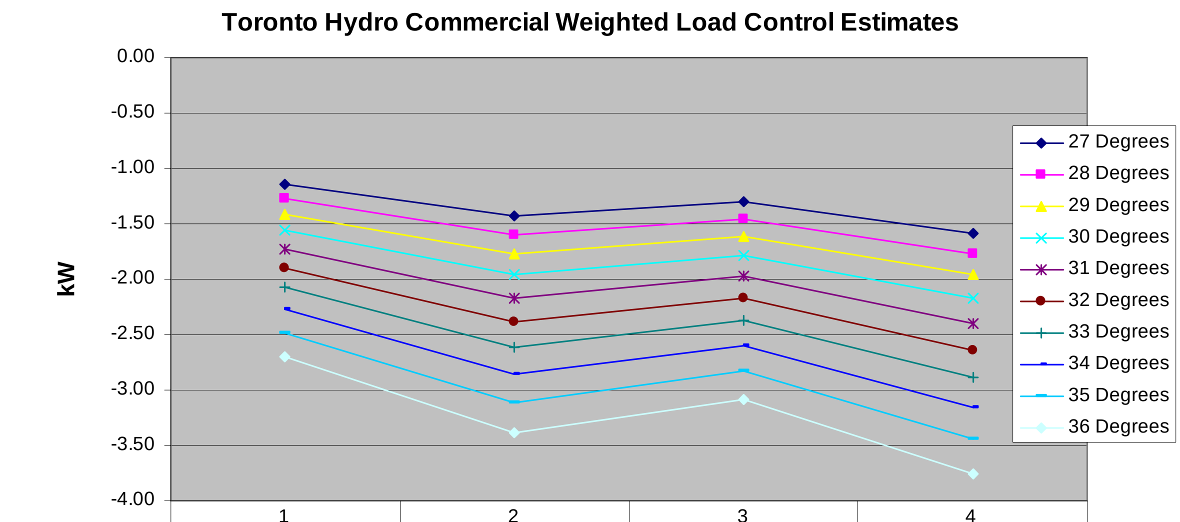
Strata 1 Weighted Control Estimate = 0.1461 * 0.5942 = 0.08684 kW

Strata 2 Weighted Control Estimate = -8.1805 * 0.3047 = -2.4926 kW

Strata 3 Weighted Control Estimate = -4.2276 kW * 0.1011 = -0.4274 kW

Commercial Population Weighted Average Control Estimate for Hour 17, Maximum Daily Temperature 35 Degrees = -2.8332 kW at the Customer's Meter.

The following chart was developed for the weighted average AC runtime load control estimates. (Note: These estimates do not include line loss factors).



	1	2	3	4
27 Degrees	-1.1380	-1.4308	-1.3006	-1.5835
28 Degrees	-1.2692	-1.5957	-1.4506	-1.7660
29 Degrees	-1.4101	-1.7729	-1.6116	-1.9621
30 Degrees	-1.5611	-1.9627	-1.7841	-2.1721
31 Degrees	-1.7224	-2.1656	-1.9686	-2.3967
32 Degrees	-1.8946	-2.3820	-2.1653	-2.6362
33 Degrees	-2.0778	-2.6123	-2.3747	-2.8911
34 Degrees	-2.2725	-2.8571	-2.5972	-3.1620
35 Degrees	-2.4789	-3.1167	-2.8332	-3.4493
36 Degrees	-2.6975	-3.3915	-3.0830	-3.7535

Hour of Control

peakSAVER Small Commercial Population Total Air Conditioner Control Estimates

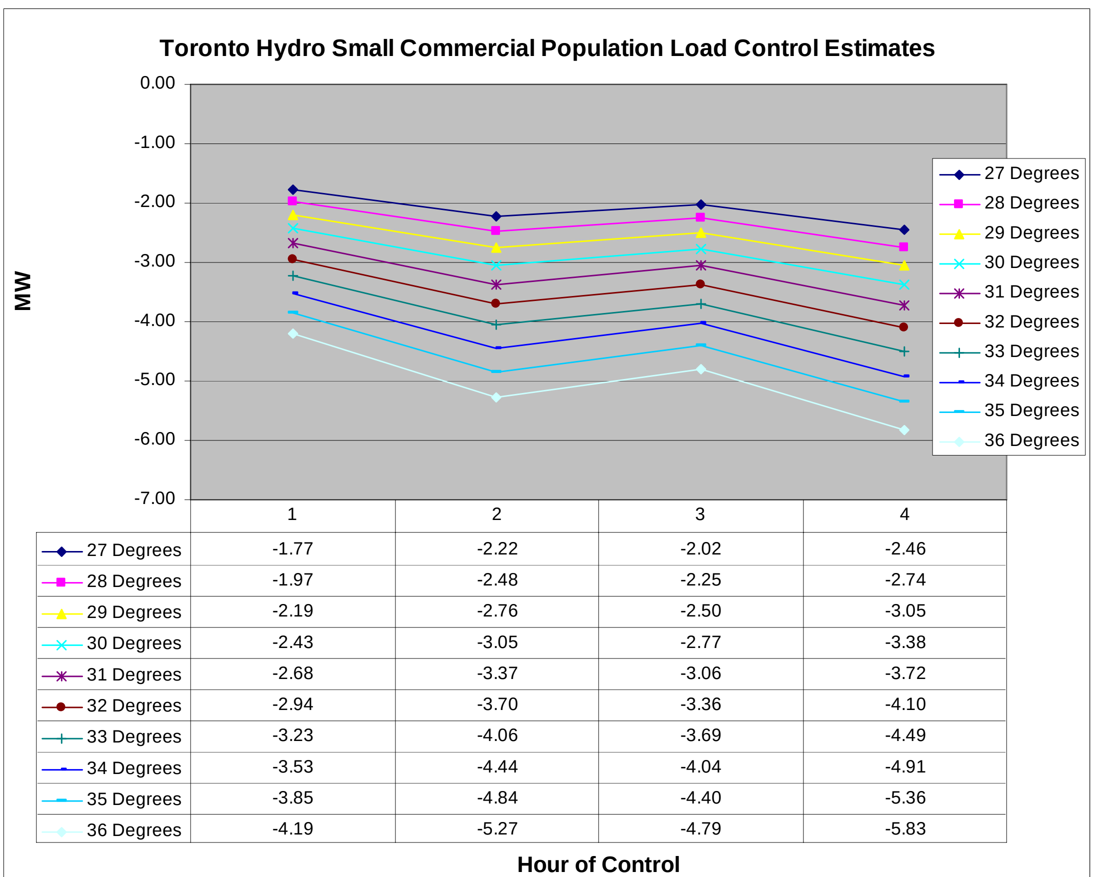
Toronto Hydro has 1,554 small commercial customers with air conditioners under control with the peakSAVER program. The majority of the small commercial customers have more than one air conditioner, allowing for 2,777 load control devices to be installed with the small commercial peakSAVER program. If we multiply the controlled population by the weighted average control reduction at a given hour and temperature, we will obtain the total kW reduction with the commercial peakSAVER program.

In the example on page 42 we found that:

Commercial Population Weighted Average Control Estimate for Hour 17, Maximum Daily Temperature 35 Degrees = -2.8332 kW at the Customer's Meter.

Total Commercial Population Weighted Average Control Estimate for hour 17, Maximum Daily Temperature 35 Degrees = -2.8332 * 1,554 = 4,403 kW

We can now develop a chart of expected load reduction for the current peakSAVER program population based on the AC runtime data. This chart is shown below. (Note: These estimates do not include any line loss factor.)



	1	2	3	4
27 Degrees	-1.77	-2.22	-2.02	-2.46
28 Degrees	-1.97	-2.48	-2.25	-2.74
29 Degrees	-2.19	-2.76	-2.50	-3.05
30 Degrees	-2.43	-3.05	-2.77	-3.38
31 Degrees	-2.68	-3.37	-3.06	-3.72
32 Degrees	-2.94	-3.70	-3.36	-4.10
33 Degrees	-3.23	-4.06	-3.69	-4.49
34 Degrees	-3.53	-4.44	-4.04	-4.91
35 Degrees	-3.85	-4.84	-4.40	-5.36
36 Degrees	-4.19	-5.27	-4.79	-5.83

Based on our calculations, Toronto Hydro can expect a residential AC load reduction of 0.66 kW per customer during the second hour of control on a moderately warm day (34 Degrees Celsius). Toronto Hydro can expect a total residential AC load reduction (population of

32,634 customers) of 22 MW on a moderately warm day. On an extreme day (36 Degrees Celsius), Toronto Hydro can expect a residential AC load reduction of 1.11 kW per customer during the second hour of control. Toronto Hydro can expect a total AC load reduction of 36 MW on an extreme day.

Toronto Hydro can expect a small commercial AC load reduction of 3.16 kW per customer during the second hour of control on a moderately warm day (34 Degrees Celsius). Toronto Hydro can expect a total small commercial AC load reduction (population of 1,554 customers) of 5 MW on a moderately warm day. On an extreme day (36 Degrees Celsius), Toronto Hydro can expect a small commercial AC load reduction of 3.75 kW per customer during the second hour of control. Toronto Hydro can expect a total small commercial AC load reduction of nearly 6 MW on an extreme day.

Statistical Accuracy of Control Estimates

Residential Statistical Accuracy

The sample and regression statistics can be used to develop an estimate of the accuracy of the control estimates. The sample was initially designed to yield control estimates within +/- 10% at 90% confidence during control hour 17 on a day whose temperature reached 35 degrees using the whole house data. The detailed estimate for a maximum temperature day of 35 degrees at hour 17 is shown below.

This calculation shows that the actual accuracy of the peakSAVER sample at 90% confidence is +/- 0.33%. This accuracy is very good. As we are able to collect additional data, we feel the accuracy will continue to get better.

Toronto Hydro peakSAVER Program
Impact Accuracy Estimate at 90% Confidence based on Residential Load Control Estimates
Maximum Temperature 35 Degrees at Hour 17

Strata	AC Size kW	Year	Month	Sample Observations	Weight	Control Estimate Coefficient	Control Estimate	Weighted Control Estimate	SE Control Coefficient	SE Control Estimate	Variance
h	Stratum			nh	Wh		Yh	Wh*Yh		sh	Wh^2*sh^2/nh
1	0 - 2.5	2007	7	38	0.3137	-0.0000027	-0.8074	-0.2533	0.0000004	0.0159	0.0000007
2	2.5 - 3.5	2007	7	49	0.3158	-0.0000025	-0.7818	-0.2469	0.0000004	0.0222	0.0000010
3	> 3.5	2007	7	66	0.3704	-0.0000022	-0.8904	-0.3298	0.0000003	0.0230	0.0000011
Total				153				-0.8301			0.0000028

	kW/Customer
Control Estimate at Customer	-0.8301
90 % Lower Limit at Customer	-0.8273
90 % Upper Limit at Customer	-0.8328
Relative Accuracy at 90% Confidence	0.33%

Commercial Statistical Accuracy

The sample and regression statistics can be used to develop an estimate of the accuracy of the control estimates. The sample was initially designed to yield control estimates within +/- 10% at 90% confidence during control hour 17 on a day whose temperature reached 35 degrees using the whole house data. The detailed estimate for a maximum temperature day of 35 degrees at hour 17 is shown below.

This calculation shows that the actual accuracy of the peakSAVER sample at 90% confidence is +/- 15.3%. As we are able to collect additional data, we feel the accuracy will improve.

Toronto Hydro peakSAVER Program
Impact Accuracy Estimate at 90% Confidence based on Commercial Load Control Estimates
Maximum Temperature 35 Degrees at Hour 17

Strata	AC Size kW	Year	Month	Sample Observations	Weight	Control Estimate Coefficient	Control Estimate	Weighted Control Estimate	SE Control Coefficient	SE Control Estimate	Variance
h	Stratum			nh	Wh		Yh	Wh*Yh		sh	Wh^2*sh^2/nh
1	0 - 4.5	2007	7	25	0.5942	0.0000	0.1461	0.0868	0.0000	0.2809	0.0011
2	4.5 - 11.5	2007	7	14	0.3047	0.0000	-8.1805	-2.4926	0.0000	3.1423	0.0655
3	> 11.5	2007	7	8	0.1011	0.0000	-4.2276	-0.4274	0.0000	0.8181	0.0009
Total				47				-2.8332			0.0675

	kW/Customer
Control Estimate at Customer	-2.8332
90 % Lower Limit at Customer	-2.4047
90 % Upper Limit at Customer	-3.2617
Relative Accuracy at 90% Confidence	15.13%

A smaller relative accuracy percentage indicates a better model. The relative accuracy for the commercial estimates is significantly higher than the relative accuracy for the residential estimates. The small sample size of the commercial population contributes to this higher percentage.

AC Snapback or Payback

The increase in AC load after control is released is referred to as snapback or payback. This is useful to the utility since some energy and therefore revenue, is potentially lost during the control of air conditioners. GoodCents attempted to analyze AC snapback on an hourly basis for the five hours after control by temperature range, as in the load control analysis previously shown, but the payback coefficients were not statistically significant. If we conduct the analysis over all control temperature ranges, the results are statistically significant. The snapback regression coefficients and sum from the residential peakSAVER sample population are shown in the table below. The complete regression output can be found in the appendix.

peakSAVER Residential Snapback Estimates
2.7 kW Average AC Size
Average Snapback 30 Degrees + (kW)

Hour						
19	**20**	**21**	**22**	**23**	**24**	**Total**
0.0052	0.1192	0.1324	0.1856	0.1992	0.2307	0.8723

The average load control coefficients and sum from the table on page 34 for the average sample population AC size are shown below. These estimates are for the residential load control estimates.

peakSAVER Residential AC Load Control Estimates
2.7 kW Average AC Size
Average Reduction 30 Degrees + (kW)

Hour				
15	**16**	**17**	**18**	**Total**
-0.6112	-0.7709	-0.7034	-0.6348	-2.7203

Difference	-1.8480

This indicates that on average the payback during the five hours following control is 1.8480 kWh less than the control kW reduction. Therefore, Toronto Hydro will see a slight reduction in energy sales and revenues due to the residential peakSAVER program.

The snapback regression coefficients and sum from the commercial peakSAVER sample population are shown in the table below. The complete regression output can be found in the appendix.

peakSAVER Commercial Snapback Estimates
2.7 kW Average AC Size
Average Snapback 30 Degrees + (kW)

Hour						
19	**20**	**21**	**22**	**23**	**24**	**Total**
1.5871	1.5207	0.6687	0.9117	0.8195	0.6619	6.1695

The average load control coefficients and sum from the table on page 43 for the average sample population AC size are shown below. These estimates are for the commercial load control estimates.

peakSAVER Commercial AC Load Control Estimates
2.7 kW Average AC Size
Average Reduction 30 Degrees + (kW)

Hour				
15	**16**	**17**	**18**	**Total**
-1.8522	-2.3287	-2.1169	-2.5772	-8.8751

Difference -2.7056

This indicates that on average the payback during the five hours following control is 2.7056 kWh less than the control kW reduction. Therefore, Toronto Hydro will see a slight reduction in energy sales and revenues due to the commercial peakSAVER program.

Summary and Conclusions

This report presents a thorough analysis of the load reductions due to the setback of temperature using control enabled smart thermostats and the cycling of water heaters achieved by Toronto Hydro's peakSAVER Program using all data collected from the summer of 2006 and 2007.

Toronto had a warm summer in 2007. As many as six days reached maximum temperatures over 32 Degrees Celsius in August, with five days reaching maximum temperatures above 32 Degrees in June, and three days in July and September. Temperatures above 28 Degrees Celsius are favorable for control days in Toronto. We had twelve control days this summer, two of which reached over 34 degrees Celsius.

Based on current peakSAVER program participation levels, Toronto Hydro can expect a total residential load reduction of about 23 MW due to AC control on a moderately warm day and 5 MW of small commercial population load reduction. On an extreme summer day, the residential reduction due to AC control will near 32 MW. An estimated load reduction of 0.99 kW per customer can be expected on a 36 degree-day. Small commercial load reduction on an extreme day will near 6 MW for the current population.

Toronto Hydro can expect 0.46 kW to 0.64 kW of load reduction per customer with summer water heater cycling during afternoon hours. Based on the current peakSAVER program participation levels, Toronto Hydro can expect a total summer water heater load reduction of as much as 286 kW during hour 16 of peaking periods.

In past studies, we have analyzed the effect of AC control on customer comfort. This data shows that moderate setback strategies used during the load management programs should not lead to large temperature or relative humidity increases in the home, nor cause the customer discomfort.

The statistical relative accuracy on residential load reduction estimates achieved in 2007 was well within the benchmark +/- 10% at 90% confidence and indicates current sample sizes are sufficient. We recommend that Toronto Hydro rotate the sample every 2 to 3 years to assure the sample is representative of the population.

Appendix

Water Heater Regression Output

Toronto Hydro kwh - whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	407
Number of Observations Used	406
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1357.95104	678.97552	350.98	<.0001
Error	403	779.60566	1.93451		
Corrected Total	405	2137.55671			

Root MSE	1.39086	R-Square	0.6353
Dependent Mean	2.69736	Adj R-Sq	0.6335
Coeff Var	51.56388		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.69524	0.11285	6.16	<.0001
whcontrol	1	-0.65421	0.18313	-3.57	0.0004
kwhr13	1	0.81478	0.03138	25.96	<.0001

Toronto Hydro kwh - whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	407

Number of Observations Used	406
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1157.39108	578.69554	266.22	<.0001
Error	403	876.03050	2.17377		
Corrected Total	405	2033.42158			

Root MSE	1.47437	R-Square	0.5692
Dependent Mean	2.71277	Adj R-Sq	0.5670
Coeff Var	54.34938		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.89098	0.11769	7.57	<.0001
whcontrol	1	-0.86703	0.21077	-4.11	<.0001
kwhr13	1	0.74875	0.03322	22.54	<.0001

Toronto Hydro kwh - whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	407
Number of Observations Used	406
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1101.09356	550.54678	246.93	<.0001

Error	403	898.52864	2.22960
Corrected Total	405	1999.62220	

Root MSE	1.49318	R-Square	0.5507
Dependent Mean	2.75142	Adj R-Sq	0.5484
Coeff Var	54.26969		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.95810	0.11919	8.04	<.0001
whcontrol	1	-0.77320	0.21346	-3.62	0.0003
kwhr13	1	0.73271	0.03364	21.78	<.0001

Toronto Hydro kwh - whcontrol kwhr13 Regressions for 27 to 37 Degrees

hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	408
Number of Observations Used	406
Number of Observations with Missing Values	2

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	1055.20719	527.60359	231.79	<.0001
Error	403	917.33184	2.27626		
Corrected Total	405	1972.53903			

Root MSE	1.50873	R-Square	0.5349
Dependent Mean	2.82210	Adj R-Sq	0.5326
Coeff Var	53.46113		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	1.05514	0.12043	8.76	<.0001
whcontrol	1	-0.70518	0.21568	-3.27	0.0012
kwhr13	1	0.71887	0.03399	21.15	<.0001

Residential Regression Output

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1288
Number of Observations Used	1287
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2051.53191	512.88298	626.34	<.0001
Error	1282	1049.78021	0.81886		
Corrected Total	1286	3101.31212			

Root MSE	0.90491	R-Square	0.6615
Dependent Mean	1.93839	Adj R-Sq	0.6604
Coeff Var	46.68360		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-0.05289	0.06390	-0.83	0.4080

maxacdb3	1	0.00000363	3.753416E-7	9.67	<.0001
controlmax3	1	-0.00000214	3.011403E-7	-7.10	<.0001
whcontrol	1	-0.27608	0.26648	-1.04	0.3004
kwhr13	1	0.74690	0.02093	35.68	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1288
Number of Observations Used	1287
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1853.47581	463.36895	444.40	<.0001
Error	1282	1336.71593	1.04268		
Corrected Total	1286	3190.19174			

Root MSE	1.02112	R-Square	0.5810
Dependent Mean	2.02754	Adj R-Sq	0.5797
Coeff Var	50.36245		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.08473	0.07238	1.17	0.2420
maxacdb3	1	0.00000393	4.251056E-7	9.26	<.0001
controlmax3	1	-0.00000272	3.515003E-7	-7.74	<.0001
whcontrol	1	-0.29195	0.32936	-0.89	0.3756
kwhr13	1	0.69393	0.02361	29.39	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1288
Number of Observations Used	1287
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1703.85839	425.96460	349.38	<.0001
Error	1282	1562.99628	1.21919		
Corrected Total	1286	3266.85467			

Root MSE	1.10417	R-Square	0.5216
Dependent Mean	2.14874	Adj R-Sq	0.5201
Coeff Var	51.38669		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.28509	0.07826	3.64	0.0003
maxacdb3	1	0.00000378	4.596806E-7	8.23	<.0001
controlmax3	1	-0.00000267	3.800889E-7	-7.02	<.0001
whcontrol	1	-0.18135	0.35615	-0.51	0.6107
kwhr13	1	0.66555	0.02553	26.07	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1289
Number of Observations Used	1287
Number of Observations with Missing Values	2

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	1504.28190	376.07048	278.25	<.0001
Error	1282	1732.67259	1.35154		
Corrected Total	1286	3236.95449			

Root MSE	1.16256	R-Square	0.4647
Dependent Mean	2.26853	Adj R-Sq	0.4631
Coeff Var	51.24723		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.59239	0.08240	7.19	<.0001
maxacdb3	1	0.00000279	4.83989E-7	5.76	<.0001
controlmax3	1	-0.00000187	4.001883E-7	-4.68	<.0001
whcontrol	1	-0.34105	0.37498	-0.91	0.3632
kwhr13	1	0.65450	0.02688	24.35	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1612
Number of Observations Used	1611
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2869.74862	717.43716	818.95	<.0001
Error	1606	1406.92628	0.87604		
Corrected Total	1610	4276.67491			

Root MSE	0.93597	R-Square	0.6710
Dependent Mean	2.13443	Adj R-Sq	0.6702
Coeff Var	43.85105		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.12125	0.06125	1.98	0.0479
maxacdb3	1	0.00000318	3.675763E-7	8.65	<.0001
controlmax3	1	-0.00000256	2.884694E-7	-8.89	<.0001
whcontrol	1	-0.21897	0.21200	-1.03	0.3018
kwhr13	1	0.73622	0.01809	40.69	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1613
Number of Observations Used	1611
Number of Observations with Missing Values	2

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2642.01875	660.50469	597.56	<.0001
Error	1606	1775.15950	1.10533		
Corrected Total	1610	4417.17825			

Root MSE	1.05135	R-Square	0.5981
Dependent Mean	2.23665	Adj R-Sq	0.5971
Coeff Var	47.00533		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.09043	0.06917	1.31	0.1913
maxacdb3	1	0.00000485	4.157591E-7	11.67	<.0001
controlmax3	1	-0.00000305	3.359463E-7	-9.08	<.0001
whcontrol	1	-0.42188	0.25632	-1.65	0.1000
kwhr13	1	0.64319	0.02035	31.61	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1613
Number of Observations Used	1611
Number of Observations with Missing Values	2

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2484.67089	621.16772	500.53	<.0001
Error	1606	1993.08277	1.24102		
Corrected Total	1610	4477.75366			

Root MSE	1.11401	R-Square	0.5549
Dependent Mean	2.34756	Adj R-Sq	0.5538
Coeff Var	47.45403		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|

Intercept	1	0.11838	0.07329	1.62	0.1065
maxacdb3	1	0.00000585	4.405404E-7	13.29	<.0001
controlmax3	1	-0.00000254	3.559704E-7	-7.13	<.0001
whcontrol	1	-0.66890	0.27160	-2.46	0.0139
kwhr13	1	0.57975	0.02156	26.89	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1612
Number of Observations Used	1610
Number of Observations with Missing Values	2

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	2353.23411	588.30853	412.51	<.0001
Error	1605	2289.01814	1.42618		
Corrected Total	1609	4642.25225			

Root MSE	1.19423	R-Square	0.5069
Dependent Mean	2.44259	Adj R-Sq	0.5057
Coeff Var	48.89193		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.23320	0.07858	2.97	0.0030
maxacdb3	1	0.00000605	4.722653E-7	12.81	<.0001
controlmax3	1	-0.00000251	3.816124E-7	-6.57	<.0001
whcontrol	1	-0.46395	0.29116	-1.59	0.1112
kwhr13	1	0.54896	0.02311	23.75	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=3 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1949
Number of Observations Used	1948
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	8210.78381	2052.69595	1366.36	<.0001
Error	1943	2918.98484	1.50231		
Corrected Total	1947	11130			

Root MSE	1.22569	R-Square	0.7377
Dependent Mean	2.78809	Adj R-Sq	0.7372
Coeff Var	43.96155		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.23032	0.06451	3.57	0.0004
maxacdb3	1	0.00000184	2.838739E-7	6.48	<.0001
controlmax3	1	-0.00000177	2.535785E-7	-7.00	<.0001
whcontrol	1	-0.00801	0.21611	-0.04	0.9704
kwhr13	1	0.81811	0.01464	55.89	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=3 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1949
Number of Observations Used	1948
Number of Observations with Missing Values	1

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	7788.22155	1947.05539	1041.69	<.0001
Error	1943	3631.72290	1.86913		
Corrected Total	1947	11420			

Root MSE	1.36716	R-Square	0.6820
Dependent Mean	2.87571	Adj R-Sq	0.6813
Coeff Var	47.54167		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.26879	0.07204	3.73	0.0002
maxacdb3	1	0.00000259	3.178821E-7	8.16	<.0001
controlmax3	1	-0.00000234	2.943048E-7	-7.96	<.0001
whcontrol	1	-0.21301	0.27399	-0.78	0.4370
kwhr13	1	0.76869	0.01634	47.05	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=3 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1950

Number of Observations Used	1948
Number of Observations with Missing Values	2

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	7397.51835	1849.37959	866.38	<.0001
Error	1943	4147.55720	2.13462		
Corrected Total	1947	11545			

Root MSE	1.46103	R-Square	0.6408
Dependent Mean	3.01838	Adj R-Sq	0.6400
Coeff Var	48.40447		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.41210	0.07699	5.35	<.0001
maxacdb3	1	0.00000291	3.397081E-7	8.56	<.0001
controlmax3	1	-0.00000218	3.14512E-7	-6.93	<.0001
whcontrol	1	-0.29427	0.29281	-1.00	0.3150
kwhr13	1	0.73542	0.01746	42.12	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 whcontrol kwhr13 Regressions for 27 to 37 Degrees

strata=3 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1952
Number of Observations Used	1947
Number of Observations with Missing Values	5

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	4	7095.74480	1773.93620	723.06	<.0001

Error	1942	4764.47921	2.45339
Corrected Total	1946	11860	

Root MSE	1.56633	R-Square	0.5983
Dependent Mean	3.10846	Adj R-Sq	0.5975
Coeff Var	50.38925		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.41745	0.08256	5.06	<.0001
maxacdb3	1	0.00000372	3.642104E-7	10.23	<.0001
controlmax3	1	-0.00000216	3.371814E-7	-6.41	<.0001
whcontrol	1	-0.40381	0.31391	-1.29	0.1985
kwhr13	1	0.68742	0.01872	36.73	<.0001

Commercial Regression Output

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	567
Number of Observations Used	567

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	5331.66722	1777.22241	906.02	<.0001
Error	563	1104.35986	1.96156		
Corrected Total	566	6436.02708			

Root MSE	1.40056	R-Square	0.8284
Dependent Mean	3.48371	Adj R-Sq	0.8275
Coeff Var	40.20306		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.19688	0.19138	1.03	0.3040
maxacdb3	1	5.82534E-7	0.00000232	0.25	0.8015
controlmax3	1	-0.00000371	0.00000186	-2.00	0.0463
kwhr13	1	0.88616	0.01731	51.19	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read 567
Number of Observations Used 567

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	4477.98335	1492.66112	620.11	<.0001
Error	563	1355.19167	2.40709		
Corrected Total	566	5833.17503			

Root MSE	1.55148	R-Square	0.7677
Dependent Mean	3.42024	Adj R-Sq	0.7664
Coeff Var	45.36168		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.34295	0.21338	1.61	0.1086
maxacdb3	1	8.925467E-7	0.00000259	0.34	0.7305
controlmax3	1	2.2513E-7	0.00000218	0.10	0.9177
kwhr13	1	0.80961	0.01917	42.22	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	567
Number of Observations Used	567

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	3706.99375	1235.66458	384.11	<.0001
Error	563	1811.15847	3.21698		
Corrected Total	566	5518.15222			

Root MSE	1.79359	R-Square	0.6718
Dependent Mean	3.23666	Adj R-Sq	0.6700
Coeff Var	55.41494		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.45096	0.24667	1.83	0.0681
maxacdb3	1	5.091593E-7	0.00000299	0.17	0.8650
controlmax3	1	0.00000131	0.00000252	0.52	0.6026
kwhr13	1	0.73621	0.02217	33.21	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=1 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	567
Number of Observations Used	567

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	2037.96710	679.32237	193.49	<.0001
Error	563	1976.67874	3.51097		
Corrected Total	566	4014.64584			

Root MSE	1.87376	R-Square	0.5076
Dependent Mean	2.77074	Adj R-Sq	0.5050
Coeff Var	67.62656		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	0.29423	0.25770	1.14	0.2540
maxacdb3	1	0.00000625	0.00000313	2.00	0.0462
controlmax3	1	-0.00000193	0.00000263	-0.73	0.4636
kwhr13	1	0.53740	0.02316	23.21	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	192723	64241	658.33	<.0001
Error	238	23224	97.58191		
Corrected Total	241	215947			

Root MSE	9.87836	R-Square	0.8925
Dependent Mean	17.40037	Adj R-Sq	0.8911
Coeff Var	56.77094		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.90507	2.06890	-0.92	0.3581
maxacdb3	1	0.00002124	0.00001080	1.97	0.0503
controlmax3	1	-0.00002145	0.00000962	-2.23	0.0267
kwhr13	1	0.87416	0.01972	44.32	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	179443	59814	646.07	<.0001
Error	238	22034	92.58109		
Corrected Total	241	201477			

Root MSE	9.62191	R-Square	0.8906
Dependent Mean	17.02601	Adj R-Sq	0.8893
Coeff Var	56.51298		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.67996	2.01581	-0.83	0.4055
maxacdb3	1	0.00002126	0.00001057	2.01	0.0454
controlmax3	1	-0.00002970	0.00001031	-2.88	0.0043
kwhr13	1	0.84265	0.01920	43.89	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	180654	60218	631.23	<.0001
Error	238	22705	95.39836		
Corrected Total	241	203359			

Root MSE	9.76721	R-Square	0.8884

Dependent Mean	16.33403	Adj R-Sq	0.8869
Coeff Var	59.79667		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-2.31062	2.04625	-1.13	0.2600
maxacdb3	1	0.00002035	0.00001073	1.90	0.0592
controlmax3	1	-0.00002726	0.00001047	-2.60	0.0098
kwhr13	1	0.84571	0.01949	43.40	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=2 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	303
Number of Observations Used	242
Number of Observations with Missing Values	61

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	175596	58532	594.85	<.0001
Error	238	23419	98.39734		
Corrected Total	241	199015			

Root MSE	9.91954	R-Square	0.8823
Dependent Mean	15.65982	Adj R-Sq	0.8808
Coeff Var	63.34392		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.93687	2.07817	-0.93	0.3523
maxacdb3	1	0.00001626	0.00001090	1.49	0.1370

controlmax3	1	-0.00003202	0.00001063	-3.01	0.0029
kwhr13	1	0.83401	0.01979	42.14	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=3 hr=15

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	186
Number of Observations Used	137
Number of Observations with Missing Values	49

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	34736	11579	1156.35	<.0001
Error	133	1331.74551	10.01312		
Corrected Total	136	36068			

Root MSE	3.16435	R-Square	0.9631
Dependent Mean	9.06989	Adj R-Sq	0.9622
Coeff Var	34.88854		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-1.30913	0.56594	-2.31	0.0222
maxacdb3	1	0.00000242	7.159956E-7	3.38	0.0010
controlmax3	1	-0.00000348	8.147533E-7	-4.27	<.0001
kwhr13	1	0.97443	0.02025	48.12	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=3 hr=16

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	186
Number of Observations Used	137
Number of Observations with Missing Values	49

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	37047	12349	1027.98	<.0001
Error	133	1597.71243	12.01288		
Corrected Total	136	38645			

Root MSE	3.46596	R-Square	0.9587
Dependent Mean	8.99914	Adj R-Sq	0.9577
Coeff Var	38.51435		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-2.14847	0.62063	-3.46	0.0007
maxacdb3	1	0.00000321	7.864926E-7	4.08	<.0001
controlmax3	1	-0.00000533	9.537012E-7	-5.59	<.0001
kwhr13	1	0.99885	0.02153	46.39	<.0001

strata=3 hr=17

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	186
Number of Observations Used	137
Number of Observations with Missing Values	49

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	36180	12060	811.19	<.0001
Error	133	1977.31173	14.86701		
Corrected Total	136	38157			

Root MSE	3.85578	R-Square	0.9482
Dependent Mean	8.71951	Adj R-Sq	0.9470
Coeff Var	44.22010		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-2.63982	0.69043	-3.82	0.0002
maxacdb3	1	0.00000372	8.749494E-7	4.25	<.0001
controlmax3	1	-0.00000548	0.00000106	-5.16	<.0001
kwhr13	1	0.98059	0.02395	40.94	<.0001

Toronto Hydro kwh - maxacdb3 controlmax3 kwhr13 Regressions for 27 to 37 Degrees

strata=3 hr=18

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	186
Number of Observations Used	137
Number of Observations with Missing Values	49

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	3	35258	11753	777.61	<.0001
Error	133	2010.13307	15.11378		
Corrected Total	136	37268			

Root MSE	3.88764	R-Square	0.9461
Dependent Mean	8.26976	Adj R-Sq	0.9448
Coeff Var	47.01037		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	-2.83947	0.69614	-4.08	<.0001
maxacdb3	1	0.00000348	8.821811E-7	3.94	0.0001
controlmax3	1	-0.00000504	0.00000107	-4.71	<.0001
kwhr13	1	0.96855	0.02415	40.11	<.0001

AC Snapback Regression Output

Residential Snapback Output

Toronto Hydro kwh - controlmaxacday cnnld Residential Snapback Regressions for 19 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1884
Number of Observations Used	1881
Number of Observations with Missing Values	3

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	15.27670	7.63835	1.66	0.1896
Error	1878	8619.26303	4.58960		
Corrected Total	1880	8634.53973			

Root MSE	2.14233	R-Square	0.0018
Dependent Mean	3.29387	Adj R-Sq	0.0007
Coeff Var	65.04009		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.19524	0.07327	43.61	<.0001
controlmaxacday	1	0.00148	0.01905	0.08	0.9382
Cnnld	1	0.02243	0.01354	1.66	0.0977

Toronto Hydro kwh - controlmaxacday cnnld Residential Snapback Regressions for 20 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1884
Number of Observations Used	1881
Number of Observations with Missing Values	3

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	18.60190	9.30095	2.00	0.1360
Error	1878	8744.59682	4.65633		
Corrected Total	1880	8763.19871			

Root MSE	2.15785	R-Square	0.0021
Dependent Mean	3.29747	Adj R-Sq	0.0011
Coeff Var	65.43969		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.24759	0.07380	44.01	<.0001
controlmaxacday	1	0.03405	0.01919	1.77	0.0762
Cnnld	1	0.00244	0.01364	0.18	0.8581

Toronto Hydro kwh - controlmaxacday cnnld Residential Snapback Regressions for 21 hour for 30 + Degrees
The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1884
Number of Observations Used	1881
Number of Observations with Missing Values	3

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	21.57826	10.78913	2.34	0.0968
Error	1878	8665.66184	4.61430		
Corrected Total	1880	8687.24011			

Root MSE	2.14809	R-Square	0.0025
Dependent Mean	3.26275	Adj R-Sq	0.0014
Coeff Var	65.83692		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.21590	0.07347	43.77	<.0001
controlmaxacday	1	0.03782	0.01911	1.98	0.0479
Cnnld	1	0.00072635	0.01357	0.05	0.9573

Toronto Hydro kwh - controlmaxacday cnnld Residential Snapback Regressions for 22 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1884
Number of Observations Used	1881
Number of Observations with Missing Values	3

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	48.83349	24.41674	5.23	0.0055
Error	1878	8773.74581	4.67186		
Corrected Total	1880	8822.57930			

Root MSE	2.16145	R-Square	0.0055
Dependent Mean	3.18561	Adj R-Sq	0.0045
Coeff Var	67.85045		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.09410	0.07392	41.86	<.0001
controlmaxacday	1	0.05304	0.01922	2.76	0.0058
Cnnld	1	0.00699	0.01366	0.51	0.6089

Toronto Hydro kwh - controlmaxacday cnnld Residential Snapback Regressions for 23 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1884
Number of Observations Used	1881
Number of Observations with Missing Values	3

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	50.42156	25.21078	5.80	0.0031
Error	1878	8169.08878	4.34989		
Corrected Total	1880	8219.51034			

Root MSE	2.08564	R-Square	0.0061
Dependent Mean	3.00904	Adj R-Sq	0.0051
Coeff Var	69.31248		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2.93188	0.07133	41.10	<.0001
controlmaxacday	1	0.05692	0.01855	3.07	0.0022
Cnnld	1	0.00263	0.01318	0.20	0.8418

Toronto Hydro kwh - controlmaxacday cnnld Residential Snapback Regressions for 24 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	1435
Number of Observations Used	1435

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	50.47380	25.23690	6.25	0.0020
Error	1432	5778.31979	4.03514		
Corrected Total	1434	5828.79359			

Root MSE	2.00877	R-Square	0.0087
Dependent Mean	2.69184	Adj R-Sq	0.0073
Coeff Var	74.62438		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2.66876	0.07786	34.28	<.0001
controlmaxacday	1	0.06591	0.01874	3.52	0.0004
Cnnld	1	-0.01535	0.01392	-1.10	0.2705

Commercial Snapback Output

Toronto Hydro kwh - controlmaxacday cnnld Commercial Snapback Regressions for 19 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	361
Number of Observations Used	319
Number of Observations with Missing Values	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F

Model	2	6168.66892	3084.33446	9.62	<.0001
Error	316	101362	320.76441		
Corrected Total	318	107530			

Root MSE	17.90990	R-Square	0.0574
Dependent Mean	7.77956	Adj R-Sq	0.0514
Coeff Var	230.21746		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	4.72842	1.23910	3.82	0.0002
controlmaxacday	1	0.17595	0.18096	0.97	0.3316
Cnnld	1	0.36685	0.10779	3.40	0.0008

Toronto Hydro kwh - controlmaxacday cnnld Commercial Snapback Regressions for 20 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	361
Number of Observations Used	319
Number of Observations with Missing Values	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	5209.88387	2604.94193	9.21	0.0001
Error	316	89341	282.72465		
Corrected Total	318	94551			

Root MSE	16.81442	R-Square	0.0551
Dependent Mean	7.27179	Adj R-Sq	0.0491
Coeff Var	231.22802		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	4.47626	1.16331	3.85	0.0001
controlmaxacday	1	0.16859	0.16989	0.99	0.3218
Cnnld	1	0.33447	0.10119	3.31	0.0011

Toronto Hydro kwh - controlmaxacday cnnld Commercial Snapback Regressions for 21 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	361
Number of Observations Used	319
Number of Observations with Missing Values	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	3623.57592	1811.78796	8.15	0.0004
Error	316	70265	222.35863		
Corrected Total	318	73889			

Root MSE	14.91169	R-Square	0.0490
Dependent Mean	6.49687	Adj R-Sq	0.0430
Coeff Var	229.52117		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	4.09763	1.03167	3.97	<.0001
controlmaxacday	1	0.07414	0.15066	0.49	0.6230
Cnnld	1	0.30284	0.08974	3.37	0.0008

Toronto Hydro kwh - controlmaxacday cnnld Commercial Snapback Regressions for 22 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	361
Number of Observations Used	319
Number of Observations with Missing Values	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	3159.96725	1579.98362	7.98	0.0004
Error	316	62570	198.00478		
Corrected Total	318	65729			

Root MSE	14.07142	R-Square	0.0481
Dependent Mean	6.05420	Adj R-Sq	0.0421
Coeff Var	232.42422		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.84262	0.97353	3.95	<.0001
controlmaxacday	1	0.10107	0.14217	0.71	0.4777
Cnnld	1	0.27183	0.08469	3.21	0.0015

Toronto Hydro kwh - controlmaxacday cnnld Commercial Snapback Regressions for 23 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	361
Number of Observations Used	319
Number of Observations with Missing Values	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	2585.20573	1292.60286	6.92	0.0011
Error	316	59050	186.86603		
Corrected Total	318	61635			

Root MSE	13.66990	R-Square	0.0419
Dependent Mean	5.79017	Adj R-Sq	0.0359
Coeff Var	236.08790		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	3.78913	0.94575	4.01	<.0001
controlmaxacday	1	0.09075	0.13812	0.66	0.5116
Cnnld	1	0.24611	0.08227	2.99	0.0030

Toronto Hydro kwh - controlmaxacday cnnld Commercial Snapback Regressions for 24 hour for 30 + Degrees

The REG Procedure
Model: MODEL1
Dependent Variable: kwh

Number of Observations Read	296
Number of Observations Used	254
Number of Observations with Missing Values	42

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	2561.20363	1280.60182	7.00	0.0011
Error	251	45893	182.84143		
Corrected Total	253	48454			

Root MSE	13.52189	R-Square	0.0529
Dependent Mean	4.93098	Adj R-Sq	0.0453
Coeff Var	274.22299		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr > |t|
Intercept	1	2.75199	1.03424	2.66	0.0083
controlmaxacday	1	0.07338	0.14019	0.52	0.6011
Cnnld	1	0.26501	0.08767	3.02	0.0028

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 6
Schedule 9
Appendix F
Filed: 2011 Apr 1
(67 pages)

Energy Efficiency Research in Corporate Real Estate

Charrette Meeting Report
August 1, 2006

Rocky Mountain Institute
1215 Spruce Street, Suite 301
Boulder, CO 80302
303.449.5226 p

Issued August 17, 2006

CoreNet Global
260 Peachtree St. NW, Suite 1500
Atlanta, GA 30303
404.589.3200 p

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EXECUTIVE SUMMARY

On August 1st, CoreNet Global hosted the first of two advisory team meetings in its Atlanta offices. Approximately half of the 30-member advisory team was in attendance or joined in by conference call.

After an introductory presentation by Greg Franta that highlighted project goals, Eric Bowles facilitated a discussion of key supply-chain participants (see Appendix G). Real-estate developers, architects, business unit managers, corporate policy makers, finance/tax departments, facility/building managers, and corporate facility departments emerged as the key participants.

Approximately 70 barriers and over 60 enablers were identified during the morning and afternoon discussions. Noted barriers were quite diverse spotlighting challenges in all phases of a project from inception to operation. Enablers were similarly original ranging from the creation of new energy benchmarking databases to the launch of CEO-inspired energy initiatives. The barriers and enablers that received the most attention during the discussion include the following:

HIGH PRIORITY BARRIERS:

- Lack of clearly stated energy-related goals by CEO/corporate leadership
- Too much focus exclusively on $/sf
- Lack of integrated design
- Lack of training/retraining for building/facility managers

HIGH PRIORITY ENABLERS:

- Hold goal-setting session with owner
- Host facilities maintenance staff conventions (maintenance staff convene to observe a single building and determine how it can be improved – they then return to their own facilities and make improvements)
- Encourage pre-lease energy audits – link efficiency improvements to TI work
- Provide comprehensive O&M training (supply DVDs)
- Create a building benchmarking database (data allowing companies to know "where they stand" compared to competitors)

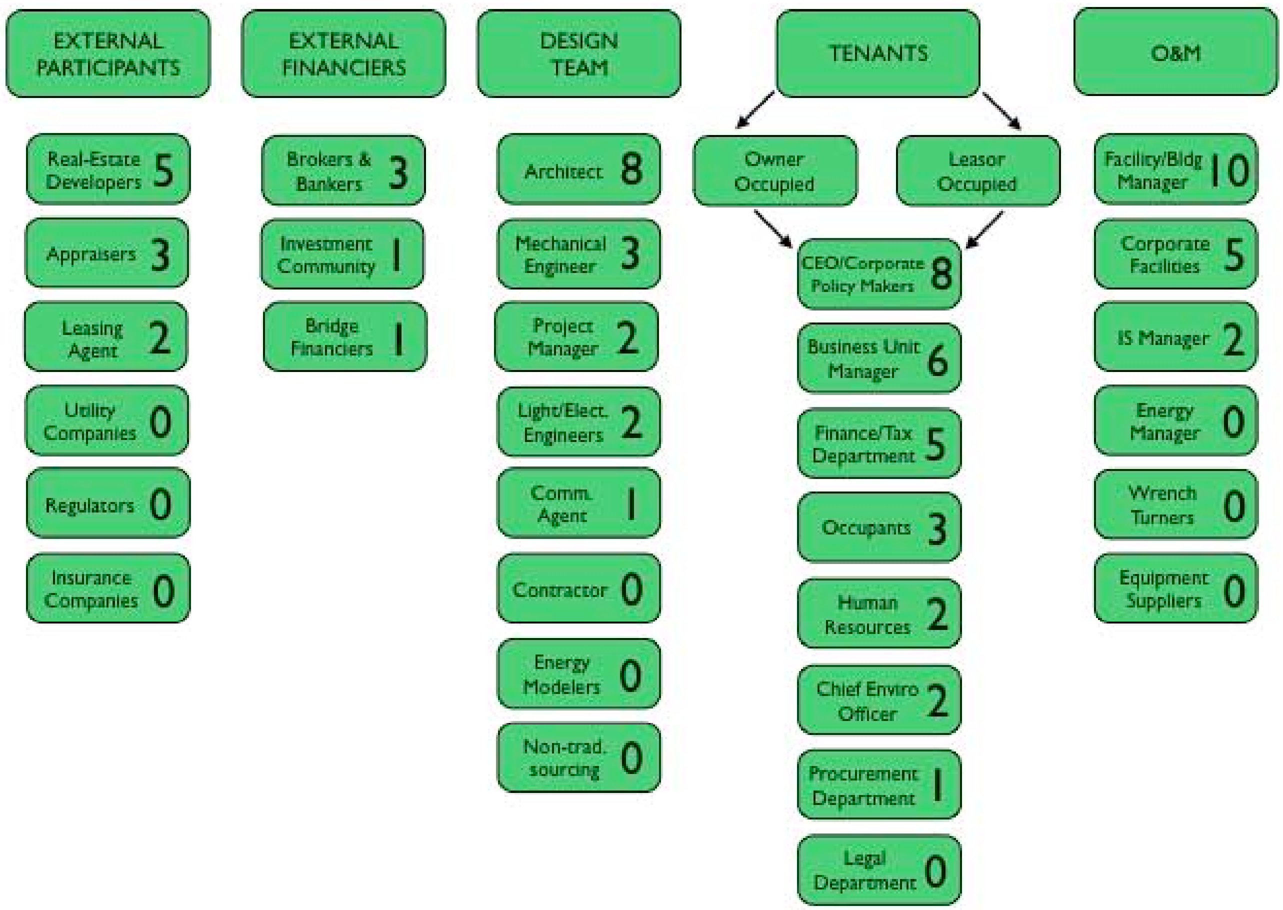
During the case study discussion, several specific projects were identified as either potential case studies or "sidebar" candidates (see pages 17-19). Numerous attendees noted they would like additional time to sort through potential projects.

The information collected during this meeting will form the basis for the upcoming survey/s to be completed by mid-August. The Zoomerang survey/s will be administered to CoreNet member companies and will take no longer than 15 minutes to complete.

The next advisory team conference call will be Tuesday, September 12th at 11am EST.

IDENTIFICATION OF SUPPLY-CHAIN PARTICIPANTS

Supply-chain participants coordinate the implementation of energy-efficiency measures. They are responsible for generating and executing great ideas. Identifying the key players in the building supply-chain is essential in order to discern which participants are best positioned to spark change. The diagram below illustrates the outcome of the supply-chain participant discussion. Each charrette attendee was given 6 dots to place on their highest priority participant – the numbers represent the number of dots each supply-chain participant received.



Based on the responses, it is evident that a few participants seem to be particularly important in the quest for energy efficiency in corporate real estate. These participants range from real-estate developers and architects to corporate policy makers and building managers. While these participants elicited the greatest interest from charrette attendees, the above figure clearly illustrates/shows that the discussion involving energy efficiency investments impacts a wide-ranging group of stakeholders, both internal and external to a corporation.

DISCUSSION OF BARRIERS

Barriers, by definition, stand in the way of achieving a desired outcome. Our purpose here was to identify barriers standing in the way of realizing greater energy efficiency in corporate office and warehouse facilities. As in the discussion of supply-chain participants, each meeting attendee was given dots to prioritize barriers. Furthermore, the barriers (and enablers) were separated into six categories: 1) financial barriers, 2) tenant/occupant barriers, 3) design barriers, 4) construction/o&m barriers, 5) metrics/other barriers, and 6) attitudinal barriers.

VOTES	FINANCIAL BARRIERS
9	Focus exclusively on $/sf
5	Cannot quantify value of energy-efficiency measures
5	Appraisal/market value of buildings does not include energy-efficiency
4	Short-term leases discourage energy investments
4	Split incentives between owner/tenant
4	Pass-through expenses
3	Short-term flexibility vs long-term financing
2	Capital budgets vs operating budgets
2	Life-cycle analysis takes time and money
2	Uncertainty and real options are not considered in financial analyses
1	Component by component cost analysis
1	Pays flat rate per sf for energy (predictability of costs valued)
0	Difficult to figure out/analyze benefits of tax credits
0	Gross leases give no incentive for energy investment
0	Capital availability - choosing other investments over energy-efficiency
0	Premium cost for renovations
0	Lack of insurance/tax incentives
0	Lack of utility incentives

VOTES	TENANT/OCCUPANT BARRIERS
2	Takes low bids for design/construction work
1	Too much emphasis on rates rather than on energy use
1	Little in-house energy expertise
0	Occupants not given instructions on how to improve performance
0	Neighbors benefit equally from energy measures you implement
0	No incentive/difficult to obtain internal energy data
0	Knows of few examples of energy-efficient design
0	Lack of corporate knowledge - "will it work for us?"
0	Assumption that "this doesn't apply to me"
0	Multiple workstations and increased mobility

VOTES	DESIGN BARRIERS
8	Lack of integrated design
3	Excessive safety margins instead of better systems monitoring
2	Lack of incentives and performance-based contracts
2	Compressed project schedules
2	Experience level of design team
2	Does not emphasize whole-systems design
1	Percentage or flat-fee contract does not incentivize extra effort
1	Pushes budget and schedule, not goal setting or communication
1	Involves key players too late in the game
1	Paid based on value of deal, not long-term financial performance
1	Oversizes equipment to avoid liability
1	Doesn't build energy model for project
0	Need to customize energy package for each client
0	Leaves sizing of equipment to manufacturers
0	Delegates work to outside consultants
0	Isolating metering is difficult
0	Uses rule-of-thumb design

VOTES	CONSTRUCTION/O&M BARRIERS
3	Lack of training/retraining for building operators
3	Doesn't receive enough training on building systems
3	Paid to make things work, not to make them work efficiently
0	Sunk costs - when should equipment be replaced?
0	Difficult to order/purchase energy-efficient products
0	Availability often dictates equipment or material selection
0	Has inadequate systems monitoring or interfaces

VOTES	METRICS/OTHER BARRIERS
5	No statistics showing after-the-fact energy use versus design capacity
2	Lack of corporate (or industry) best practices for efficiency
2	Timing of information (access to)
1	Few metrics against which to compare energy costs
1	Prescriptive contracts as a result of too few best practices
1	Legislation doesn't push US companies on enviro issues
1	Lack of general knowledge base
0	Building standards - "this is the way we've always done it"
0	Disconnect amongst technical languages
0	Little demand for green buildings
0	Energy is a profit center
0	Technologies change quickly

VOTES	ATTITUDINAL BARRIERS
9	Lack of clearly stated energy-related goals by CEO/corporate leadership
3	Attitude: Lack of leadership, skill, or desire
3	Commissioning process not fully embraced
1	Believe energy-efficiency measures will increase first costs
1	Risk at all steps/fear of failure
1	Risk perception
1	Architect/engineer partnerships not strong enough
0	Single investments vs culture of change (annual energy budget)
0	Complexity and compromises dominate design
0	Value location and aesthetics not energy-efficiency
0	Is unfamiliar with project goals and sensitivities

Several other comments, mentioned during the group's discussion, did not make their way into the above matrices. These include:

- → Energy investments in the US are driven by financial consideration, whereas investments in Europe are driven by sustainability considerations;
- → Information systems restrictions may make it difficult to install energy monitoring or other related software on computer systems;
- → Information technology (IT) personnel create data rooms that are energy intensive; however they resist incorporating energy-efficiency for fear of IT interruptions or data loss;
- → Complexity of market (many different vendors supplying different information) and rapid technological change create a tendency to wait before making energy efficiency investments.

Revisiting Historical Barriers

Following the discussion that focused on the barriers to achieving energy efficiency, Bill Browning facilitated a conversation about the present status of the energy efficiency barriers identified in the 1992 Lovins study, *Energy-Efficient Buildings: Institutional Barriers and Opportunities* (those barriers are outlined in the attached literature review). Statements made during the discussion underscored the progress that has been made regarding energy-efficiency in the real estate industry over the last 14 years.

Financial Barriers

Barrier: Developers are more concerned with minimizing capital cost per square foot of net marketable floorspace, than with maximizing the building's long-term financial performance. Similarly, brokers, mortgage bankers, and investment advisors are rewarded based on the original project value, not on the building's long-term financial performance.
Current Status: There is no current evidence that developers are seeking improved long-term financial performance resulting from incorporating energy efficiency measures. Furthermore, brokers, mortgage bankers, and investment advisors are not being rewarded for incorporating energy efficiency measures in current building projects. DTZ has a recent study in the UK that points out the likelihood of the new building rating system impacting property values.

Barrier: The additional value of energy-efficient commercial buildings is rarely reflected in the appraisal process, security ratings, or market value. Often, emphasis is placed solely on market conditions, aesthetics, and location – low operating costs or innovative technologies are rarely highlighted.
Current Status: HOK is working with developers who have witnessed lease rates increase and timing between turnover of lessors decline for buildings that incorporate energy efficiency; however, the appraisal process still does not reflect the benefits of energy efficiency. One issue identified by participants is that there is some subjectivity in the performance of energy efficiency measures unless the LEED rating system is used. In the UK, it is likely that all buildings will be soon be rated for energy efficiency.

Barrier: The concept that capital cost can be reduced through thoughtfully designed building systems seems far-fetched.
Current Status: The group agreed that education and evidence are required to convince decision makers that capital costs can actually be reduced by implementing/employing thoughtful design practices. Furthermore, collective experience suggests that decision makers remain unconvinced. One participant questioned how many corporations truly understand LEED-inspired building design and construction. In their evaluation of energy efficiency and LEED practices, most companies use cash flow analyses. Some companies use an Internal Rate of Return (IRR) metric; however, few analyses incorporate discount rates or tiered rates. There is also little evidence that firms are considering uncertainty or the probability of changes. The group noted that many executives believe that something better has to cost more. Thus, even if an investment that incorporates energy efficiency costs less, it still may require a rigorous body of evidence to convince decision makers.

Barrier: There is rarely a local average energy bill against which to compare your building's bill, due to relatively few commercial-sector "truth-in-renting" energy-disclosure rules.
Current Status: BOMA publishes energy cost data per sq. ft., but it is unclear if this data is widely known or used by corporations. Energy star target finder is a tool also used by corporations to benchmark energy performance, but it is often difficult to do energy use, benchmarking, particularly for industrial warehouse facilities. The multitude of space uses and configurations renders some benchmarking numbers irrelevant, creating cases where time-series benchmarking may be the most appropriate measure, especially if production output can also be included in the analysis.

Barrier: "Many commercial leases, too, are still written on a 'gross' basis (*i.e.*, they include energy and other operating costs in a total rent figure), giving the tenant no incentive to save even though the landlord could in principle keep the saving. 'Net' leases reverse this problem to the extent that energy cost components typically for lights and plug loads but sometimes also for space-conditioning, are individually metered and billed. *Neither lease form, as conventionally written, gives both parties an appropriate incentive to save."*
Current Status: This issue remains problematic and is particularly important if energy efficiency measures are to be incorporated in leased spaces. There are, however, fewer commercial leases that are written on a 'gross' basis, these days.

<u>Design-related Barriers:</u>

Barrier: To avoid liability, designers often round up equipment sizes or rely on advice from manufacturers creating ridiculous safety margins (as great as tenfold) – often without performing models to verify performance.
Current Status: Although the safety margin may have declined over the years, the use of a safety margin for equipment size is still common practice unless challenged. Right-sized equipment design based on performance models remain an elusive goal on a large number of projects and design teams.

Barrier: Furthermore, percentage-of-cost contracts reward oversizing of equipment. "Designers who do extra work to design and size innovative HVAC systems exactly right, thereby cutting their clients' capital and operating costs, are directly penalized by lower fees and profits as a result, in two different ways: they are getting the same percentage of a smaller cost, *and* they are doing more work for that smaller fee, hence incurring higher costs and retaining less profit."
Current Status: Although some firms are paid for hourly work or provided a lump sum amount (e.g., HOK), many firms continue to receive compensation based on a percentage-of-cost method. The percentage-of-cost contract leads to the replication and slight modification of old design projects.

Barrier: A single entity rarely takes responsibility for ensuring designers communicate to create an integrated design.
Current Status: Different fee structures, perspectives, and technical languages inhibit interaction between designers; however, a shift toward integrated design is starting to happen.

Barrier: Most architects lack the time and knowledge to check the engineers' work for maximal energy efficiency.
Current Status: Most architects do not possess the education required to assure that the project's engineers are designing for maximum energy efficiency. While the architect may not be able to perform this role, a commissioning agent may be willing to challenge the engineer. This is also probably more beneficial, given that the best practice would be for a commissioning agent to be an owner's representative, not typically hired as part of the design team. Further limiting the ability to verify the engineer's work; following the completion of construction, it would be costly to look at costs of running the building, particularly because the building is not fully occupied just after construction. These circumstances create a situation where the engineer may add in a safety margin and "fudge" numbers so they resemble more closely the sizing requirements set forth in the design. The mechanical engineer is typically risk averse and oversizing equipment reduces liability. There is no easy way to determine if systems are oversized. It is more important to hit the ventilation targets than it is to assure the sizing and energy efficiency demands are met. One mechanism that may keep the engineers in line with the project's energy efficiency goals is the allure of future business with the architect and the client.

Barrier: Mechanical designers are brought on too late in the project, when the most critical decisions have already been made.
Current Status: This barrier may be shifting; the group agreed that MEP engineers and energy modelers are being brought onto projects earlier in the design process.

Barrier: Time-pressed superiors, as well as code officials, would rather approve safe and familiar designs. The U.S. Office of Technology Assessment summarizes: "It is usually easier for the designer to follow accepted, standard practice, especially if the designer's fee is the same in either case. And as one interviewee said, 'The path of least resistance does not include energy innovative design.'"
Current Status: Participants noted evidence from the adoption of LEED and construction in Chicago that this barrier may be changing. Furthermore, in some areas like San Francisco the approval process for LEED buildings is pushed to the front of the line.

Barrier: Price competition between engineers encourages fast and easy "catalog engineering," which is hardly engineering, but "only the application of crude and outmoded rules-of-thumb to selecting common listings from major vendors' catalogs. *This procedure is at the root of today's appallingly low mechanical-system efficiencies.*"
Current Status: The use of "catalog engineering" remains prevalent. Representatives from several firms that sell energy efficient equipment noted their motivations to sell up front value in energy efficiency measures into marketplace. While the catalog may be getting better, the acceptance of using this catalog hasn't changed.

<u>Construction-related Barriers:</u>

Barrier: Equipment availability sometimes dictates selection – whatever "equivalent" (usually in terms of capacity, not energy efficiency) pump or duct is handy may be installed.
Current Status: Currently, equipment choice is better, but this situation still happens. A shift occurs when a client/team is willing to wait for the right equipment, or when the contractor's experience leads to earlier equipment requests.

Barrier: Suppliers can be reluctant to sell new products – for example, "people who use imaging specular reflectors buy only half as many fluorescent lamps to go under them, so vendors may discourage competing products that save customers' dollars and energy at the expense of their own sales."
Current Status: This point has changed a lot with the proliferation of green products.

Barrier: The commissioning team is rarely rewarded for the initial building performance or for how well the building operators understand the building systems.
Current Status: The commissioning process is not fully embraced everywhere; it is a cost that people have a hard time accepting. Time pressure may also account for a reluctance to embrace/implement the process.

<u>O&M-related Barriers:</u>

Barrier: Building operators are usually poorly trained and tend to disable equipment or features they don't understand. Also, monitoring equipment is rarely installed, thus creating a barrier to measuring actual building performance against intended building performance or warranty-related specifications. Furthermore, confusing building interfaces make it difficult for operators to understand, let alone optimize, building performance.
Current Status: This occurrence has not changed over the years. The number one issue at the facilities run by one charrette participant has been "how to get the operators to run the building as it is supposed to". Not all building operators operate the building efficiently, and there is a dearth of documentation surrounding how the building should be operated.

Barrier: Building operators may never even see meter readings or utility bills.
Current Status: Some occupants receive meter data; however, even if these data are received, there is often a time lag. Real time monitoring is expensive. Often, whoever sees the accounts payable is the default energy manager simply because they pay the bills. There are few incentives for those individuals who receive usage data to actually take action.

Barrier: Tenants are seldom given instructions as to how they can positively influence building performance.
Current Status: This issue remains true.

Barrier: Commercial building operators are mostly concerned with occupant comfort and minimizing complaints.
Current Status: This issue remains true.

Barrier: There is little feedback to real-estate developers regarding occupant satisfaction – "The building industry is in this sense quite primitive: we would not dream of running a manufacturing business with so little and oblique contact with our customers, and if we tried to, we'd soon be out of business. But that is what the building industry tries to do with its complete disjunction of design, manufacturing, marketing, sales, delivery, repair, and renovation or demolition."
Current Status: This issue may be changing, developers are increasing efforts to communicate with their tenants, and roll-over vacancy is now a bigger issue.

Tenant-related Barriers:

Barrier: Few commercial tenants are familiar with energy efficiency. "Notable exceptions exist: in Sydney, Australia, it has become fashionable to compete on how efficient and 'smart' one's office building is, and many tenants ask penetrating questions about details of design and efficiency down to the component level."
Current Status: While tenant familiarity with energy efficiency remains a barrier, engaging and informing tenants about energy efficiency presents a big opportunity. Issues that must be addressed include: comparability of energy efficiency measures, shorter lease terms that make energy efficiency investments with a payback of more than two years unattractive, the predominance of gross leases eliminate incentives for energy efficiency, and the perception of a tenant mind-space issue – tenants have no mind space for energy efficiency because they are focused on their jobs and lessees don't want to require them to think about peripheral things.

Barrier: There are many misunderstandings regarding energy efficiency; retail managers treat energy bills as "immutable as death and taxes." Furthermore, "A survey of small businesses found that energy efficiency was thought to require turning down heat or turning off lights."
Current Status: As rates increase, these misunderstandings are being revisited; however, there is still room for major improvement in this area.

DISCUSSION OF ENABLERS TO OVERCOME OR REMOVE BARRIERS

An enabler is a tool or instrument used to accomplish a task or implement a process. Numerous enablers were identified to overcome barriers identified during the morning session. As in previous sessions, the enablers are grouped and prioritized.

VOTES	FINANCIAL ENABLERS
4	Whole-system life-cycle cost analysis
3	Actually use life-cycle analysis tools
2	Data on comparative costs of energy-efficient buildings
2	Federal, state, and local tax credits and/or energy modeling subsidies
2	Create visibility for energy costs in leases
2	Shared development of financial models for energy investments
1	Green REITS (real estate investment trusts)
0	Use track record of operating costs to encourage appraisers to incorporate energy efficiency
0	Dow Jones Sustainability Index
0	Sell PR value of energy-efficiency measures
0	Monetize financial energy benefits

VOTES	TENANT/OCCUPANT ENABLERS
6	Pre-lease audits linked to Tenant Improvement (TI) phase energy improvements
2	Pay energy costs per metered amount
1	Occupant/tenant user manual for space
1	Score each building in portfolio and hold one individual accountable
0	Gather historical data on energy use before signing lease
0	Quantify/get data on improved productivity
0	Demand energy audits for newly leased spaces
0	Create lease guidelines for energy-efficiency

VOTES	DESIGN ENABLERS
3	Hold a charrette early on
3	Publish summaries/mechanisms for performance-based (PB) fees
2	At risk contracts; contractor PB fees; bonuses
2	Let green projects go to the front of the approval line
2	Identify keys to integrated design process early on
1	Create baseline to compare to design case
1	Bring MEP modelers in early on
1	Provide/Develop a toolkit of design resources (or design and resources toolkit)
0	Make contracts reflect time expenditures during design

VOTES	CONSTRUCTION / O&M ENABLERS
6	"Wrench-turner" convention
4	Provide comprehensive O&M training (supply owners with DVDs)
3	Replacement cycle decisions
2	Demand and capture energy data
2	DVD systems manual
1	Provide scientific/diagnostic training to empower facilities maintenance staff
1	Commission building on seasonal or annual basis
1	Pilot studies on non "no-brainer" upgrades to convince business owners
0	Establish/provide an internal energy checklist by business unit
0	Require report on commissioning avoided-cost data
0	Set equipment to reflect actual use schedule
0	Recommission building to reflect changes in use

VOTES	METRICS / OTHER ENABLERS
3	Collect before and after data by measure completed
2	Create a building benchmarking database
1	Mandate certain data to be part of leases (building "nutrition sticker")
0	Create building ranking system within industry
0	Develop sustainable product standards
0	Prorate multi-use space by sf
0	Motivate changes in classification of buildings (class "A")
0	Developers/brokers distribute flyers to potential tenants on green features

VOTES	ATTITUDINAL ENABLERS
5	Hold goal-setting session with owner
4	Involve entire company in mission-oriented energy program
4	Develop internal enviro metrics (energy savings and emissions)
4	Provide media (videos) to excite decision makers about green building
3	Link financial rewards (for employees) to energy measures
3	Interview CEO's to find out what motivated their environmental agenda
0	Develop standard company metrics for energy-efficiency
0	Develop more award programs for green buildings
0	Develop strategic peer pressure presentations
0	Enhance recognition of green projects
0	Quantify benefits of greater employee retention
0	Leverage competition over environmental goals (Toyota vs Honda)

CASE STUDY GOALS AND PROJECT SUGGESTIONS

A series of case studies will be used in the final report to highlight proven strategies used to overcome distinct barriers. These case studies will be selected from a range of industries and represent different levels of energy efficiency. It was decided that projects chosen for case studies must be completed and operational. Also, to better substantiate the business case, it would be helpful if selected projects had at least one year of M&V data available.

Before diving into potential projects for the case studies, the group brainstormed other items that could be included in case studies or used as "sidebars" in the final report.

→ Example of a "sustainable" lease

→ Example of an RFP that includes energy-efficient mechanisms

→ A focus on United Technologies Corporation's integrated building control center

→ A discussion of motivation triggers – what prompts a CEO to initiate a company-wide energy program . . . perhaps interview CEO's from Bank of America, Wal-mart, GE, UTC, Toyota, etc. to find out – publish these interviews to put pressure on CEO's who haven't yet focused on, or made policy statements regarding energy-efficiency

→ A comparison of business units within a particular company where one unit is making great strides in energy-efficiency and another is not

→ A discussion of the Dow Jones Sustainability Index and how it (and other indices, e.g., the FTSE4Good) are affecting market change

→ A few basic examples of green building design that range from standard to highly energy efficient

→ An investment decision example . . . why an energy-efficiency upgrade in an existing building was made over another investment

→ An integrated design example with M&V data

Following this brainstorm session, the group jumped right into specific project suggestions. It should be noted, however, that the following list of project ideas is by no means comprehensive. Rather, it summarizes ideas that were generated on the spot. Several attendees noted that they would email additional projects at a later time.

CASE STUDY NOMINATIONS

PROJECT NAME	OWNER / DEVELOPER	CEO / INTERVIEW CANDIDATE	LOCATION	DATE COMPLETED	LEED STATUS
PNC Firstside Center	PNC Financial Services Group	Gary Slauson	Pittsburgh, PA	2001	LEED NC Silver
Anixter distribution warehouse	Anixter Inc.	Robert W. Grubbs Jr.	Alsip, Ill	2004	LEED NC Certified
One Bryant Park	Bank of America	Mark Nichols	New York City, NY	2008	LEED NC Platinum
Toyota Portland Vehicle Distribution Center	Toyota Motor Sales, U.S.A., Inc.	?	Portland, OR	2005	LEED NC Gold
California Department of Education	CA Department of General Services	?	Sacramento, CA	2006	LEED EB Platinum
Missouri Department of Natural Resources	MO Department of Natural Resources	?	Jefferson City, MO	2005	LEED NC Platinum
Four Times Square	Durst Organization	?	New York City, NY	1998	-
ABN AMRO Bank Head Office	ABN AMRO	?	Amsterdam, The Netherlands	1999	-
HSBC Corporate Building	HSBC Bank	?	Mexico City, Mexico	2006	LEED NC Certified
Interface Showroom and Offices	Interface	Ray Anderson	Atlanta, GA	2004	LEED CI Pilot Platinum
Brengel Technology Center	Johnson Controls	John M. Barth	Milwaukee, WI	2004	LEED EB Gold

Other projects or companies mentioned include BP, VeriFone, Patagonia, SC Johnson, Wal-Mart, a UK multi-tenant project (architects: HOK), a LEED platinum office building in India, and a Phoenix call center (architects: HOK). Comments or clarifications on the above (or any additional) projects can be provided to Aalok Deshmukh and Eric Maurer of RMI (adeshmukh@rmi.org, emaurer@rmi.org).

NEXT STEPS

This charrette forms a basis from which to develop and implement the upcoming survey. The survey will be administered to CoreNet member companies and will take no longer than 15 minutes to complete – Eric Bowles noted that he fully expects a 60-70% response rate based on other invitation-only surveys he has administered. Prior to launching the actual survey, a pilot survey will be given to a select group to ensure responses provide useful data.

The survey content will be based on information gathered during the meeting and subsequent comments regarding this report. Specifically, several issues need to be addressed:

1) Should we create several different surveys aimed at different supply-chain participants?
2) How will we differentiate between owner-occupied buildings and non-owner-occupied buildings?

Further, case studies need to be identified and selected. Additional projects that highlight specific barriers and how they were overcome should be brought to the attention of Aalok Deshmukh and Eric Maurer of the RMI project team (please email to adeshmukh@rmi.org, emaurer@rmi.org).

Lastly, the final report will also include sidebars that illustrate unique energy efficiency practices or provide examples of numerous new energy efficient projects that are in the design or construction phase, and incorporate energy efficiency measures. For example, the report may highlight the steps taken during the design phase to incorporate energy-efficiency into a large, mixed-use development in Beijing's Feng Tai district. Ideas for these sidebars should be directed to Aalok Deshmukh and Eric Maurer of the RMI project team (adeshmukh@rmi.org, emaurer@rmi.org).

Appendices

Appendix A: Charrette Agenda

Energy Efficiency Research in Corporate Real Estate (EERCRE)
CoreNet Global & Rocky Mountain Institute
Tuesday, August 1st, 2006: 9am – 5pm

Project Goals:
Ultimately, this project will serve as a resource for corporate tenants to understand and remove barriers to achieving greater energy efficiency. The final report will provide them with an understanding of what the barriers are and how they can be removed. Additionally, case studies will provide examples of energy efficient buildings that have overcome the stated barriers.

Charrette Goals:

1) Define critical supply-chain participants
2) Outline barriers experienced by each supply-chain participant
3) Suggest methods to overcome or remove these barriers
4) Identify case studies to be used as model success stories

Introduction: Welcome remarks from CoreNet and RMI

Morning Session: Defining barriers from a Corporate Tenant's Perspective
This session will focus on defining barriers from a corporate tenant's perspective. Given that this report will serve as a tool for corporate tenants, what barriers to energy efficiency do tenants experience during the design, construction, and operation of buildings?

12:30pm Lunch Session: Case Studies

Afternoon Session: Creating powerful case studies and brainstorming solutions to barriers
A brainstorming session will provide possible case study candidates. Following the focus on case studies, the participants will be placed into small groups to discuss how barriers identified during the morning session can be overcome.

Recap: A brief description of the day's events followed by steps to be taken in the upcoming months.

APPENDIX B: PROJECT ADVISORY TEAM MEMBERS

NAME	COMPANY	POSITION	PHONE	EMAIL
Eric Bowles	CoreNet Global	Director, Global Research	404-589-3231	ebowles@corenetglobal.org
Ron Adams	CoreNet Global		44 1428 651140	Radam@corenetglobal.org
Greg Franta	RMI	FAIA, Principal & Team Leader	303-449-5226	gfranta@rmi.org
Aalok Deshmukh	RMI	Sustainable Design Consultant	303-449-5226	adeshmukh@rmi.org
Eric Maurer	RMI	Intern	303-449-5226	emaurer@rmi.org
Caroline Fluhrer	RMI	Intern	303-449-5226	cfluhrer@rmi.org
Bill Browning	Browning & Bannon LLC	Partner	202-470-0401	bill@browningplusbannon.com
Bill Frain	Staubach	Principal	312-245-5020	bill.frain@staubach.com
Jim Cooke	Toyota	AIA, Real Estate & Facilities	502-867-4622	jim_cooke@toyota.com
Tim Frank	Toyota	PE, Field Operations Manager	330-498-0609	tim_frank@toyota.com
Kelly Speakes	UTC Power	Sustainable Strategies Leader	860-727-2375	kelly.speakes@utcpower.com
Mary Ann Lazarus	HOK	Senior Vice President	314-754-3927	mary.ann.lazarus@hok.com
Mike Harris	Johnson Controls	Vice President, Energy Services	414-524-5450	michael.harris@jci.com
Brenna Walraven	USAA Realty Company	Executive Director	949-442-7700	brenna.walraven@usaa.com
Mukesh Khattar	Oracle	Energy Director	650-506-6980	Mukesh.Khattar@oracle.com
John Schinter	Jones Lang LaSalle			John.Schinter@am.jll.com
Chris Owens	Microsoft			chrisow@microsoft.com
Keith Tabacek	Sun Microsystems			keith.tabacek@sun.com
Stephen Smith	UK ABN AMRO			stephen.c.smith@uk.abnamro.com
Timo Salonen	Nokia	Electrical and IT Solutions Manager	358-40-042-3938	Timo.M.Salonen@nokia.com
Mia Ranta-aho	Nokia	Environmental Solutions Manager	358-50-383-9490	mia.ranta-aho@nokia.com
Joe Wick	Cushman & Wakefield	Managing Director	212-709-0767	Joe.Wick@cushwake.com
Bill Sisson	United Technologies	Director, Sustainability	860-610-7317	sissonwm@utrc.utc.com
Gary Jensen	Ford Motors	Senior Architect-Planner	313-220-7928	gjensen@ford.com
Andy Bray	Johnson Controls	Head of Energy Services, EMEA	01252-451000	andrew.bray@jci.com
Kevin Oakes	Motorola	Sr. Manager of Strategic Sourcing	847-576-1092	kevinoakes@motorola.com
Pat Crumley	Staubach			Pat.Crumley@Staubach.com
Brad Hancock	Dept. of Defense			Brad.Hancock@osd.mil
Nick Axford	CB Richard Ellis Ltd	Head of EMEA Research & Consulting	44-020-71823039	nick.axford@cbre.com

* Indicates attendance at meeting; ** Indicates participation via conference call

APPENDIX C: ROCKY MOUNTAIN INSTITUTE PROJECT TEAM

Greg Franta, FAIA
Principal Architect and Team Leader

From 1981 to 2005, Mr. Franta led ENSAR Group in providing services on more than 800 energy efficient and environmentally sound projects, including offices, laboratories, educational buildings, health facilities, libraries, homes (including the White House), and other buildings—many considered the most energy efficient in the United States. Mr. Franta's work is widely recognized and he is the recipient of the 1998 AIA Colorado Architect of the Year Award. He has served on the National Board of Directors for the American Institute of Architects and is a co-founder (past Chairman) of the AIA Committee on the Environment. He participated in the development of the U.S. Green Building Council's LEED program; he is a LEED Accredited Professional, LEED trainer for USGBC, and part of the LEED certification team for the USGBC. Greg is coordinating RMI's research efforts for the RMI/CoreNet project. *Contact information: Tel: 303-449-5226; email: gfranta@rmi.org*.

Bill Browning, HAIA
Senior Fellow

Mr. Browning had key roles in creating both the U.S. Green Building Council and its LEED™ rating system, and is active on the USGBC Board and LEED committees. He is currently a Senior Fellow at Rocky Mountain Institute, a partner in a new green development consulting firm, Browning Partners LLC, also in Browning + Bannon LLC and formerly a principal in Haymount, a green new-town development in Virginia. Mr. Browning led the greening of the White House, and has consulted on more than 300 green development projects worldwide. Mr. Browning lectures extensively throughout the world. His books include *A Primer on Sustainable Building*, and the groundbreaking text *Green Development: Integrating Ecology and Real Estate*. He co-authored the influential *Greening the Building and the Bottom Line: Increasing Productivity through Energy-Efficient Design*, which presented a new economic case for green design in the workplace based on higher worker productivity, lower absenteeism, fewer errors, better quality, and increased sales. Bill is serving as an advisor to the RMI/CoreNet team. *Contact information: email: bill@browningplusbannon.com.*

Aalok Deshmukh
Sustainable Design Consultant

Aalok has experience using a variety of building simulation tools, including energy simulation and computational fluid dynamics tools. He has experience in building commissioning, retro-commissioning, energy auditing, building energy analysis, and sustainable consulting. He has a master's degree in building design with an emphasis in energy and climate from Arizona State University. He is a LEED Accredited Professional, a part of the LEED project certification review team for the

USGBC and a licensed architect in India. He has a keen interest in the development and application of appropriate technologies, standards, and rating systems as they pertain to energy use and the environmental impact of buildings—in both India and the developing world in general. Aalok is leading RMI's research efforts in identifying barriers to energy efficiency in corporate real estate and formulating strategies to overcome these barriers. *Contact information: Tel: 303-449-5226; email: ADeshmukh@rmi.org.*

Eric Maurer
Stanback Fellow – Duke University

After receiving an undergraduate degree in finance from Miami University, Eric spent three years working for the Investor Responsibility Research Center (IRRC). At IRRC, he assessed the social and environmental performance of US corporations for their inclusion in the FTSE4Good investment index. Following this experience, Eric began pursuing a Master of Environmental Management degree at Duke University. Prior to returning to Duke to complete his degree, Eric is applying his experience in survey design and implementation to a number of projects within RMI. Eric is providing research support and lending his expertise in survey design and implementation for the RMI/CoreNet project. *Contact information: Tel: 303-449-5226; e-mail: emaurer@rmi.org.*

Caroline Fluhrer
MAP Fellow – Stanford University

Caroline recently graduated from Stanford with an undergraduate degree in Civil Engineering and a Master's degree focused on Energy Engineering. As a graduate student, she served as a teaching assistant for Energy Efficient Building and Renewable Energy & Power courses. During her summers, she has spent time at structural engineering, construction, and civil engineering firms as well as studied abroad at Oxford University. At RMI, Caroline's work thus far has focused on factor-10 engineering, integrated design, and making the business case for green building. For the RMI/CoreNet project, Caroline is providing research support and technical expertise. *Contact information: Tel: 303-449-5226; e-mail: cfluhrer@rmi.org.*

APPENDIX D: PLATINUM & GOLD LEED PROJECT LIST

LEED New Construction

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Alberici Corporate Headquarters	Alberici Corporation	US	Plat.	110,000	8-Jul-05	Commercial Office	Profit
Artists for Humanity EpiCenter	Artists For Humanity	US	Plat.	23,500	13-Oct-05	Multi Use	Nonprofit
Audubon Center at Debs Park	Audubon Society	US	Plat.	5,000	11-Dec-03	Interpretive Center	Nonprofit
Center for Neighborhood Technology	Center for Neighborhood Technology	US	Plat.	13,800	22-Nov-05	Commercial Office	Nonprofit
CII-Sohrabji Godrej Green Business Centre	Confederation of Indian Industry	IN	Plat.	17,000	31-Oct-03	Commercial Office	Nonprofit
Donald Bren School of Env. Sci. & Management	University of California, Santa Barbara	US	Plat.	85,000	18-Apr-02	Higher Edu.	Other
Genzyme Center	Genzyme Corporation/ Lyme Properties	US	Plat.	350,000	23-Aug-05	Commercial Office	Profit
Gurgaon Development Center, Wipro Ltd	Wipro Technologies	IN	Plat.	120,000	12-Aug-05	Other	Profit
Hawaii Gateway Energy Center	Natural Energy Lab of Hawaii Authority (NELHA)	US	Plat.	5,600	12-Dec-05	Multi Use	State
Inland Empire Utilities Agency Administrative Headquarters	Inland Empire Utilities Agency	US	Plat.	33,000	31-Mar-04	Other	Other
ITC CENTRE PROJECT	ITC LIMITED	IN	Plat.	170,000	26-Oct-04	Multi Use	Profit
Lake View Terrace Branch of the L.A. Public Library	City of Los Angeles - L.A. Public Library	US	Plat.	10,700	18-Nov-05	Library	Local
Lewis and Clark State Office Building	Missouri Department of Natural Resources	US	Plat.	120,000	13-Mar-06	Commercial Office	State
NRDC So. California Office, Robert Redford Building	NRDC	US	Plat.	15,000	12-Nov-04	Commercial Office	Nonprofit

LEED New Construction							
Project Name	**Owner**	**Country**	**Rating**	**Sq.Ft.**	**Cert. Date**	**Project type**	**Owner Type**
Phillip Merrill Environmental Center	Chesapeake Bay Foundation	US	Plat.	30,600	30-Mar-00	Commercial Office	Nonprofit
The Chicago Center for Green Technology	City of Chicago Dept. of the Environment	US	Plat.	32,000	17-Jun-03	Multi Use	Local
Big-D Corporate Office Headquarters	Big-D Corporation	US	Gold	70,000	13-Mar-06	Commercial Office	Profit
Building 10	Honda R&D Americas, Inc.	US	Gold	15,100	20-Apr-06	Industrial	Profit
Calvin College Bunker Interpretive Center	Calvin College	US	Gold	5,270	10-May-05	Multi Use	Nonprofit
Cambria Office Building	PA Department of the Environment	US	Gold	36,000	03-Dec-01	Commercial Office	State
Cambridge City Hall Annex	City of Cambridge	US	Gold	32,000	1-Sep-05	Commercial Office	Local
Camp Aldersgate Commons	Camp Aldersgate	US	Gold	12,000	15-Jun-05	Multi Use	Nonprofit
Capitol Area East End Complex, Block 225	State of California Dept. of General Services	US	Gold	479,000	10-Jan-03	Commercial Office	State
Carkeek Park Environmental Learning Center	City of Seattle, Dept. of Parks & Recreation	US	Gold	1,700	03-Nov-03	Interpretive Center	Local
Carl T. Curtis Midwest Regional Headquarters Bldg	Noddle Development Company	US	Gold	68,000	5-May-05	Multi Use	Profit
Case Middle School, Punahou School	Punahou School	US	Gold	85,000	26-Jun-06	K-12 Education	Nonprofit
Cedar Water Treatment Facility	Seattle Public Utilities	US	Gold	5,600	31-Jan-06	Industrial	Local
Clean Water Services Administrative Offices	Clean Water Services	US	Gold	29,600	31-Aug-05	Commercial Office	Profit
Clearview Elementary School	Hanover Public School District	US	Gold	43,000	24-Mar-04	K-12 Education	Local
Colorado Court	Community Corporation of Santa Monica	US	Gold	30,200	6-Jan-05	Community	Profit
Conard Env. Research Area (CERA) Env. Education Center	Grinnell College	US	Gold	7,400	9-May-06	Higher Edu.	Other

LEED New Construction							
Project Name	**Owner**	**Country**	**Rating**	**Sq.Ft.**	**Cert. Date**	**Project type**	**Owner Type**
David L. Lawrence Convention Center	Sports & Exhibition Authority	US	Gold	1,486,000	07-Nov-03	Assembly	Local
DEP California Office Building	MBC Properties	US	Gold	21,200	22-Jun-04	Commercial Office	Profit
DEP Southeast Regional Office Building	Vision Properties, LLC	US	Gold	111,700	30-Mar-05	Commercial Office	Profit
Doug and Darcy Orr Cottage	Warren Wilson College	US	Gold	6,800	29-Jun-06	Higher Edu.	Nonprofit
Douglas B. Gardner '83 Integrated Athletic Center	Haverford College	US	Gold	101,000	18-Apr-06	Higher Edu.	Other
Doyle Conservation Center	The Trustees of Reservations	US	Gold	14,100	26-Jun-06	Interpretive Center	Nonprofit
Edmonton Police Service - Southeast Division Station	City of Edmonton	Canada	Gold	48,944	18-Jan-06	Public order/safety	Local
Energy Efficiency Demonstration Project of Ministry of Sci. & Tech.	Ministry of Science and Technology	CN	Gold	139,000	19-Jul-05	Commercial Office	Federal
EPA Science and Technology Center	Kansas EPA Lab, LLC	US	Gold	72,100	04-Aug-03	Lab	Indiv.
Escalante Science Center	USDI, Bureau of Land Management	US	Gold	13,225	15-May-06	Multi Use	Federal
Far Southeast Austin EMS Station # 28	City of Austin	US	Gold		13-Jul-05	Public order/safety	Local
Ford Rouge Visitor Center	Ford Motor Company	US	Gold	31,200	05-Jun-03	Interpretive Center	Profit
French Wing Additon to Conservation Center	SPNHF	US	Gold	11,132	10-Mar-03	Commercial Office	Nonprofit
Frito-Lay Jim Rich Service Center	Frito-Lay, Inc.	US	Gold	40,900	17-May-05	Multi Use	Profit
George L. Stevens Senior Center	City of San Diego	US	Gold	11,000	26-Apr-06	Other	Local
GM Lansing Delta Township Assembly Plant	General Motors Corporation	US	Gold	1,500,000	30-Jun-06	Industrial	Nonprofit

LEED New Construction

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Green Operations Building	Corporation of the City of White Rock	CA	Gold	6,785	25-Jul-03	Industrial	Local
Grundfos Pumps India	Grundfos Pumps India Pvt Ltd.,	IN	Gold	25,000	10-May-05	Other	Other
Happy Feet Plus, Inc.	Happy Feet Plus	US	Gold	6,000	15-Oct-04	Retail	Profit
Hayward Building Systems Plant	Hayward Building Systems	US	Gold	43,000	28-Jan-04	Multi Use	Profit
Hensley Field Operations Center	City of Dallas	US	Gold	80,000	22-Nov-05	Multi Use	Local
Herman Miller C1 Main Site	Herman Miller, Inc.	US	Gold	19,076	18-Nov-02	Commercial Office	Profit
Herman N. Hipp Hall	Furman University	US	Gold	38,000	11-Jul-03	Multi Use	Other
Hewlett Foundation Headquarters	The William and Flora Hewlett Foundation	US	Gold	48,000	12-Sep-02	Commercial Office	Nonprofit
Hillsboro Civic Center	City of Hillsboro	US	Gold	108,030	3-Feb-06	Multi Use	Local
Hillsdale Library	Multnomah County	US	Gold	5,097	02-Nov-04	Library	Local
Institute of EcoTourism	Institute of EcoTourism	US	Gold	1,559	08-Jul-04	Interpretive Center	Nonprofit
IslandWood: A School in the Woods	Puget Sound Environmental Learning Center	US	Gold	55,000	24-Sep-02	Interpretive Center	Nonprofit
J. Richard Carnall Center, PFPC Worldwide Headquarters	PNC Financial Services Group	US	Gold	113,500	13-Jun-03	Commercial Office	Profit
Jane D'Aza House of Formation	Sisters of St. Dominic	US	Gold	6,200	31-Mar-06	Multi Use	Nonprofit
Jean Vollum Natural Capital Center	Ecotrust	US	Gold	70,000	12-Dec-01	Multi Use	Nonprofit
Joel and Linda Abromson Community Education Center	University of Southern Maine	US	Gold	32,000	22-Mar-06	Higher Edu.	Other
John R. Howard Hall	Lewis & Clark College	US	Gold	51,000	5-Dec-05	Higher Edu.	Profit
Kelley Engineering Center	Oregon State University	US	Gold	136,000	14-Jun-06	Higher Edu.	Other

LEED New Construction

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Life Sciences Center, University of British Columbia	The University of British Columbia	Canada	Gold	561,521	19-Dec-05	Multi Use	Other
Lowe's of S.W. Austin	Lowe's Home Centers Inc.	US	Gold	134,563	6-Mar-06	Retail	Profit
McGowan Institute for Regenerative Medicine	University of Pittsburgh	US	Gold	45,200	2-May-05	Lab	Other
Melink Corporation Headquarters	Melink Corporation	US	Gold	30,000	24-May	Multi Use	Profit
Michigan Alternative and Renewable Energy Center	City of Muskegon	US	Gold	26,990	30-Jun-05	Multi Use	Local
MidState Electric Cooperative Administration Building	MidState Electric Cooperative	US	Gold	13,303	3-Mar-06	Other	Nonprofit
Navy Federal Credit Union Remote Call Center	Navy Federal Credit Union	US	Gold	57,000	29-Jul-04	Commercial Office	Nonprofit
Navy's Energy & Sustainable Design Demonstration Facility	Naval Base Ventura County	US	Gold	17,000	3-Mar-05	Other	Federal
North Mall Office Building	State of Oregon, Dept. of Admin. Services	US	Gold	115,000	8-Dec-05	Multi Use	State
North Sarasota Public Library	Sarasota County Government	US	Gold	24,880	28-Jun-05	Library	Local
Nose Creek Recreation & Library Facility	Cit of Calgary	CA	Gold	193,000	2-May-05	Multi Use	Local
One Potomac Yard	Crescent Resources, LLC	US	Gold	323,995	19-Jun-06	Multi Use	Profit
PA DEP Bureau of Laboratories	Vartan Group Inc.	US	Gold	120,000	20-Apr-05	Lab	Profit
PA-DEP Moshannon District Office	MBC Properties	US	Gold	14,400	20-Apr-05	Commercial Office	Profit
Park 90/5 C	City of Seattle	US	Gold	172,000	25-Oct-04	Multi Use	Local
Pavilions Lassonde-École Polytechnique de Montréal	École Polytechnique de Montréal	CA	Gold	333,000	10-Oct-05	Higher Edu.	Nonprofit
Pennsylvania Housing Finance Agency	Pennsylvania Housing Finance Agency	US	Gold	100,000	27-Sep-05	Commercial Office	Profit

LEED New Construction

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Plantronics Factory	Plantronics	China	Gold	150,600	19-Apr-06	Industrial	Profit
Pleasanton Fire Station 4	Livermore-Pleasanton Fire Department	US	Gold	7,545	23-Dec-05	Public order/safety	Local
Presentation Center Dining Hall & Welcoming Center	Presentation Center	US	Gold	11,372	10-Mar-06	Multi Use	Nonprofit
Q Building Lab	Pharmacia	US	Gold	176,000	07-Feb-02	Lab	Profit
RAND Corporate Headquarters	RAND Corporate Headquarters	US	Gold	321,111	12-Jan-06	Commercial Office	Nonprofit
Regional Training & Distribution Center	American Honda	US	Gold	211,000	29-Aug-02	Industrial	Profit
Regional Training Center	WA Department of Corrections	US	Gold	10,372	27-Oct-05	Campus (Corp. or school)	State
Rinker Hall	University of Florida-Gainesville Campus	US	Gold	47,470	07-May-04	Higher Edu.	State
Royal Caribbean International Customer Contact Center	Royal Caribbean Cruises, Ltd.	US	Gold	168,453	17-Mar-06	Multi Use	Profit
S. T. Dana Building Renovation	The University of Michigan	US	Gold	107,803	6-May-05	Higher Edu.	State
Schlitz Audubon Nature Center	Schlitz Audubon Nature Center	US	Gold	20,000	12-Oct-04	Interpretive Center	Nonprofit
Seattle City Hall	The City of Seattle, Fleets & Facilities Dept.	US	Gold	202,000	26-Sep-05	Multi Use	Local
Seattle Terminal Radar Approach Control	Federal Aviation Administration	US	Gold	52,000	19-May-04	Other	Federal
Seminar II	The Evergreen State College	US	Gold	165,423	24-Feb-06	Higher Edu.	State
South Campus Office Development	Toyota Motor Sales	US	Gold	630,000	15-Apr-03	Commercial Office	Profit
Stoller Winery	Stoller Vineyards	US	Gold	23,000	17-Apr-06	Other	Profit
Sun Valley Branch of the Los Angeles Public Library	City of Los Angeles	US	Gold	12,500	11-Aug-05	Library	Local

LEED New Construction

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Suwannee River Visitor Center	Georgia Department of Natural Resources	US	Gold	14,000	29-Aug-05	Interpretive Center	State
The Arthur M. Blank Family Office	AMB Realty	US	Gold	98,462	14-Oct-04	Commercial Office	Indiv.
The Helena Apartment Building	The Durst Organization	US	Gold	602,021	1-Jun-06	Multi-Unit Residential	Profit
The Henry	Gerding/Edlen Dev. Company, LLC	US	Gold	211,700	1-Apr-05		Profit
Herman Miller MarketPlace - an intellisys bldg	Granger Group of Companies	US	Gold	100,000	24-Jan-03	Commercial Office	Profit
The Plaza at PPL Center	Liberty Property Trust	US	Gold	280,000	10-Mar-04	Commercial Office	Other
The Solaire/20 River Terrace	River Terrrace Associates, LLC	US	Gold	386,000	13-Apr-04	Multi-Unit Residential	Profit
The Willow School Phase I	Willow School	US	Gold	13,866	08-Oct-04	K-12 Education	Profit
Third Creek Elementary School	Iredell-Statesville Schools	US	Gold	92,000	06-Nov-02	K-12 Education	Local
TKG Consulting Engineers, Inc. Oberlin Office	TKG Consulting Engineers, Inc.	US	Gold	18,420	12-Oct-04	Commercial Office	Profit
Toyota Portland Vehicle Distribution Center	Toyota Motor Sales, U.S.A., Inc.	US	Gold	68,600	24-May-05	Industrial	Profit
Tumwater Office Building	Tumwater Office Properties	US	Gold	220,000	10-Apr-06	Commercial Office	Profit
Twin Lakes Park Office Complex	Sarasota County Government	US	Gold	27,592	23-Sep-05	Commercial Office	Local
Two Potomac Yard	Crescent Resources, LLC	US	Gold	309,270	19-Jun-06	Multi Use	Profit
U.S. EPA, New England Regional Lab	iStar Financial for U.S. GSA, Region 1	US	Gold	66,233	02-Feb-03	Lab	Profit
University of Denver College of Law	University of Denver	US	Gold	210,000	12-Jun-05	Higher Edu.	Other

LEED New Construction

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Vancouver Island Technology Park	BC Buildings Corporation	CA	Gold	171,750	04-Feb-02	Commercial Office	State
Washington Veterans Home, Skilled Nursing Facility	Washington Department of Veterans Affairs	US	Gold	171,775	7-Apr-06	Housing	State
Wind NRG Partners, LLC	NRG Systems, Inc.	US	Gold	46,000	1-Mar-05	Multi Use	Profit
Winnipeg Mountain Equipment Co-operative	Mountain Equipment Co-operative	CA	Gold	25,157	20-Dec-04	Retail	Other
Winrock International Headquarters	Winrock International	US	Gold	25,000	13-Jul-05	Commercial Office	Nonprofit
Wisconsin DNR - NE Regional Headquarters and Service Center	State of Wisconsin	US	Gold	34,560	8-May-06	Multi Use	State

LEED Existing Buildings

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Adobe Systems Incorporated, West Tower	Adobe Systems Incorporated	US	Plat.	391,708	9-Jun-06	Commercial Office	Profit
California Department of Education Building	California Department of General Services	US	Plat.	421,150	28-Jun-06	Multi Use	State
Joe Serna Jr. – California EPA Headquarters Building	Thomas Properties	US	Plat.	950,000	1-Nov-03	Commercial Office	Local
200 Market Building	200 Market Associates Limited Partenership	US	Gold	388,191	14-Mar-06	Commercial Office	Profit
260 Townsend - Swinerton Headquarters	Swinerton Builders	US	Gold	66,945	12-Jul-04	Commercial Office	Profit
Alliance Center	Alliance for Sustainable Colorado	US	Gold	38,000	7-Jul-06	Commercial Office	Nonprofit
Brengel Technology Center	Johnson Controls, Inc.	US	Gold	130,000	25-May-04	Commercial Office	Profit

LEED Existing Buildings

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Conservation Consultants Incorporated Center	Conservation Consultants, Inc.	US	Gold	11,500	30-Jun-05	Commercial Office	Nonprofit
Denver Place	Amerimar Realty Management Company	US	Gold	815,000	5-Nov-04	Multi Use	Profit
Goizueta Business School	Emory University	US	Gold	122,000	28-Feb-05	Commercial Office	Other
JohnsonDiversey Inc. Global Headquarters	JohnsonDiversey, Inc.	US	Gold	2,316,996	10-Aug-04		Profit
Karges-Faulconbridge, Inc. Headquarters	Karges-Faulconbridge, Inc. Headquarters	US	Gold	33,400	1-Nov-04	Commercial Office	Profit
King Street Center	King County	US	Gold	327,000	6-Apr-04	Multi Use	Local
Len Foote Hike Inn	Georgia Department of Natural Resources	US	Gold	6,000	5-Nov-04	Multi Use	State
Moss Landing Marine Laboratories	Moss Landing Marine Laboratories	US	Gold	60,000	24-Jun-04		Other
NEG Micon (India) Private Ltd.	NEG Micon	IN	Gold	17,750	9-Sep-05		Other
Nike, Inc. Ken Griffey Jr. Building	Nike, Inc.	US	Gold	95,189	12-Jul-05	Commercial Office	Profit
The Lubin manufacturing facility	Knoll, Inc.	US	Gold		29-Oct-04	Industrial	Profit

LEED Commercial Interiors

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Interface Showroom Office	Interface Americas, Inc.	US	Plat.	486,993	23-Sep-04	Multi Use	Profit
AIA Honolulu Chapter Office	American Institute of Architects	US	Gold	1,676	30-Aug-04		Profit
Boulder Associates Office	Boulder Associates, Inc.	US	Gold	13,323	6-Oct-05	Commercial Office	Profit
Chong Partners Architecture	Chong Partners Architecture	US	Gold	43,254	12-Aug-04	Commercial Office	Profit

LEED Commercial Interiors

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Coro Center Terminal Building Tenant Space	Coro Center for Civic Leadership	US	Gold	10,326	5-Oct-04	Commercial Office	Nonprofit
DPR Office Interiors	DPR Construction, Inc.	US	Gold	11,600	11-Aug-04	Commercial Office	Profit
Haworth Chicago Showroom	Haworth	US	Gold	23,560	8-Jun-05	Retail	Profit
Haworth Santa Monica Showroom	Haworth	US	Gold	18,500	15-Mar-06	Retail	Profit
Herman Miller Design Yard Front Door	Herman Miller, Inc.	US	Gold	25,503	31-Oct-05	Commercial Office	Profit
Herman Miller National Design Center, Washington, DC	Herman Miller, Inc.	US	Gold	293,000	25-Jul-05	Other	Profit
HOK Canada + Urbana Architects Office	HOK Canada + Urbana Architects	Canada	Gold	24,795	3-Jan-06	Commercial Office	Profit
Kimball International Corporate Showroom	Kimball Office	US	Gold	35,000	30-Nov-05		Profit
Natural Resources Defense Council, San Francisco Office	Natural Resources Defense Council	US	Gold	15,530	9-Feb-05	Commercial Office	Nonprofit
Nusta Spa	Elizabeth Snowden	US	Gold	127,140	14-Mar-05	Multi Use	Indiv.
Omicron Office Tenant Improvement	Omicron AEC	Canada	Gold	15,400	3-Jan-06	Commercial Office	Profit
REI Portland	Recreational Equipment, Inc. (REI)	US	Gold	37,448	30-Sep-04	Retail	Profit
SCA Americas Headquarters	SCA Americas	US	Gold	75,000	21-Apr-06	Commercial Office	Profit
SERA Architects Offices	SERA Architects	US	Gold	10,000	18-Apr-06	Commercial Office	Profit
Starbucks 1st & Main	Starbucks Coffee Company	US	Gold	1,686	17-Apr-06	Multi Use	Other
SUGEN, Inc. Building 3	SUGEN, Inc.	US	Gold	67,674	25-Aug-04	Lab	Profit
Vancouver Port Authority Offices	Vancouver Port Authority	Canada	Gold	55,000	21-Feb-06		Federal

LEED Commercial Interiors

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
Wells Fargo Bank- Pearl District Branch	Wells Fargo	US	Gold	2,700	25-Jan-06	Multi Use	Profit
West Michigan Environmental Action Council	West Michigan Environmental Action Council	US	Gold	7,200	6-Jul-06	Commercial Office	Nonprofit
Wetland Studies and Solutions, Inc.	Wetland Studies and Solutions, Inc.	US	Gold	53,614	2-Mar-06	Commercial Office	Profit
WRT - Philadelphia Office	Wallace Roberts & Todd, LLC	US	Gold	24,000	2-Feb-05	Commercial Office	Profit

LEED Core & Shell

Project Name	Owner	Country	Rating	Sq.Ft.	Cert. Date	Project type	Owner Type
111 South Wacker Drive	The John Buck Company	US	Gold	1,400,000	13-Oct-05	Commercial Office	Profit
1180 Peachtree at Symphony Center	NOP 1180 Peachtree LLC	US	Gold	792,209	14-Oct-05	Multi Use	Profit
318 Sentinel Drive	Corporate Office Properties Trust	US	Gold	125,000	25-Oct-05	Commercial Office	Profit
7 World Trade Center	Silverstein Properties	USA	Gold		7-Mar-06		
Collaborative Innovation Center at Carnegie Mellon	Regional Industrial Development Corporation of Southwestern Pennsylvania	USA	Gold	136,000	5-Dec-05	Campus (Corp. or school)	Profit
East Hills Center	East Hills Center LLC	USA	Gold	7,200	3-Feb-06	Multi Use	Profit
The Restaurant at Abercorn Common	Melaver, Inc	USA	Gold	4,700	8-Jun-06	Restaurant	Profit

APPENDIX E: LITERATURE REVIEW

The following 20 barriers (in no particular order) originate from the articles summarized below. While not exhaustive, the listed barriers represent many of the major impediments to incorporating energy efficiency measures – *please comment on their relevance and importance (perhaps even rank them?) as barriers to energy efficiency investments in corporate real estate.*

a) Higher first cost myth
b) Failure to apply life-cycle metrics
c) Cost of full information is prohibitive
d) No capitalization of energy efficiency into market value
e) Competing capital investments and/or access to capital
f) Perceived project risk determines discount rates
g) Energy costs are a small fraction of operating expenses
h) Investment decisions are affected by market strength
i) Supply chain participants are not compensated based on building performance
j) Buildings are not metered appropriately to align tenant/landlord incentives
k) Lack of widespread market demand for energy efficient buildings
l) It is easier to maintain the status quo than to incorporate innovative design measures
m) Designers are typically not involved in initial, yet crucial, design decisions
n) Building codes and regulations reinforce current practice and technologies
o) Risk-averse, uninformed, or powerless decision makers
p) Perception that energy code creates energy-efficient buildings
q) Fragmentation and urgency of building design and construction process
r) Numerous technical languages inhibit communication amongst key players
s) Building managers are not given the proper tools or training to optimize building performance
t) Benefits of energy efficiency are uncertain and not easily quantifiable

ARTICLE SUMMARIES
As stated in a December 1992 report on energy efficiency by Amory Lovins, "It is inconceivable that in a market economy, such large and profitable savings would remain untapped. But to a practitioner who knows how buildings are created and run, it is not only conceivable but obvious." The following short paragraphs summarize articles that discuss previously identified barriers to realizing greater energy efficiency in commercial office spaces and warehouses. It is intended that this in-progress research, plus the upcoming charrette discussions, will form the basis for developing the survey content.

Russell, C. (2003). Motivating Business Leaders to Improve Profitability through Energy Efficiency. Alliance to Save Energy. (USA)

Co-sponsored by the New York State Energy Research and Development Authority and the U.S. Department of Energy, this report investigates corporate receptiveness to energy efficiency. The report is based on the premise that, "The same investments and practices that enable energy efficiency also often improve productivity, plant reliability, emissions compliance, and workplace safety." The purpose of the project is to develop strategies that will facilitate motivation of New York business leaders to "improve business performance through energy efficiency." The report concludes that there are eight different rationales that typically make energy efficiency projects less appealing to decision-makers including: 1) lacks organizational stability, 2) investment bias for core business, 3) fixation on energy price rather than expense, 4) lacks technical appreciation, 5) defers to production/business climate risks, 6) jaded by energy "snake oil" from the past, 7) conservative capital investment criteria, and 8) sensitive to fuel price/tariff risk. Furthermore, each hurdle is matched with a "solution" or method for encouraging a company with that particular mentality to proceed with an energy efficiency project. For example, a segment 4 company that lacks technical appreciation needs to be shown more case studies and data. Lastly, the report notes that, "Any overture to the business community regarding energy efficiency requires a vision that speaks primarily to business interests more so than energy-efficiency goals."

Jones, D.W., Bjornstad, D.J., Greer, L.A. (2002). Making Energy-Efficiency and Productivity Investments in Commercial Buildings: A Choice of Investment Models. Environmental Sciences Division, Oak Ridge National Laboratory. (USA)

This report, prepared for the U.S. Department of Energy by the Oak Ridge National Laboratory, investigates what information and tools are employed when making commercial building investment decisions. A major motivation for the report is to understand why commercial building investors consistently choose first-cost over life-cycle analyses – a major barrier to implementing energy efficiency projects. Factors that affect building energy investments include logistical circumstances (timing, staff availability and knowledge, etc.), scale of investment (small or big), market conditions, status of entire building portfolio, implicit discount rate, degree of capitalization of assets (are productivity or lower operating costs included in rental prices?), and value and time horizon of options that may reduce uncertainties. Investment criteria used in making building energy investments include the payback period, the internal rate of return, and the cost/benefit analysis. The report concludes that reducing uncertainty in any informational hole (such as technological performance or market capitalization) reduces the option cost of an immediate investment, thereby reducing the hurdle rate for the investment. Thus, generating data on how much individual technologies or efficiency upgrades contribute to the profits of the buildings' users and owners is critical to reducing hurdle rates for investment.

Cavanagh, R. (2004). Energy Efficiency in Buildings and Equipment: Remedies for Pervasive Market Failures. National Commission on Energy Policy. (USA)

This short article, prepared for the National Commission on Energy Policy, contends that "pervasive market imperfections" have led to systematic underinvestment in energy efficiency measures. Market failure is understood as "distorted energy prices and/or a gap between the private discount rate that households and businesses apply to energy-efficiency investment decisions and the social discount rate." Cavanagh states that energy consumers are demanding annual rates of return of 40-100% for energy efficiency projects. Additional barriers include discrepancies between decision makers and bill payers, landlords and tenants, and designers and their contract structures.

Sustainable Energy Policy Concepts. (2004). Instruments for a Sustainable Energy Policy in Germany: Context and Barriers to Energy Efficiency. (Germany)

This qualitative short article on energy efficiency is part of a larger project that examines instruments for a sustainable energy policy in Germany. Funded by the German Federal Ministry for the Environment, this article discusses six main barriers to implementing energy efficient and demand-side management measures. These barriers include 1) a lack of information on the part of consumers, vendors, manufacturers and policy makers, 2) institutional and legal barriers, 3) financial barriers, 4) technological barriers and infrastructure, 5) energy prices and rate making, and 6) diversity of actors and expectations. One unique barrier discusses how legal accounting procedures may impede utilities from considering investments in their customers' facilities as part of the utility investment. Another section highlights how energy efficiency may not be a high priority investment – "an industrial customer may prefer to spend capital on a new line of products rather than consider a retrofit in existing installations." They also state, "Many new and efficient technologies incorporate electric components that rely on good quality power to operate. Voltage fluctuations and frequent power failures will shorten the equipment's designed lifetime." And lastly they authors, "The evaluation of the economic attractiveness and the convenience (or inconvenience) of implementing a given measure depends on the perspective and criteria of each agent."

Lovins, A.B. (1992). Energy-Efficient Buildings: Institutional Barriers and Opportunities. E Source. (USA)

In this comprehensive paper, the topic of institutional barriers to achieving greater energy efficiency in commercial buildings is discussed in detail. Lovins argues that "Buildings are rarely built to use energy efficiently, despite the costs that inefficient designs impose on building owners, occupants, and the utility companies that serve them." The rationale behind this "market failure" originates within and amongst the fragmented sectors of the building supply chain. Pertinent barriers within each area of the supply chain are outlined below:

Financial barriers:

→ Developers are more concerned with minimizing capital cost per square foot of net marketable floorspace, than with maximizing the building's long-term financial performance. Similarly, brokers, mortgage bankers, and investment advisors are rewarded based on the original project value, not on the building's long-term financial performance.

→ The additional value of energy-efficient commercial buildings is rarely reflected in the appraisal process, security ratings, or market value. Emphasis is often solely placed on market conditions, aesthetics, and location – low operating costs or innovative technologies are rarely highlighted.

→ The concept that capital cost can be reduced through thoughtfully designed building systems seems far-fetched.

→ There is rarely a local average energy bill against which to compare your building's bill due to relatively few commercial-sector "truth-in-renting" energy-disclosure rules.

→ "Many commercial leases, too, are still written on a 'gross' basis (i.e., they include energy and other operating costs in a total rent figure), giving the tenant no incentive to save even though the landlord could in principle keep the saving. 'Net' leases reverse this problem to the extent that energy cost components, typically for lights and plug loads but sometimes also for space-conditioning, are individually metered and billed. Neither lease form, as conventionally written, gives *both* parties an appropriate incentive to save."

Design-related barriers:

→ To avoid liability, designers often roundup equipment sizes or rely on advice from manufacturers creating ridiculous safety margins (as great as tenfold) – often without performing models to verify performance

→ Furthermore, percentage-of-cost contracts reward oversizing of equipment. "Designers who do extra work to design and size innovative HVAC systems exactly right, thereby cutting their clients' capital and operating costs, are directly penalized by lower fees and profits as a result, in two different ways: they are getting the same percentage of a smaller cost, *and* they are doing more work for that smaller fee, hence incurring higher costs and retaining less profit."

→ A single entity rarely takes responsibility for ensuring designers communicate to create an integrated design – different fee structures, perspectives, and technical languages further inhibit interaction.

→ Most architects lack the time and knowledge to check the engineers' work for maximum energy efficiency.

→ Mechanical designers are brought on too late in the project, when the most critical decisions have already been made.

→ Time-pressed superiors, as well as code officials, would rather approve safe and familiar designs. "The U.S. Office of Technology Assessment summarizes: It is usually easier for the designer to follow accepted, standard practice, especially if the designer's fee is the same in either case. As one interviewee said, 'The path of least resistance does not include energy innovative design.'"

→ Price competition between engineers encourages fast and easy "catalog engineering," which is hardly engineering, but "only the application of crude and outmoded rules-of-thumb to selecting common listings from major vendors' catalogs. *This procedure is at the root of today's appallingly low mechanical-system efficiencies.*"

Construction-related barriers:

→ Equipment availability sometimes dictates selection – whatever "equivalent" (usually in terms of capacity, not energy efficiency) pump or duct is handy may be installed.

→ Suppliers can be reluctant to sell new products – for example, "people who use imaging specular reflectors buy only half as many fluorescent lamps to go under them, so vendors may discourage competing products that save customers' dollars and energy at the expense of their own sales."

→ The commissioning team is rarely rewarded for the initial building performance or for how well the building operators understand the building systems.

O&M-related barriers:

→ Building operators are usually poorly trained and tend to disable equipment or features they don't understand. Also, monitoring equipment is rarely installed, thus creating a barrier to measuring actual building performance against intended building performance or warranty-related specifications. Furthermore, confusing building interfaces make it difficult for operators to understand, let alone optimize building performance.

→ Building operators may never even see meter readings or utility bills
→ Tenants are seldom given instructions as to how they can positively influence building performance
→ Commercial building operators are mostly concerned with occupant comfort and minimizing complaints.
→ There is little feedback to real-estate developers regarding occupant satisfaction – "The building industry is in this sense quite primitive: we would not dream of running a manufacturing business with so little and oblique contact with our customers, and if we tried to, we'd soon be out of business. But that is what the building industry tries to do with its complete disjunction of design, manufacturing, marketing, sales, delivery, repair, and renovation or demolition."

Tenant-related barriers:

→ Few commercial tenants are familiar with energy efficiency. "Notable exceptions exist: in Sydney, Australia, it has become fashionable to compete on how efficient and 'smart' one's office building is, and many tenants ask penetrating questions about details of design and efficiency down to the component level."
→ There are many misunderstandings regarding energy efficiency; retail managers treat energy bills as "immutable as death and taxes." Furthermore, "A survey of small businesses found that energy efficiency was thought to require turning down heat or turning off lights."

Lutzenhiser, L., Biggart, N., 2003. Market Structure and Energy Efficiency: The Case of New Commercial Buildings (USA).

The article examines both the actors involved in the new construction process as well as in the real estate development process. The authors pay specific attention to the interactions between market participants, and they gather much of their data from semi-structured interviews conducted with key supply chain actors from a variety of large West-coast entities.

Traditional analyses of energy efficiency investments generally rely on two assumptions. First, the energy efficiency problem is viewed as one centered around design. Second, traditional analyses view market actors as possessing a great deal of autonomy. However, as decisions are made by the financiers and developers upstream, the downstream agents become increasingly constrained, further limiting their ability to add innovative items to a building. The incorporation of energy efficiency investments runs into additional problems as it is also considered a low priority building feature by most market actors. The authors note that energy efficiency measures are generally incorporated not for their energy saving capacity, but for other reasons entirely. Often these measures are picked up as a result of other design elements.

Similar to many other building amenities, the degree to which energy efficiency investments are incorporated in new buildings is often affected by the state of the market. During a market boom, energy efficiency investments are more likely to be incorporated into a building because there is excess market demand. However, regardless of the state of the market, many real estate professionals view innovations as costly, increasing interest rates and equity requirements. Thus, most risk-averse real estate investors tend to view efficiency investments with skepticism. A variety of widely held perceptions common to many actors in the real estate supply chain further limits the adoption of energy efficiency measures. Many participants believe that simply meeting the energy code, creates an energy efficient building. Furthermore, there is a perception that the incorporation of one or a variety of energy efficient measures will create an energy efficient building. Lastly, whether one energy efficiency measure is installed or a variety of measures are installed, sometimes energy efficiency is incorporated in the building simply to offset less energy efficient features.

To further shed light on the adoption rates of energy efficiency measures, the authors describe four attributes that facilitate the incorporation of an innovation. An innovation should have an apparent relative advantage, be compatible with current conditions, be easily comprehensible, and facilitate an easy cost-benefit analysis. Energy efficient investments typically lack visibility, and it is often difficult to measure benefits. While the authors remain skeptical about the adoption of energy efficiency investments for their own sake, they do posit hope that these measures may be adopted as a component of another innovation (e.g., green building, better workplace, etc.).

Jones, D., Bjornstad, D., Greer, L., 2002. Measurement Issues for Energy Efficient Commercial Buildings: Productivity and Performance. (USA)

The authors describe the range of benefits that can accrue from buildings that incorporate energy efficient design strategies. Most often, energy efficiency practices are discussed in the context of their energy and cost savings potential; however, important productivity benefits may also accrue from incorporating measures like occupant thermal comfort and daylighting. While productivity benefits may provide substantial incentive to incorporate energy efficiency measures, there is little empirical evidence that productivity benefits are the direct result of energy efficiency improvements. Most of the evidence supporting this assertion tends to be anecdotal. The authors propose a methodology to statistically analyze the impact of certain energy efficiency measures on productivity. In addition to developing a method to link energy efficiency to productivity, the authors also describe the uncertainty, both technological and market-based, surrounding efficiency measures. These uncertainties drive the hurdle rate (the measure often used to evaluate the feasibility of a project), to levels that prevent the adoption of energy efficiency measures. The authors note that a survey of potential commercial building owners would be useful to determine the perceived uncertainties surrounding new building technologies. Such survey data may provide equipment designers with useful information for making design tradeoffs and may also pinpoint specific operational aspects in need of field-testing.

Kulakowski, 1999. Large Organizations' Investments in Energy-Efficient Building Retrofits. (USA)

To elaborate on how energy efficiency retrofits are performed within an organization's building stock, Kulakowski performed two case studies in California. The case studies revealed that an organization's facilities department generally makes energy efficiency retrofit decisions. Moreover, energy efficiency retrofits are funded from the facilities department's budget, and these investments are viewed as expenses, rather than as investments evaluated in conjunction with other capital investments. In some cases, energy efficiency retrofits undergo more extensive analysis than other capital improvements like new carpet installation. Kulakowski also found that the financial analysis used to evaluate retrofits was often performed incorrectly.

APPENDIX F: ROUGH MEETING NOTES – 8/1/06

Introductory Presentation – GF

- See attached presentation

Supply-Chain Participant Discussion

- Suppliers of energy efficiency equipment and materials are not experiencing pull in the marketplace
- Finance department is focused on return on investment, but these participants need to be educated about down cycle benefits, e.g., greenhouse gas reductions
- Energy efficiency investments may also create a more comfortable and enjoyable work experience; these investments may become an important employee retention tool
- The focus on short-term orientation in US relative to the long-term outlook demonstrated by many European companies may affect energy efficiency adoption
- In the UK there has been a shift from using a long-term lease structure (15+ years) to a more short term lease structure (5-10 years)
- Focus on projects with short-term paybacks, which may override lease life anyway
- Measurement tends to be more common in Europe than the US
- Sustainability drives demand for energy efficiency in Europe; in the US, demand is fueled by financial drivers
- Difficult to attach financial metrics to some environmental benefits that arise from incorporating energy efficiency, e.g., how do we put a number on enhanced carbon trading position or better energy security
- Local, state, regional, and federal governments may push energy efficiency adoption => In the UK, a new regulation is requiring buildings to display their energy efficiency ratings much like the EnergyGuide labels that US retailers must display on large appliances
- Corporate procurement staff have an increasingly important role to play in the purchase of real estate services
- The need to educate corporate decision makers about energy efficiency measures tends to slow the process down
- Strategic planning groups may impact lease term decisions
- Building manager may mean different things in different organizations; in one organization, the building manager may be a "wrench turner", while in another organization, an administrator
- Information systems restrictions may make it difficult to install energy monitoring software on computer systems
- The words "barrier" and "hurdle" may each mean something different in the context of adopting energy efficiency measures
- Information technology personnel create data rooms that are energy intensive; these personnel are skeptical of continuous energy use measurement
- Increasing information technology usage and higher density of use creates increased energy demands
- Companies seek flexibility because of changing supply chain composition, these companies pursue shorter term leases; compounding this short term perspective,

buildings are increasingly flipped to a situation of institutional ownership rather than the developer as owner

- Outsourcing distribution to 3pls, functional outsourcing is an issue =>rent space and manpower, additionally, many companies are now outsourcing their manufacturing function
- Investment community doesn't recognize energy efficiency at all, gross rents adjusted for office expenses may acknowledge energy efficiency issues to a limited expense
- Can't go outside ranges of tenant comfort level
- Multi-purpose developments experience different energy demands (e.g., necessary to light parking lots for extended period); if a multi-use development has one meter, one tenant can set the peak demand and detrimentally affect other tenants energy costs
- Business units can be a barrier or enabler: one participant saw the barriers to energy efficiency concentrated at the corporate level; however, another participant noted that business units are definitely a barrier – e.g. a corporation wants to green its business, but the business unit focuses on first costs rather than life cycle costs
- How do personal financial incentives and principal-agent problems play into the making or maintenance of a barrier to energy efficiency?
- It is important to separate corporate vision and direction from those actually implementing the corporate vision

Barriers Discussion

- Timely access to information is key – often times, no one analyzes the energy bills, and in some instances where sub-metering is available, the metering data may be provided, but with a significant lag time
- Lack of a clearly stated goal by businesses
- Energy use monitoring will allow you to determine the baseline energy efficiency of your building
- Premium cost of renovations vs. designing and constructing it right the first time
- When do you retire an asset – this is a sunk costs issue
- Incorporating energy efficiency measures is an uphill battle against standard systems currently employed by designers and contractors
- Many firms only invest in energy efficiency when there is a very short payback (e.g., less than three years) - there is also preference given to investments in a company's core business. Further limiting energy efficiency adoption, these investments are often analyzed using huge discount rates, and most analyses are not able to account for all the benefits that will be realized (e.g., reduced O&M)
- Operating budgets – same year (neutral) vs. capital budgets (fixed)
- Tenants see expense, but building owners don't – pass through expense
- Measure the expense vs. the utilization, pass through is recorded in GL as an expense
- Predictability is comforting to many tenants; thus, flat fee pricing is attractive
- On the O&M side, maintenance contracts are generally very prescriptive. These contracts typically focus on simply making sure equipment is running, rather than trying to incorporate new best practices, even if these best practices are simple to achieve. If best practices were supplied to the operating manager, they could be incorporated at very little expense. A great deal of O&M is outsourced, and there is significant room to make these out contracts more outcome oriented
- Product schedule duration: projects happen so fast that no one has enough time; time pressure is becoming an even more important driver. Companies see lost time in the

context of missed sales and revenues; In many cases, staff is already hired to show up on Day 1, so there is tremendous cost associated with delivering a building late

- Lack of anecdotal information: at certain times the general knowledge base has been a barrier, while at other times it has been an enabler
- The need to take expensive retrofits higher up the chain of command creates a demand for increased information, which creates a time lag on investments
- Culture of corporation, "make sure it can be done in our environment." Even if evidence exists that a technology has been successfully used in other environments, there is still substantial doubt that it will produce the same outcome in one's own company
- For big capital recommendations you want all of your bases covered. The big word is RISK, how do you cover your risk, and how do you convince all the people that must be involved in the investment that it will work and that they will not lose their jobs or credibility
- There needs to be a linkage between visionaries (top), architects (middle), and "wrench turners" (bottom)
- Complexity of market (many different vendors providing slightly different information) and speed of change in technology creates a situation where decision makers want to delay decisions
- Six sigma is generally focused on one-off investments and does not have a big project budget for starting a major investment program
- There is little in-house expertise about managing energy and seeking best practices. Additionally, energy managers tend to be reactive
- From the owner perspective, how do you integrate all the proposals into a management process across the whole business?
- Rate escalation places overemphasis on how to reduce energy costs. Decision makers are looking for the ability to control rates, and emphasis is being put on the procurement of power, rather than a focus on a holistic program that reduces consumption
- Johnson Controls tries to get to the highest management level where it all comes together so you don't have to deal with a variety of different goals
- Policy makers are key because they filter the CEO mission down to the rest of the organization
- Understanding the incentives of all the players involved is important
- There is a notion that energy efficiency measures don't apply to me
- Emphasis on sustainability in US is growing, especially for international companies
- Some voluntary measures are actually driving green buildings and practices
- Regulation doesn't play a role
- Experience level of team players makes a huge difference in design
- Pressure on increasing or decreasing energy efficiency based on each of the specialist's desires (see list in Lovins, 1992, p. 15); plus there are so many different interests. We can begin to overcome these issues through integrated design.
- Safety margin is incorporated from each participant, over-design ends up being major – how do you streamline the design process and grapple with perceived risk and incentive to over-design
- Level of tenant interest in energy efficiency is all over the map
- Default parameter is always to the lowest cost option, "we can't afford to pursue energy efficiency"

- Chief engineers plays a huge role in what lighting systems and what HVAC system is chosen, and if they have no guiding light then they typically choose the cheapest option
- Energy can sometimes be a profit center (more for lessors)
- Some companies want the sub-metering and don't want the flat price, others just want the certainty of a flat rate
- Strong disincentive for energy efficiency in some markets
- First cost myth is beginning to shift
- Lessees have minimal opportunity to impact lighting, etc.
- If you are leasing then it comes down to what features are available, and your ability to deviate from lighting features or sub-metering
- Life cycle analysis takes time and money up front; schedules don't allow for this kind of assessment, so it comes down to first costs
- Costs are typically analyzed component by component, rather than from a systems perspective
- Fees in design/construction haven't responded to integrated design concepts, everyone still thinks that LEED buildings are more expensive – follows a what is cost rather than what is benefit theme
- Despite data disproving first cost myth, there is still perceived risk of how can this happen in "my" case – can we set up a structure which would guarantee there is no risk? Perhaps minimize risk by CEO talking to CEO and picking the right team. There is a process that will minimize risk and increase chance of success, but it is not an easy task
- Setting quantifiable goals publicly creates a sense of accountability and quickly sets all kinds of action into motion
- Construction manager's goal is to get the project done on time
- Goldman Sachs identified a 5-7 percent value increase for sustainability performers, investors understand the benefits of sustainable companies
- If lending and insurance industries could recognize that sustainable measures reduce risk than this would facilitate the incorporation of energy efficiency
- Incentives create shift in markets and increase affordability in energy efficiency measures
- Telecommuters create a demand for unoccupied space in the office. Additionally, the energy that telecommuters use while they are at home is not captured by metering

Case Study Discussion

- Participant described a case where their company's public affairs office in Washington, D.C. requested the best building within a defined block, the participant focused on how they could create a lease to improve upon the space, are there similar examples of a more sustainable RFP or lease
- Each case should highlight specific barriers and describe how they were overcome
- One or more cases may make an internal comparison within a company between where they were able to incorporate energy efficiency and where they were not
- What is the trigger to open a dialogue about energy efficiency? What does it take to get the decision makers' attention? Are decision makers reactionary or are they progressive (e.g., CEO of UTC forced into sustainability, but now approaching it progressively)
- Can we incorporate the DJSI in any of these cases?
- It may be informative to showcase studies of things that didn't work

- Is there a place for a basic green renovation example
- Publishing survey results and case studies in magazines read by CEOs may put pressure on those CEOs not investing in energy efficiency
- A tenant space certified with LEED CI may be informative
- Case studies should focus on the office environment, but it may be worthwhile to highlight a warehouse facility, particularly because there are only a few warehouse case studies available (Patagonia, Verifone, Anixter Wire & Cable)
- In the Beijing Fun Tai district a huge mixed-use development is seeking to become a LEED showcase. In China, scarcity around energy availability is a major issue, and in new construction projects energy efficiency is mandated
- India platinum is the bottom – three platinum office buildings
- While not included in the case study portion, the report will include projects under development to demonstrate momentum
- What caused Wal-Mart to embrace sustainability?
- Johnson Controls headquarters example
- Interview candidates: Ray Anderson, H. Lee Scott, Mark Nichols, Kevin Oaks, GE CEO
- Toyota south campus, DC office (no real data, though), working on stuff in the enabler factory, Portland example – vehicle processing center, mainly paperwork and QC and ship them, something that mundane you can do a project makes it really a compelling case, shows adaptability and ease of application
- SC Johnson basic green example part of president's initiative in early 90's; led from the top and brought in Bill, lots of data, got LEED EB, well documented
- Highlight importance of natural lighting in call center in Phoenix designed by HOK
- Standardized RFP – Chicago example

Enablers Discussion

- When making retrofit decisions it is important to recognize where a building is in its life cycle
- Data on comparative costs of already existing efficient buildings (e.g., Davis/Langdon or Katz study)
- Life cycle cost data not historically used in the analysis, but Toyota is beginning to look at LCC in existing buildings. LCC is still not really done well; How detailed do you look? The level of difficulty has kept many from diving into it
- Tax credits are sometimes the only way to get the necessary ROI for a project; however, the problem is that the window for applying for incentives is often short for projects. Standards are pretty onerous, it may be tough to qualify, and the costs associated with acquiring the necessary information may be too high. If timing is out of sync, your window of opportunity is very short for applying and receiving the incentive.
- In the leasing world, how do you separate energy costs from the rest of the building costs and make it visible to the right people. Using energy star could play a role here. => Ability to sub-meter and purchase own power
- Conventional LCC tools aren't used enough
- Provide the right people with the right tools that are easily accessible. For example, make it easy for the Chief Engineer to understand and use energy modeling tools.
- Still a question of if institutional investors will pay for energy efficiency measures. If they are just buying NOI its tough to convince the Wall Street people, but on the other hand, it is pure cash so maybe this is good.

- Can you find a tenant interested, further down the line, in utilizing the space that you've improved with energy efficiency measures
- Several green REITS now exist – 100 million range
- Ability to monetize the value of an energy efficiency investment. In this scenario, you allow an external firm that specializes in valuing these investments to monetize future benefits – this is a way to "shift the risk"
- Early adopters will have to try and evaluate the benefits and provide a track record of operating costs so the appraiser can provide an appropriate value
- LEED may not be the way to go to push energy efficiency because LEED certified does not necessarily guarantee energy efficiency
- What if the building manager lets the building go, even if it is LEED certified it may not be in good shape
- Some utilities/state agencies will pay for energy modeling, providing the right people with a list of these resources would be helpful
- Charrette process becoming more and more common
- Performance based architectural fees, addendum to AIA contracts, also want that to apply to the contractor
- Bring in MEP early in design; get CEO informed enough to invest in getting the MEP there early
- Prior to using something like LEED, it is important to do a goal setting exercise to see what you are trying to accomplish
- Create a standard process for analyzing and selling energy efficiency measures (some level of customization is required) and distribute it to the decision makers to show them that creating a new project is not really all that difficult. Show this process to a broad spectrum then you don't have to reinvent the process each time
- Expedited approvals for environmentally efficient design, this doesn't cost municipalities much money
- Streamline paperwork process, trend in market is utilizing building information modeling (BIM), a 3-D model (Autodesk is marketing an off the shelf model), which allows you to spend more time upfront because the documentation is already done.
- Bonuses and incentives according to meeting environmental metrics that everyone can follow
- Ability to analyze energy history before lease is signed
- Johnson Controls has a facility assessment program where they analyze the clients proposed space before move in. Any identified problems are rolled into the Tenant Improvements (TIs) to increase the allowance. Johnson Controls will also help the tenant write the RFP. The space audit looks for obvious problems with energy efficiency to make sure the building systems are operating appropriately
- Tenant guidelines/user's manual, occupant's manual for everyone
- Data on productivity or retentions issues
- Ability to "walk the talk"
- Financial side: Allow the finance department to develop a financial model, use that model for every energy investment analyzed. This translates energy efficiency into their language
- One participant noted that in every case where they've seen improvements made, the organization making the improvements has always embraced a bigger goal
- Documenting statements by CEOs may be a valuable exercise. For example, why is it that particular companies signed up for EPA Climate Leaders? Disclose this information in articles in CEO magazines, and let competition drive other companies to

incorporate energy efficiency. Many CEOs don't want to be low hanging fruit in terms of regulatory pressure

- Comprehensive O&M training, turnover of O&M employees is usually pretty high, so video tape the O&M training, and show new employees a DVD of previous training sessions
- Important to do seasonal testing, rather than just testing during one season
- Make sure the "wrench turners" understand the concepts behind what it is they are doing
- Do you make up for the commissioner's fee in other areas?
- Use of buildings changes over time and nobody readjusts the building for operating efficiency according to its new use
- Toyota uses a "Treasure Hunt" to drive improvement. This activity involves sending "wrench turners" out to another facility to find bugs in a facility. The hunt starts on a Sunday when nothing is running and then continues as the place comes to life. The last day of the site visit is spent assessing what needs to be done and how to implement these alterations. Toyota has seen that as "wrench turners" go off site to assess other factories, they typically return to their job site and make similar fixes. To do this effectively, business-unit "buy in" is important. Incremental training is acquired as the participants identify new issues
- A 1 percent reduction in energy usage can actually mean an avoidance of a 3 percent increase in energy usage
- PR value to doing some of these things, may be able to assign a monetary value to the media placement a company receives from adopting energy efficiency measures
- Providing benchmarking data, companies self-report information on an anonymous basis and can have access to that database
- Internal data collection to assess internal energy efficiency improvements
- Data that tells executives where they stand relative to their competitors is compelling
- Give buildings a score relative to each other, so people don't want to have the low ranked building
- Benchmarking could provide a way to prioritize investments, this is separate from giving people scores; benchmarking would help in decision making for those first timers who haven't collected data, etc., quantify the potential; in benchmarking you may miss the opportunities to replace, how do you capture the replacement cycle with overlapping of benchmarking? System allows you to see where you are and match it up with the replacement cycle as far as what you want to implement when things come to cycle
- Build in opportunities to benchmarking
- Legislative enablers… e.g., building energy use labels
- Could class A gravitate toward energy efficiency, is there a class A-Energy, developers landlords and brokers who want marketing edge could do some kind of internal audit to put in a brochure about space as marketing edge, pre due-diligence
- Comprehensive electronic manual for systems, cut sheets, drawings and specs, recommissioning manual, vendor, etc.

Survey Process

Following the creation of the survey, it will be tested with a small group to determine the necessary amount of time required and to verify that choices provided are appropriate and comprehensive. We expect the survey to take between ten to fifteen minutes. Roughly speaking, it will cover what's being done (current practices) and include some open-ended questions. With the right sample audience, we expect a 60-70 percent response rate. To communicate back to respondents, we typically have several conference call debriefings to share the survey results in a relatively raw manner.

Appendix G: Introductory Presentation

Energy Efficiency Research in Corporate Real Estate

CoreNet Global & Rocky Mountain Institute

August 1st, 2006

9am - 5pm

Charrette Agenda

Introduction: Welcomes from CoreNet and RMI

Morning Session: Defining barriers

➡GOAL 1: Define key supply chain participants

➡GOAL 2: Define barriers experienced by each participant

Lunch: 12:30 - 1:30pm

Afternoon Session: Identify case studies and enablers

➡GOAL 3: Develop selection criteria and identify potential case studies

➡GOAL 4: Define enablers to overcome barriers identified in the morning session

Recap: Survey example

Summarize the day and set the agenda for the next few months

Project Participants

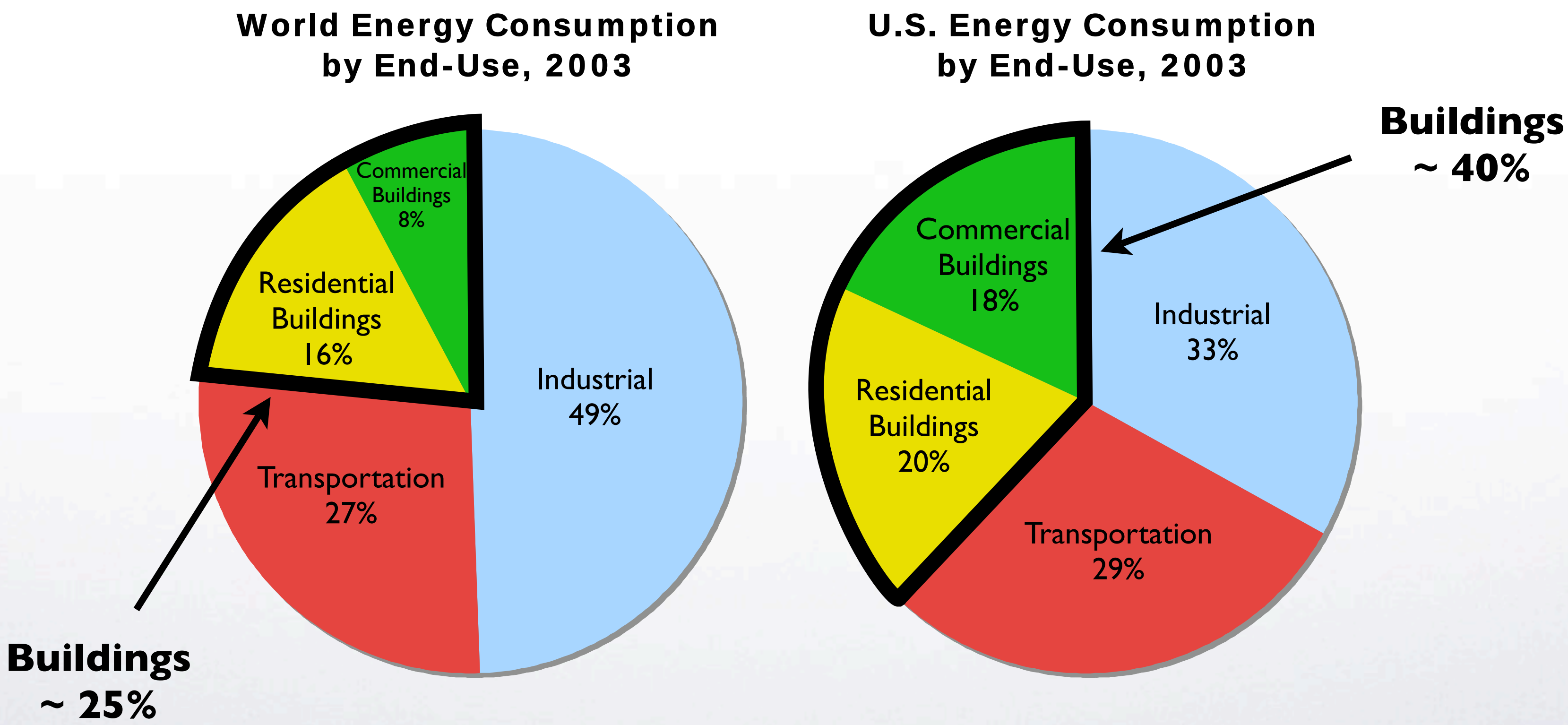
Facilitators: Eric Bowles & Ron Adams (CoreNet Global)
Greg Franta, Bill Browning, Aalok Deshmukh, Eric Maurer, & Caroline Fluhrer (RMI)

Advisory Team:

- Bill Sisson (United Technologies)
- Mike Harris (Johnson Controls)
- Tim Frank & Jim Cooke (Toyota Motors)
- Gary Jensen (Ford Motors)
- Timo Salonen & Mia Ranta-Aho (Nokia)
- Mukesh Khattar (Oracle)
- John Schinter (Jones Lang LaSalle)
- Andy Bray (JCI - Europe)
- Brenna Walraven (USAA Realty Company)
- Kevin Oakes (Motorala)
- Bill Frain & Pat Crumley (Staubach)
- Stephen Smith (ABN Amro)
- Johannes Ketel (Deutsche Bank)
- Mary Ann Lazarus (HOK)
- Bill Rodgers (Emcor Group)
- Jim Scannel (St. Paul Travelers)
- Brad Hancock (Dept. of Defense)
- Joe Wick (Cushman & Wakefield)

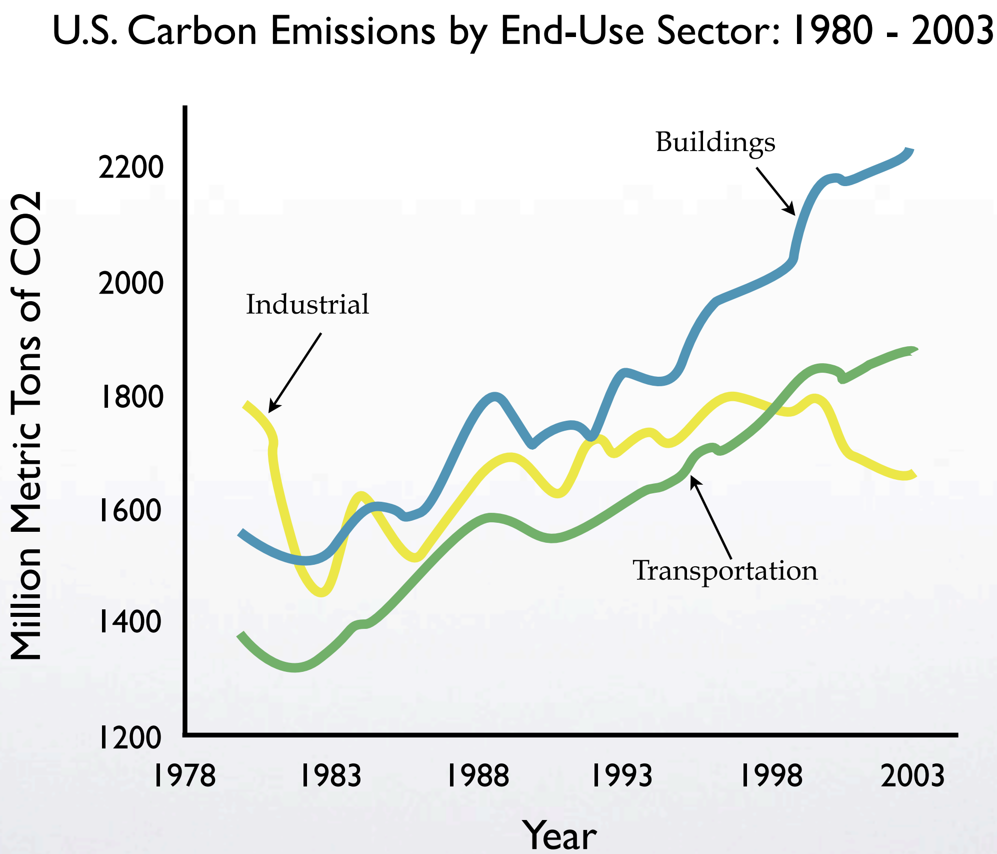
Survey Respondants: TBD

Buildings consume a lot of energy . . .



Data (2003) for figures from the EIA's International Energy Outlook 2006

. . . and contribute significantly to CO2 emissions

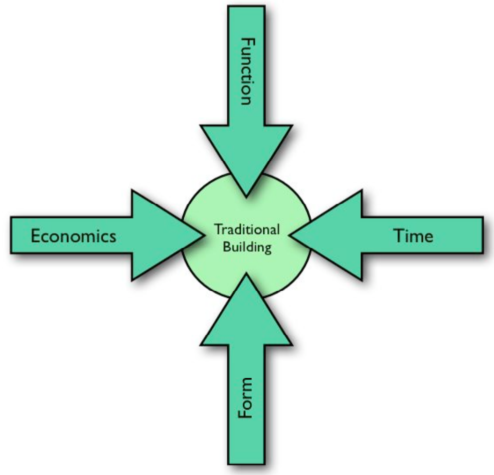


Data (2003) for figure from the 2004 Annual Energy Review

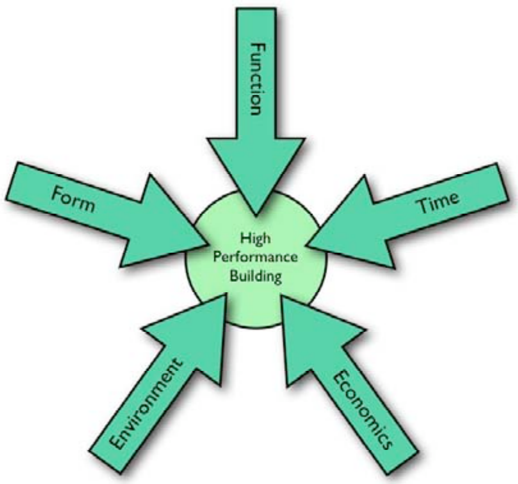
Are there opportunities for savings?

In most commercial, industrial, and institutional facilities, there are abundant opportunties to save ***70-90 percent*** of the energy and cost for lighting, fan, and pump systems, ***50 percent*** for electric motors, and ***60 percent*** in areas such as heating, cooling, office equipment, and appliances.

How can we exploit these savings?

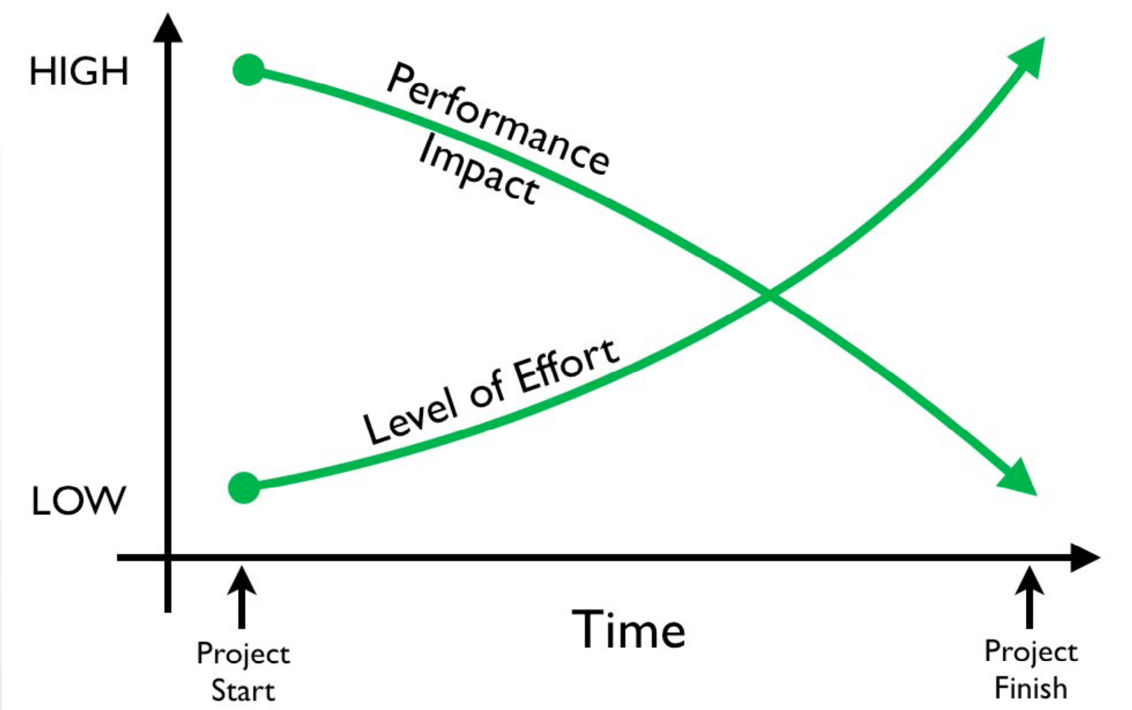


Traditional Design



Integrated Design

Early Impact



Why are savings remaining untapped?

"It is inconceivable that in a market economy, such large and profitable savings would remain untapped. But ***to a practitioner who knows how buildings are created and run***, it is not only conceivable but obvious."

- Amory Lovins

Why are such "large and profitable" savings remaining untapped?

What is wrong with the way buildings are created and operated?

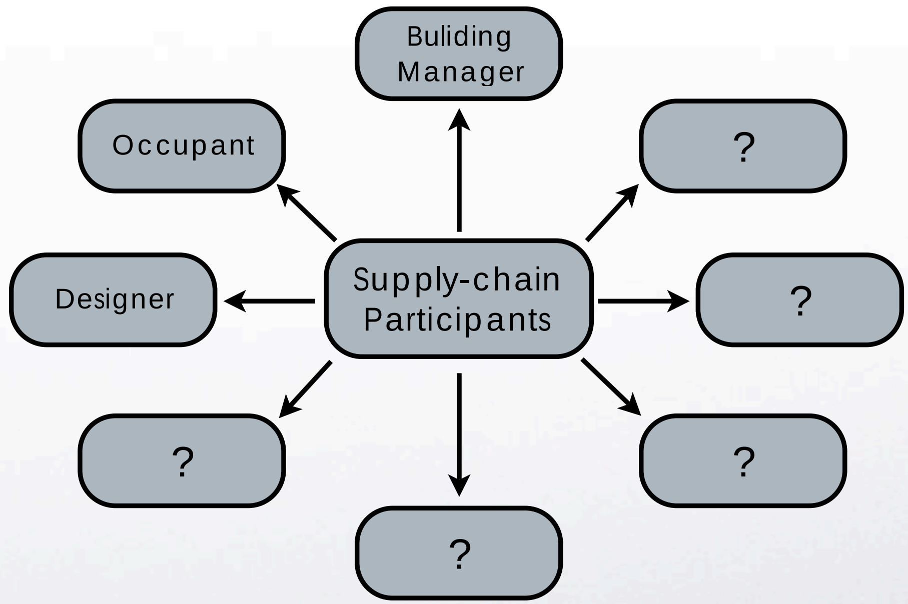
What is standing in the way of these "practicioners?"

Our Purpose

To supply large corporations with strategies to remove or overcome barriers to realizing greater energy efficiency

How will we do this?

1. Identify key supply-chain participants

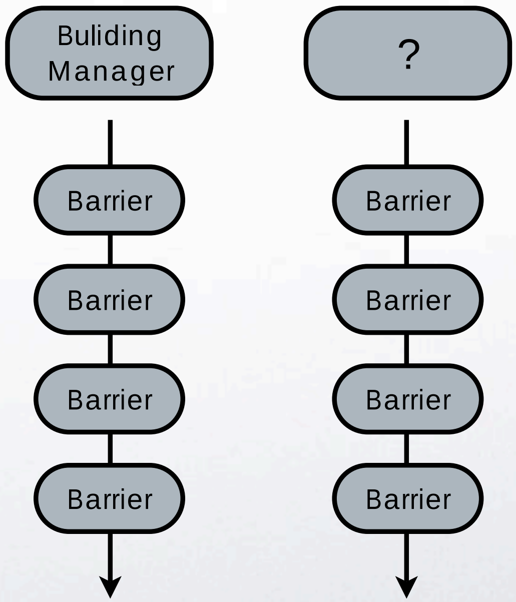


Our Purpose

To supply large corporations with strategies to remove
or overcome barriers to realizing greater energy efficiency

How will we do this?

1. Identify key supply-chain participants
2. Identify barriers facing each supply-chain participant



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2. Identify barriers facing each supply-chain participant
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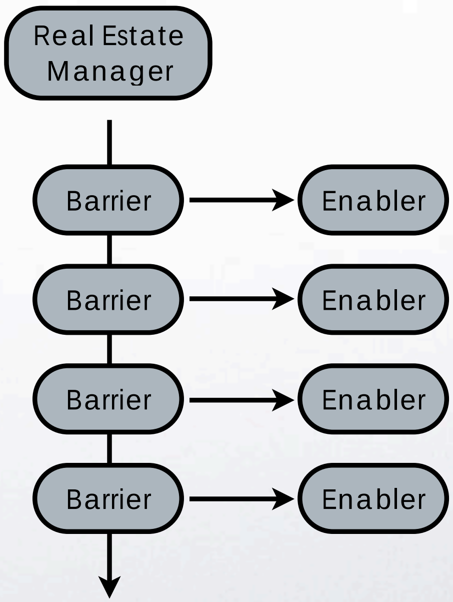

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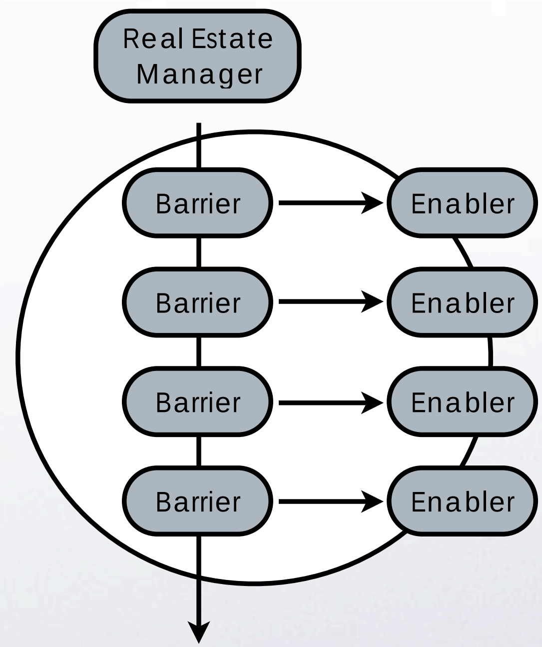
1. Identify key supply-chain participants
2. Identify barriers facing each supply-chain participant
3. Identify enablers to overcome or remove these barriers
4. Develop case studies that highlight success stories



Our Purpose

To supply large corporations with strategies to remove
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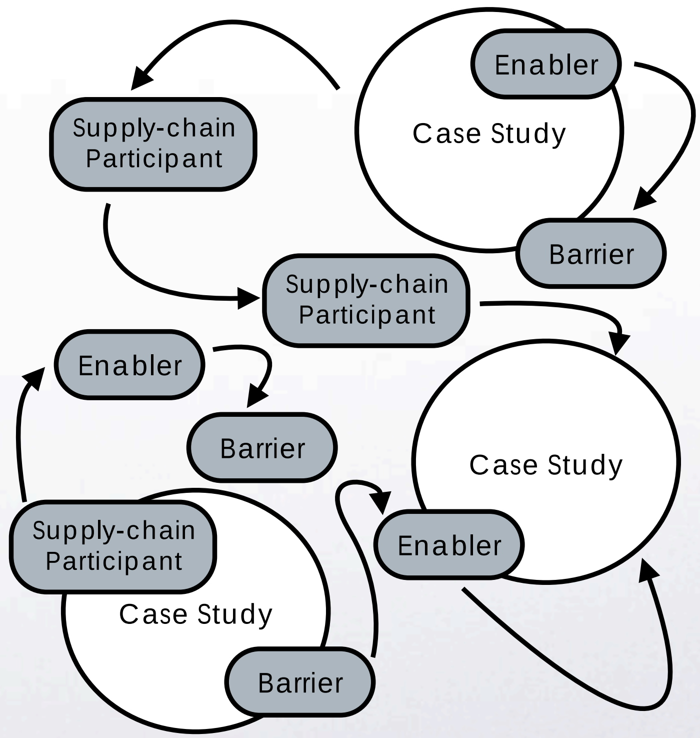
How will we do this?

1. Identify key supply-chain participants
2. Identify barriers facing each supply-chain participant
3. Identify enablers to overcome or remove these barriers
4. Develop case studies that highlight success stories
5. Summarize findings in a functional written report



Our Purpose

To supply large corporations with strategies to remove
or overcome barriers to realizing greater energy efficiency

How will we do this?

1. Identify key supply-chain participants
2. Identify barriers facing each supply-chain participant
3. Identify enablers to overcome or remove these barriers
4. Develop case studies that highlight success stories
5. Summarize findings in a functional written report
6. Distribute and present findings

Target Audience:
Large Corporations

Distribution Mechanisms:
TBD

A Starting Point

Energy-Efficient Buildings: Institutional Barriers and Opportunities
Amory Lovins & E SOURCE - 1992

Participants		**Barriers**
Real-estate developers	→	Focus exclusively on $/sf
	→	Believe energy efficiency measures will increase first cost
Brokers & Bankers	→	Paid based on value of deal, not long-term finanicial performance
Appraisers	→	Cannot quantify value of energy efficiency measures
	→	Value location and aesthetics, not energy efficiency

Architect	→ Percentage or flat-fee contract does not incentivize extra effort
	→ Delegates work to outside consultants
	→ Uses rules-of-thumb design
Mechanical Engineer	→ Oversizes equipment to avoid liability
	→ Leaves sizing exercise to manufacturers
	→ Does not build energy model for project
	→ Does not like architect
Project Manager	→ Does not emphasize whole-systems design
	→ Pushes budget & schedule not goal setting or communication
	→ Involves key project players too late in the game
Owner	→ Takes low-bids for design/construction work
	→ Knows of few examples of cost-effective energy-efficient design

Building Manager → Paid to make things work, not to make them work efficiently
→ Has inadequate systems monitoring or interfaces
→ Does not receive enough training on building systems

Multi-tenant occupant → Pays flat rate per sf for energy
→ Neighbors benefit equally from any energy-efficiency measures your company completes

Contractor → Availability often dictates equipment or material selection
→ Is unfamiliar with project goals and sensitivities

Who else? **What else?**

Considerations

How should we group supply-chain participants?

Do we need to further dissect each supply-chain participant?

Terminology . . . Does building manager imply the same thing as facility manager?

INTERNAL PARTICIPANTS	EXTERNAL PARTICIPANTS	DESIGN TEAM	TENANT	FACILITIES
Finance Department	Contractor	Contractor	Facilities department	Technician
Real Estate Manager	Architect	Architect	Business Unit using space	Manager
Building Manager	Engineer	Engineer	Real estate department	
Construction Manager	Consultant		Corporate management	

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 6
Schedule 9
Appendix G
Filed: 2011 Apr 1
(102 pages)

Canadian Industry Program for Energy Conservation
CIPEC

Energy Management Information Systems

ACHIEVING IMPROVED ENERGY EFFICIENCY

A handbook for managers, engineers and operational staff



Natural Resources Canada
Ressources naturelles Canada

Canada

Published by the Office of Energy Efficiency of Natural Resources Canada

Co-authored by James H. Hooke
Byron J. Landry, P.Eng.
David Hart, M.A., C.Eng.

Funded by Natural Resources Canada, Union Gas Limited, Enbridge Gas Distribution

CEATI – End-Use Technologies Interest Group
(BC Hydro, Manitoba Hydro, Hydro-Québec, Pulp and Paper Research Institute of Canada, New York State Electric & Gas Corporation)

2003

Disclaimer
The views and ideas expressed in this handbook are those of the authors and do not necessarily reflect the views and policies of the funding organizations. The generic opportunities presented herein do not represent recommendations for implementing them at a specific site. Before modifying any equipment or operating procedures, consult qualified professionals and conduct a detailed site evaluation.

Library and Archives Canada Cataloguing in Publication

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a handbook for managers, engineers and operational staff

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Contents

Preface

01

The Kyoto Protocol requires Canada to reduce its greenhouse gas emissions by 6 percent below 1990 levels by 2008–2012. This, in addition to rising energy costs and deregulation in the electricity and gas industry, has once again provided new impetus for companies to improve their energy use efficiency in order to reduce operating costs, increase profits and reduce greenhouse gas emissions that contribute to climate change.

This handbook, written for all levels of management and operational staff, aims to give a structured and practical understanding of an Energy Management Information System (EMIS) and to serve as an instruction guide for its implementation. Because it covers all aspects of an EMIS – including metering, data collection, data analysis, reporting and cost/benefit analyses – this handbook is an integral part of a company's Energy Management Program (EMP). The authors present state-of-the-art techniques coupled with their own experience and technical input from this handbook's sponsoring organizations: Natural Resources Canada, Union Gas Limited, Enbridge Gas Distribution and CEATI – End-Use Technologies Interest Group (BC Hydro, Manitoba Hydro, Hydro-Québec, the Pulp and Paper Research Institute of Canada and New York State Electric & Gas Corporation).

There are vast opportunities to improve energy use efficiency by eliminating waste through process optimization. Applying today's computing and control equipment and techniques is one of the most cost-effective and significant opportunities for larger energy users to reduce their energy costs and improve profits.

In his widely acclaimed book *Megatrends* (1982), John Naisbitt states, "Computer technology is to the information age what mechanization was to the industrial revolution." This insight has proven to be extremely accurate. Modern computing and control techniques, particularly in larger companies, are among the most cost-effective and significant tools with which industrial and commercial facilities can improve energy use efficiency.

> *"Computer technology is to the information age what mechanization was to the industrial revolution."*
>
> – JOHN NAISBITT

Today it is normal for companies, particularly in process sectors, to collect huge amounts of real-time data from automated control systems, including Programmable Logic Controllers (PLCs), Supervisory Control and Data Acquisition (SCADA), etc. In addition, a host of other computerized systems and associated databases are maintained at the corporate and/or managerial level. Integrated computer systems are commonly used to enhance performance in most facets of business, including finance and accounts, personnel, stock control, sales and marketing, production and scheduling, resource planning, asset management, maintenance planning, process control and monitoring, design, training and other areas.

However, unless this captured data is shared and analysed in an orderly and precise way that identifies problem areas and provides solutions, this mass of data is merely information overload.

Unanalysed data is information overload.

Data is not knowledge! Knowledge is information learned from patterns in data, and it follows that there must be the capacity and ability to convert information into knowledge in order to make sound energy-related business decisions. This is key in any management function. In many businesses it is often difficult to comprehensively analyse total energy use. Patterns of energy use are very complex, particularly in process industries where it is difficult to understand what causes energy use to rise and fall, especially when production rates are highly variable, when the product mix varies, or when there are several interacting processes at a single site. It is vital, however, for managers to be able to decipher this information in order to make good energy and business decisions.

Advances in information technology (IT), defined here as the use of computers to collect, analyse, control and distribute data, have developed rapidly. It is now common for managers and operators to have access to powerful computers and software. Today there are a number of techniques to analyse the factors that affect efficiency, and models are automatically generated based on "what if" scenarios in order to improve decisions to be taken.

In the 1980s, the Canadian Industry Program for Energy Conservation (CIPEC) developed two versions of an energy accounting manual (basic and advanced) to help Canadian organizations in the industrial, commercial and institutional sectors design and implement energy-accounting systems that were capable of monitoring energy productivity and performance. A 1989 revision of these manuals, still available from the Office of Energy Efficiency of Natural Resources Canada, discusses the fundamentals of energy accounting and provides a standard format that can be applied to single- and multi-unit organizations. The manual has been referred to as a first-generation energy management tool for businesses and other organizations.

In the 1990s, the UK Office of Energy Efficiency developed the first recognized energy management system, called Monitoring and Targeting (M&T). Based on the same fundamentals as CIPEC's energy accounting manual, it took full advantage of the increased use of computers and was the first automated energy management system. In the field of energy management, it was known as the second-generation energy management tool.

Both approaches, however, tend to focus exclusively on energy, with varying degrees of success. Most of the initiatives relate to low- or no-cost projects and seldom look beyond HVAC systems (set-points), compressors (air leaks) and similar actions for potential savings. Many businesses are unaware of opportunities for increasing energy use efficiency because there has been no in-depth analysis of credible and shared data that will identify profitable energy use efficiency improvements. As a general yardstick, most companies must sell $10 worth of product to realize a profit of $1. Conversely, every $1,000 saved by eliminating waste and improving energy use efficiency is the equivalent of an additional $10,000 in sales.

Recognizing the proliferation of computerized systems and the potential that databases offer, the consortium members (see inside cover) supported the development of this handbook. Its goal is to identify what a company needs in order to develop an EMIS and what it should do to get there.

This handbook is structured to allow each level of staff within an organization to refer to sections that are specifically pertinent to them, but the authors recommend that all levels of management read the entire handbook.

The authors have been part of the groups that developed and implemented the EMIS examples described in this handbook, and their practical application of proven information reflects the authors' underlying theme that energy is a variable operating cost, not a fixed overhead charge.

Energy is a variable operating cost, not a fixed overhead charge.

02 What Is an Energy Management Information System?

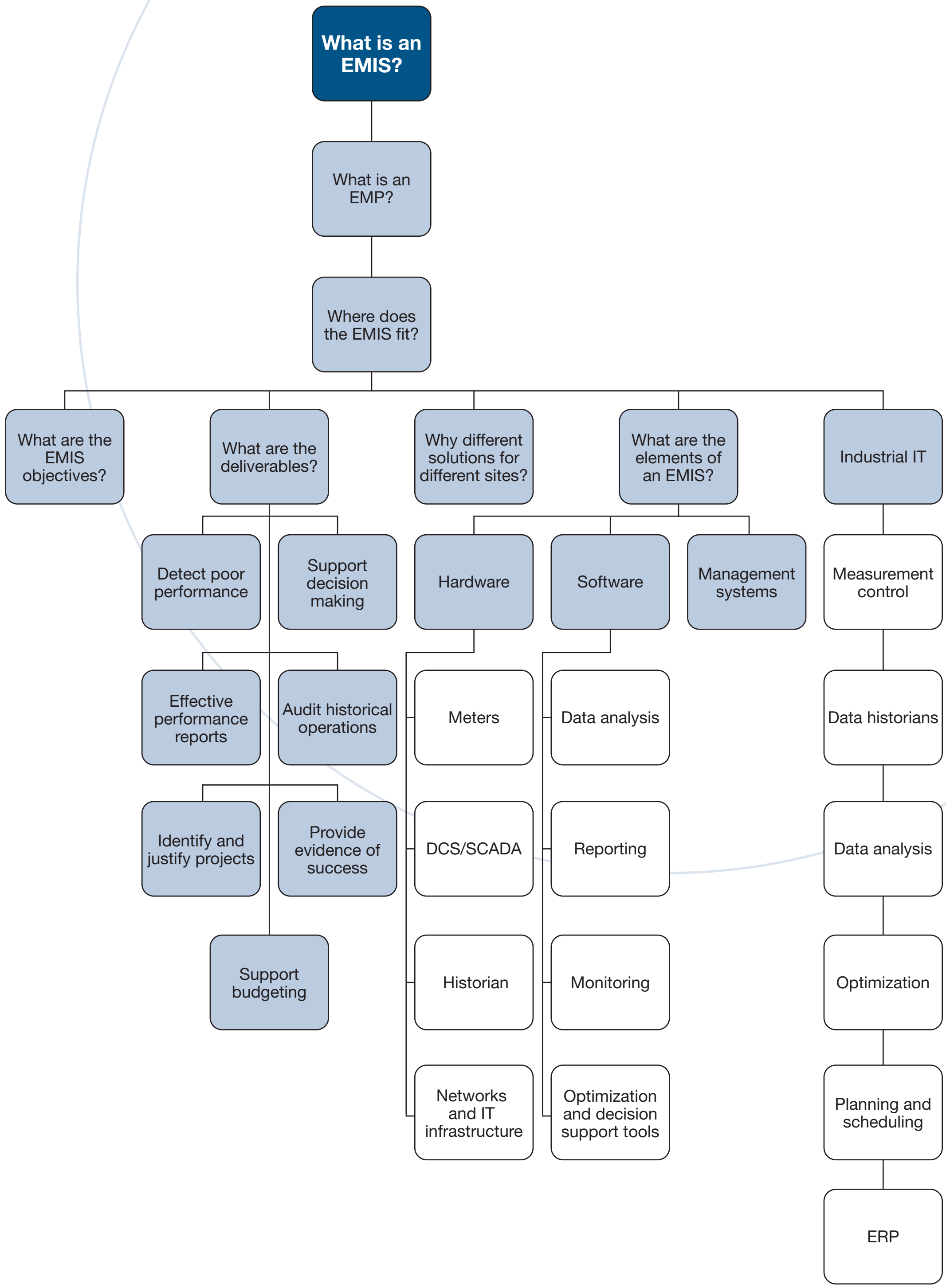
Overview

An Energy Management Information System (EMIS) is an important element of a comprehensive energy management program. It provides relevant information to key individuals and departments that enables them to improve energy performance.

An EMIS can be characterized by its deliverables, features, elements and support. Deliverables include the early detection of poor performance, support for decision making and effective energy reporting. Features of an EMIS include the storage of data in a usable format, the calculation of effective targets for energy use, and comparison of actual consumption with these targets. Elements include sensors, energy meters, hardware and software (these may already exist as process and business performance monitoring systems). Essential support includes management commitment, the allocation of responsibility, procedures, training, resources and regular audits.

This section outlines what constitutes an effective EMIS. The checklist in Section 10 will help determine whether a proposed or existing EMIS will succeed. Questions addressed in this section are summarized in Figure 1.

Figure 1. Basics of an EMIS



2.1 What Is an EMIS?

An EMIS provides information to appropriate personnel within an organization to help them manage energy use and costs. The exact nature of the EMIS will depend on

- the particular site
- the processes and plant involved
- the cost of energy (in relation to other costs)
- existing meters and instruments
- monitoring and control systems
- the data historian
- data analysis and reporting systems
- existing management systems

In this handbook, an EMIS is defined principally in terms of what it delivers to the organization; how the deliverables are achieved is secondary.

Over the years, EMISs have been implemented with varying levels of success and sustainability. The checklist in Section 10 outlines what constitutes an effective EMIS, i.e., one that will reduce energy costs by at least 5 percent and sustain that improved performance. Readers should ensure that their proposed or existing EMIS meets these requirements (examine each of the items in the checklist).

This handbook discusses the components in the checklist in some detail, and we strongly suggest that readers revisit the checklist once they have studied this handbook.

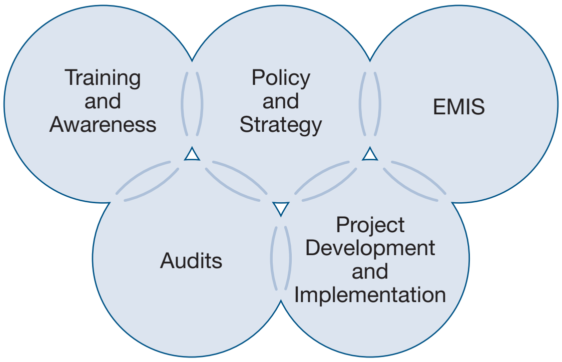
2.2 Energy Management Programs and the EMIS

An Energy Management Information System (EMIS) is only one element of a comprehensive energy management program (EMP), albeit an important one without which full benefits will not be achieved and sustained. A good EMIS should reduce energy use (and cost) by at least 5 percent.

Actions that generally need to be taken in order to address energy use in an EMP may include one or more of the following:

- developing and approving an energy policy and strategy
- training and actions to raise knowledge and awareness
- energy audits to identify and evaluate opportunities
- developing and implementing improvement opportunities
- implementing performance management systems, including the EMIS

Figure 2. Elements of an energy management program (EMP)



How does the EMIS fit with an Energy Management Initiative?

An organization's energy policy should have agreed-upon objectives and demonstrate senior management's commitment. The policy's energy strategy should outline specific plans to achieve improved performance.

Training is essential to ensure that operations personnel understand key energy issues and what actions they need to perform in order to reduce costs. Activities to raise awareness can also be used to emphasize the need to reduce energy use and make the link between energy and the environment.

Energy audits are traditionally the foundation of an organization's energy conservation plan. Audits are usually carried out by experienced engineers and identify and quantify where energy is used and find measures for improvement. These measures may be low- or no-cost changes or require capital investments.

Once opportunities are identified, they need to be developed into projects that can be justified and implemented. Developing the project includes accurate estimates of costs and benefits and assessments of practical, safety and environmental issues.

Performance management systems aim to ensure that benefits are achieved and sustained through monitoring, performance analysis and effective reporting to all levels of an organization.

An EMIS is the key element of performance management; it also provides essential support to the energy auditing process. A modern EMIS will be a software solution that is tightly integrated into an organization's systems for process monitoring and control and IT systems. Furthermore, the EMIS will often be part of a larger system used to manage process (and business) performance more generally.

It is important to recognize that an EMIS does not stand alone. It needs management commitment, procedures, organization, training and appropriate technical expertise.

2.3 What Does an EMIS Deliver?

The principal objective of an EMIS is to support an organization's energy management program. Its specific deliverables are as follows:

2.3.1 Early detection of poor performance
2.3.2 Support for decision making
2.3.3 Effective performance reporting
2.3.4 Auditing of historical operations
2.3.5 Identification and justification of energy projects
2.3.6 Evidence of success
2.3.7 Support for energy budgeting and management accounting
2.3.8 Energy data to other systems

Understanding what an EMIS can deliver is vital if an effective system is to be designed and implemented. Based on the following discussion, readers should be able to specify the requirements of an EMIS for their particular site.

Specify what the EMIS will deliver.

2.3.1 Early Detection of Poor Performance

A key deliverable of an EMIS is that it will identify poor operations quickly and effectively. Examples are:

- incorrect control set-points
- equipment left operating unnecessarily
- faults with equipment, for example, heat exchanger fouling, air in refrigeration condensers, etc.

Such faults should be identified as quickly as possible and corrected with practical and cost-effective solutions. It is not sufficient to detect a problem that has occurred in the past (for example, last week) that cannot now be rectified because too much time has elapsed and operations have moved on to a new "mode."

Comparing actual performance with targets generally identifies poor performance. A deviation from the target causes an alert. Performance indicators include energy consumption, but can also include measures of efficiency and indirect indicators of performance (for example, the oxygen level in a boiler's exhaust).

Targets can be defined in a number of ways, all of which can be usefully applied. Examples are:

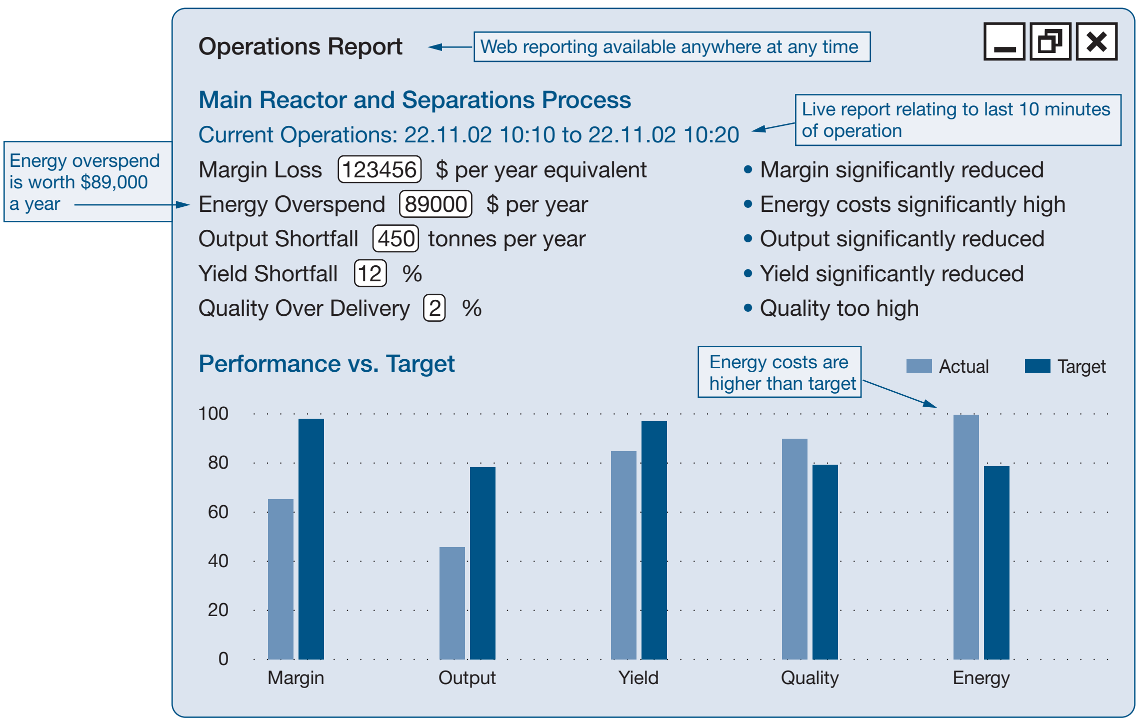
- the performance typically achieved by the process in the past – current and future performance can be measured against this to demonstrate progress (**benchmark**)
- the best performance that the process could achieve or has achieved in the past (**best practice**)
- a desired level of performance, for example, 5 percent below the benchmark (**reduction**)
- budget performance (**budget**)

Comparing actual performance with targets identifies poor performance.

Key to success is that targets are sound, taking full account of relevant influencing factors. This is discussed in detail in Section 8.

The frequency of performance monitoring will vary depending on the application. In a complex process that uses a lot of energy, reporting every 15 minutes may be appropriate, especially where the operator can make process changes in response to performance alerts. On the other hand, an EMIS associated with a central refrigeration unit, for example, may report only daily or weekly because faults are likely to be slow to develop and be rectified only through maintenance actions (for example, condenser cleaning, refrigerant charging, etc.).

Figure 3. Operations report showing poor performance



Figures 3 and 4 show examples of reports that identify performance. Shown in Figure 3 is an alert that the last 10 minutes of performance is poor. Shown in Figure 4 is a shift performance summary showing performance that is improving.

Figure 4. Operations report showing improving performance

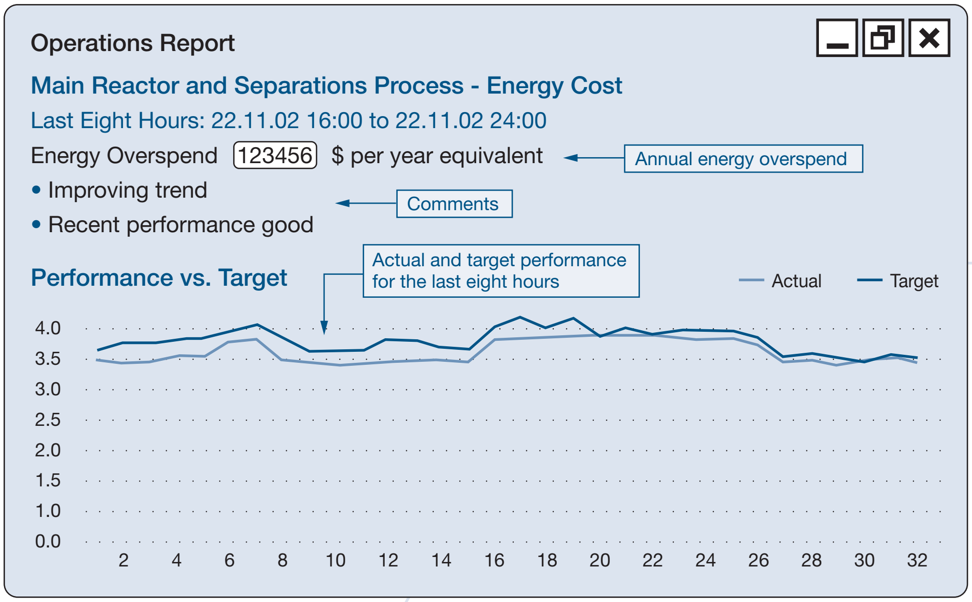


Table 1 lists examples of typical problems and their respective monitoring frequencies that a performance monitoring system can identify.

Table 1. Examples of typical problems that cause higher energy costs

Typical Problems	Monitoring Frequency*
Process Operations	
• incorrect set-points	hourly
• fouled heat exchangers	daily
• advanced controls switched off	hourly
• poor control timing	hourly
Boilers	
• poor air-fuel ratio	hourly
• fouled exchangers	daily
• excessive blow-down	hourly
• incorrect boiler selection	hourly
Refrigeration	
• fouled condenser	daily
• air in condenser	daily
• incorrect superheat settings	daily
• high head pressure settings	daily
• incorrect compressor selection	hourly
Compressed Air	
• leaks	daily
• poor compressor control	daily/hourly
• incorrect pressure	hourly
Steam	
• leaks	hourly
• failed traps	hourly
• poor isolation	hourly
• incorrect set-points	hourly
• low condensate return	hourly
Space Heating/Cooling	
• excessive space temperature	hourly
• excessive fan power use	hourly
• overcooling	hourly
• heating and cooling	hourly
• high chilled water temperature	hourly
Power Generation	
• poor engine performance	hourly
• incorrect control settings	hourly
• poor cooling tower operation	hourly
• fouled heat exchangers	hourly

* Appropriate monitoring frequency depends on the application.

2.3.2 Support for Decision Making

Often, alerting operational personnel and management to poor performance is enough to solve a problem. Such personnel may be experienced enough to understand the reasons for higher energy use and take appropriate remedial action. On the other hand, they may not have the needed experience or sufficient time to conduct an analysis.

Where there is a difficulty in deciding how to act on a problem, decision support systems should be considered as part of an EMIS. Such systems provide supporting information and can take several forms, from guides and charts to sophisticated computer systems.

The "knowledge" within these decision systems can be either

- from experts (**expert systems**, or **knowledge-based systems**); or
- learned from operating data (**data mining**).

The more complex and energy intensive the process, the more likely a decision support system can be justified.

Example 1. Brewery Refrigeration Expert System

A large brewery implemented an expert system to provide decision support to utility plant engineers to help them respond to sub-optimal refrigeration performance. The result was a 29.5 percent reduction in electricity consumption by the refrigeration system. The payback period for the system was well under one year.

The refrigeration plant provided chilled secondary refrigerant at approximately −3.5°C to the brewery to cool process streams, vessels and cold rooms. The energy use efficiency of the refrigeration systems was significantly affected by

- the secondary refrigerant temperature
- evaporator operation, especially fouling and the level of refrigerant
- refrigerant leaks
- expansion valve settings
- condenser performance, especially fouling and the buildup of air and non-condensable gases
- head pressure set-points
- cooling tower performance

Problems had been occurring from time to time, but they had not been specifically identified. Monitoring energy use against targets and using the expert system rectified this. Diagnosing the cause of high energy use is a relatively complex task; the key performance indicators will vary with cooling demand, secondary refrigerant temperature, ambient temperature and humidity. Analysing the situation involves

- modelling refrigeration system operation to determine expected operating conditions
- comparing actual values with the model expectations
- interpreting deviations (for example, the presence of air or non-condensable gases is indicated if the condensing pressure is high or if the liquid sub-cooling is high)

Although engineers can work through this analytical process, few have sufficient time to do so. The expert system automated the task and rapidly diagnosed the problem.

Today, developing and implementing expert systems is relatively easy. Establishing "rules" for such systems should not be difficult or complex; it is necessary only to apply simple rules consistently, accurately and quickly.

Recently, decision support systems have been implemented where "rules" are learned from historical operating data. In these cases, the system tells the operator how to modify process operations in order to achieve the best performance levels observed in the past (see Figure 3). This ensures that operations employ consistent best practices.

Figure 5. Report with instructions on how to achieve optimum operating conditions

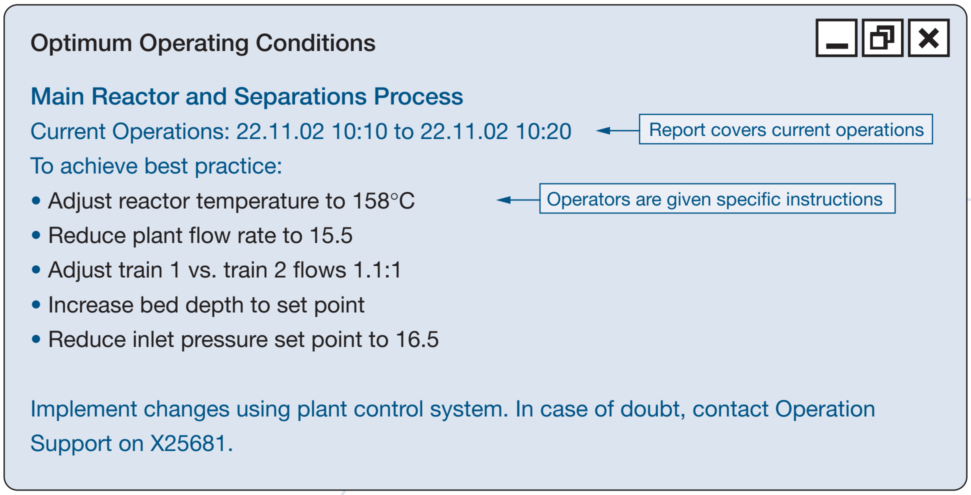
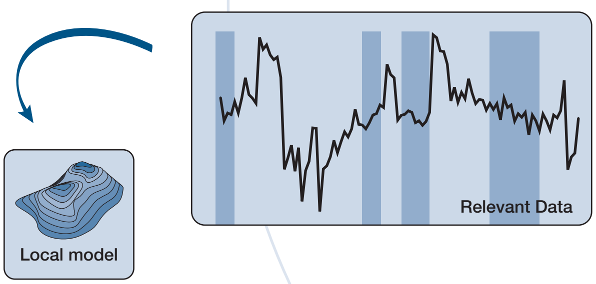


Figure 6 illustrates the concept of learning from data. Operating periods in the past that were similar to current operations (i.e., similar external disturbances such as production levels, quality, ambient conditions, etc.) are found. The best performing periods are then identified and used to determine the best set of operating conditions. In some circumstances, a simple paper-based system (based on experience or theory) can be useful.

Figure 6. Learning from data



In general, capturing knowledge about operations performance is worth serious consideration. This knowledge should be made readily available within the organization (for example, via corporate intranets).

2.3.3 Effective Performance Reporting

In addition to reporting problems to operations staff, the EMIS should also provide reports to management, executives, engineers and other key personnel (see Section 7). This is to ensure that the appropriate resource(s), commitment and expertise are applied to energy use efficiency. It is a key part of the management process to ensure that those responsible for performance are taking effective action.

Figure 7. Example of management report, showing weekly progress

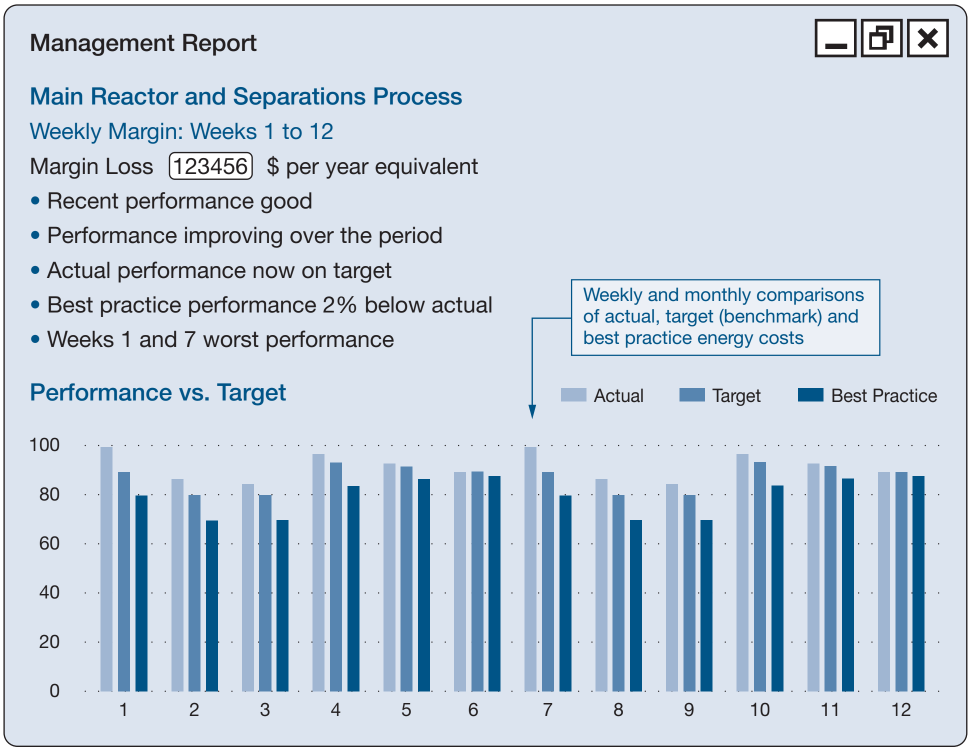
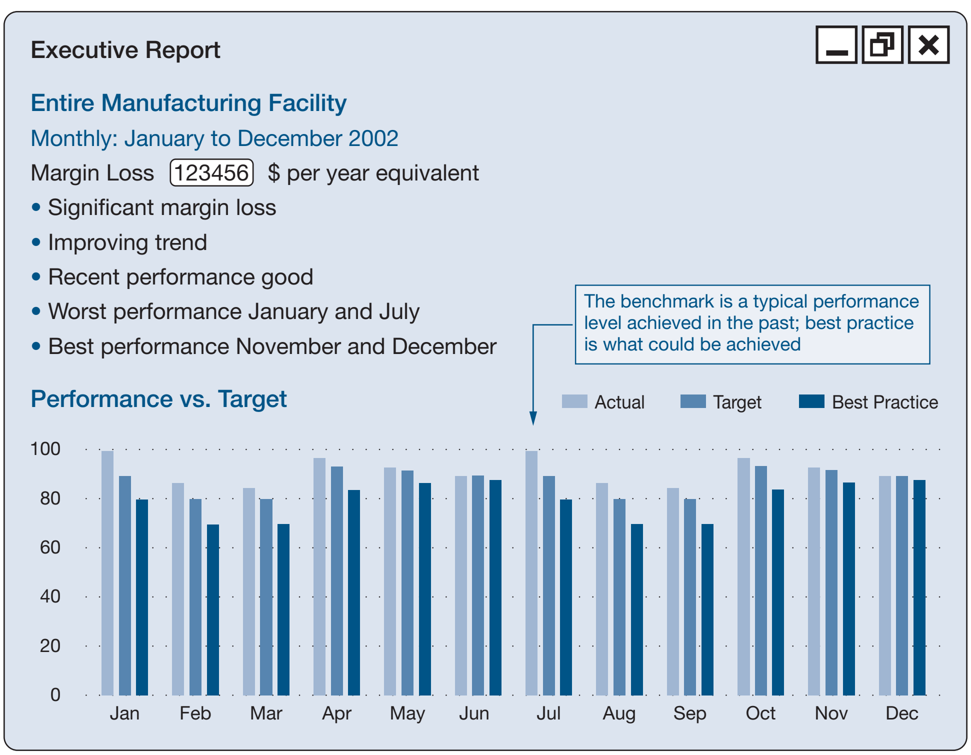


Figure 8. Example of executive report, showing monthly progress



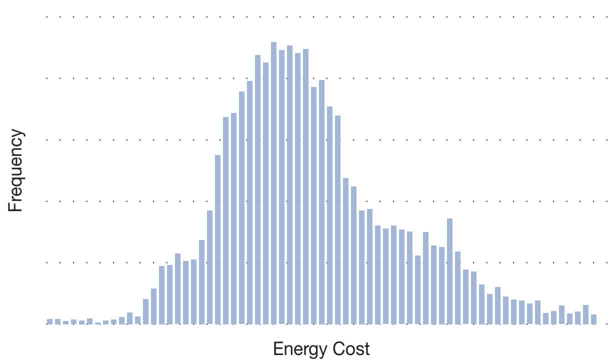
2.3.4 Auditing of Historical Operations

As well as providing ongoing information about the current energy performance of processes and equipment, an EMIS can be used to analyse historical performance. To do this, the EMIS needs a database of historical energy information and influencing factors. With modern data analysis techniques (see Section 8) this data can provide

- an audit of historical operations (**what has happened**)
- an explanation or variations in energy performance (**why energy use varied**)
- an audit of energy use and costs (**what operations cost**)

From this analysis, engineers and managers can improve their understanding of energy use efficiency, leading to better decisions.

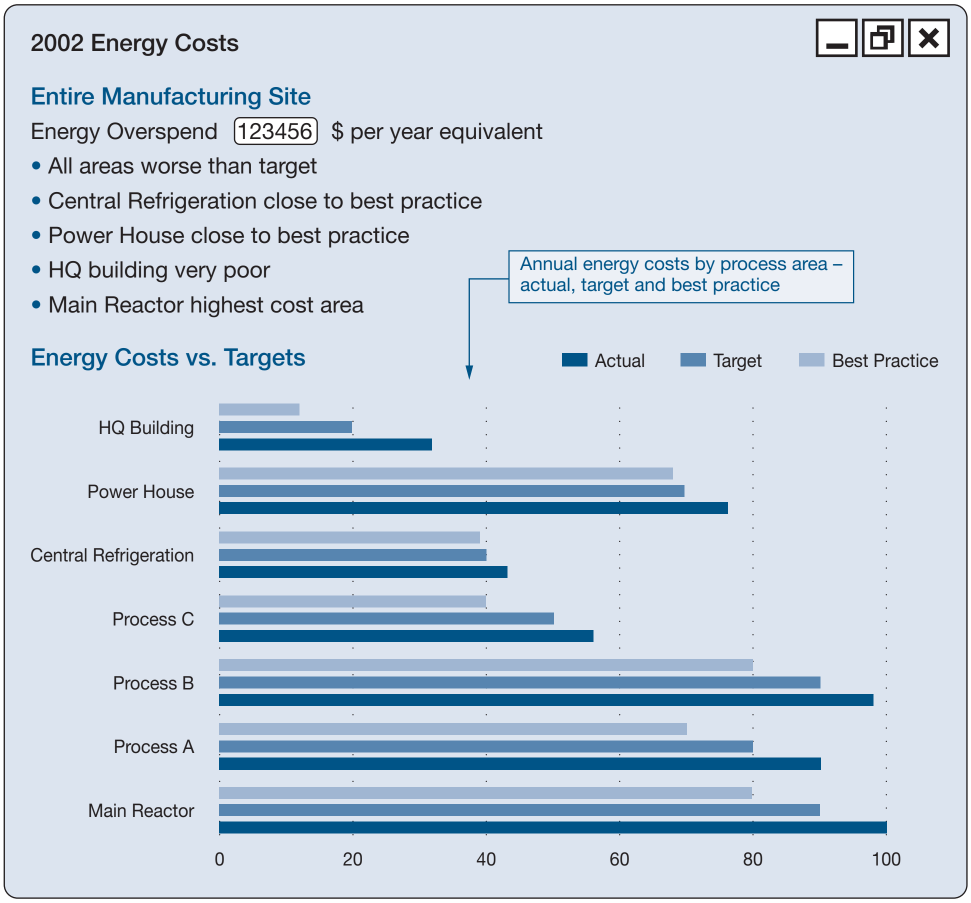
Figure 9. Example of frequency distribution



The EMIS facilitates the understanding of energy performance variations. In Figure 9, the frequency distribution shows that energy costs vary considerably about the mean. Is this due to external factors or to decisions made by plant operations and management personnel?

The "what has happened" factor is especially important in order to challenge under-performing areas (see Figure 10).

Figure 10. The EMIS should quantify energy use and costs



2.3.5 Identification and Justification of Energy Projects

An EMIS can be the foundation for identifying and justifying energy use efficiency projects. Improvements to operations and control settings can be identified using historical operating data with advanced analysis techniques (see Section 8). These improvements tend to be low- or no-cost "quick hits" and are especially attractive because they can quickly justify investment in an EMIS. Often it makes economic sense to conduct this analysis as a first step.

Analysing historical data can also reveal opportunities that require investment. Importantly, the data available from a correctly configured EMIS can

- challenge barriers to energy projects, including disagreement about how the plant is operated (e.g., is it operated close to a process or marketing constraint?)
- quantify improvements and allow energy investment to be justified

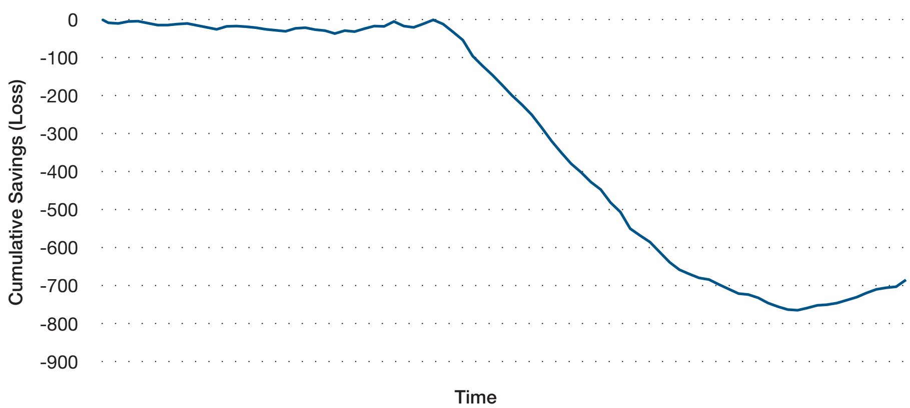
2.3.6 Evidence of Success

The EMIS must clearly show that actions taken to reduce energy use and costs have been successful (or not!). This is to justify ongoing investment in the systems, validate energy-saving decisions, demonstrate the improvements achieved and satisfy regulatory and voluntary reporting, etc.

To do this, there should be a benchmark – a value for energy use that can be compared with current usage. The benchmark must take into account external influences on energy use (production, ambient temperature, etc.). Typically, the benchmark is a model built from historical operating data. Regression is sometimes acceptable, but analysis techniques that are further advanced are more often needed (see Section 8).

A cumulative sum (CUSUM) graph can show improved performance effectively.

Figure 11. Graph showing cumulative savings achieved since an EMIS was installed



2.3.7 Support for Energy Budgeting and Management Accounting

An EMIS provides information to facilitate budgeting. Historical relationships between production and energy use can be used with production estimates to forecast future energy use.

The EMIS will also provide a breakdown of energy use and cost by product, process or department in order to

- improve management accounting;
- determine the true cost of energy, for example, to make specific products; or
- understand the impact of production volumes on energy cost per tonne of product.

2.3.8 Energy Data to Other Systems

An EMIS may also provide energy data and models to other systems. Examples are production planning and scheduling systems, energy, resource planning systems, management information systems, corporate systems and environmental reporting, etc.

2.4 What Are the Elements of an EMIS?

An EMIS comprises a number of elements that are integrated to form a complete solution. These elements include sensors and instruments, data infrastructure and software tools. Typically, separate suppliers will provide individual modules of the system.

As far as possible, EMIS components will be the same as those used to operate and manage the plant and process performance more generally, i.e., the performance management information system. There is a danger in developing an independent system for energy alone, and this approach has resulted in failures in the past. Energy use efficiency is only one aspect of process (and business) performance and should be considered in conjunction with other business objectives such as output, yield, quality, reliability, environment and **profit**.

In addition to hardware, the EMIS includes management systems to ensure that performance improvements are achieved.

It may well be that the elements of an EMIS already exist within an organization but are not employed to manage energy use.

Sensors and instruments include energy meters (electricity, gas, oil, steam), other utility meters directly associated with energy use (heat flow, cooling flow, compressed-air flow) and temperature, pressure, flow, composition and similar devices used to measure factors that influence energy use.

The sensors and instruments will usually be connected to a monitoring system, which should always be the monitoring and control system used for the process generally. This may be a distributed control system (DCS) in larger installations or a SCADA/PLC installation. In commercial installations, building management systems are used that are similar to SCADA/PLC.

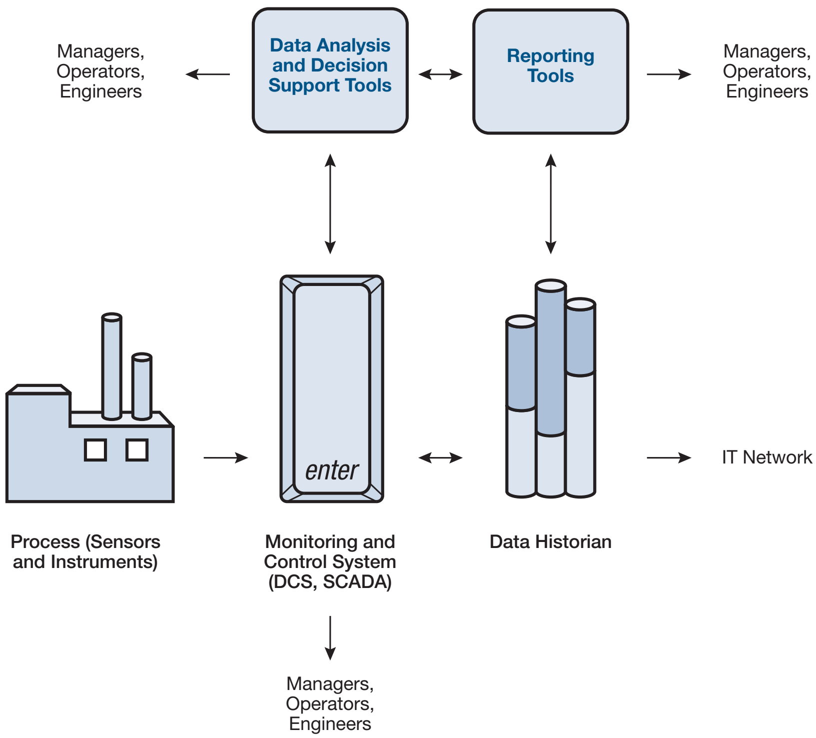
Data collection should be automated. A data historian that is designed for time-series data storage is typically used. Manual data collection is considered all but obsolete.

Software tools that form an EMIS typically integrate directly with the control/monitoring system and data historian. These include:

- data analysis tools
- reporting tools
- monitoring software
- optimization and decision support software

Interfaces between these tools and the control/monitoring and data historian systems are standard and generally simple to implement. Typically, the EMIS and process monitoring and management infrastructure will be networked with the corporate IT systems. Figure 12 illustrates the elements of a typical EMIS.

Figure 12. Elements of a typical EMIS



2.5 Solutions for Different Circumstances

The features, benefits and elements of the EMIS should be appropriate to the specific site. At a larger, energy-intensive site where there is a modern monitoring and control infrastructure, all the capabilities described in this handbook will be needed. At a smaller site, however, there may be a case for less comprehensive instrumentation, less frequent monitoring and reporting, and less sophisticated analysis of data. This handbook allows readers to choose system elements that are appropriate for their situations. The optimum solution depends on

- the importance and level of energy cost savings achievable
- the rate at which faults can develop and the time required to act on them
- the existing infrastructure that the EMIS can utilize
- the capital available for investment in the EMIS

Many companies that have developed a vision for an EMIS are obliged to move ahead in stages, earning the capital for the next step from savings realized. In terms of system requirements, there is little difference between an EMIS that is used in the industrial sector or the commercial sector, although its implementation may differ. For example, monitoring in the commercial sector will typically involve the building management system, and more responsibility will rest with facility operating personnel to reduce energy use, although feedback from building occupants should be factored into consideration.

Multi-site organizations may want to introduce a corporate EMIS to report centrally and analyse the organization's energy performance as a whole. To achieve this, data historians at each site should be linked, and the analysis and reporting tools should be able to access the combined data. There may be an additional central database of selected information. In addition to providing corporate energy reports (total company energy use vs. targets, for example), it may be possible to analyse corporate data to reveal higher-level patterns in energy use. For example, where several sites operate processes that are similar, it may be possible to find best-practice operating systems and conditions, optimum maintenance, best contractors, best equipment types and suppliers, etc. Advanced data analysis is discussed in Section 8.

What Makes an EMIS Successful?

03

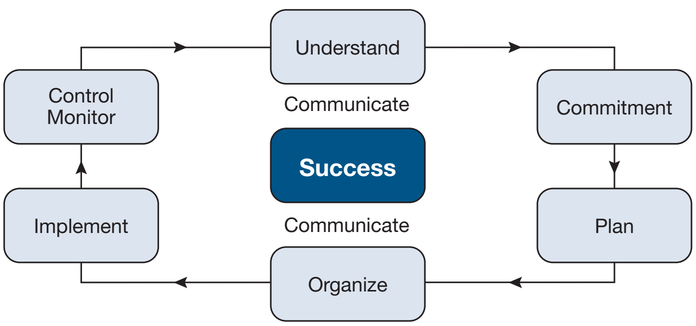
Overview

This section identifies some of the critical elements that should be addressed if an EMIS is to be successful. As stated in Section 2, an EMIS is only one element of an energy management program. Energy management requires the same sound business practices that are applied to finance, production, marketing and administration.

Energy management will deliver sustainable results when there is a clear direction that is embedded in the company's long-range business plan (i.e., policies, objectives, personnel and financial resources).

Sustainability can be achieved only through commitment at all levels of a company's organization – from the board of directors, the president, senior management, operational staff and administration. As shown in Figure 13, the first step toward commitment is understanding. What is not understood will not be supported!

Figure 13. Steps toward achieving success



Although an energy management program and an EMIS are intrinsically connected, there is an important distinction between them. An EMIS provides information; an energy management program takes action and returns results. It is important to recognize the difference when evaluating an organization's situation.

3.1 Elements of Success

The following elements directly influence how successful an EMIS will be:

3.1.1 Management's understanding and commitment
3.1.2 Company policies, directives and organization
3.1.3 Program responsibilities
3.1.4 Procedures and systems
3.1.5 Project selection and focus
3.1.6 Approved budget
3.1.7 Approved investment criteria
3.1.8 Training
3.1.9 Integrated information systems
3.1.10 Reports on savings achieved
3.1.11 Motivation
3.1.12 Marketing

3.1.1 Management's Understanding and Commitment

To achieve any sustainable energy initiative, it is essential to have senior management's visible and active support. This may seem obvious, but it is routinely identified as a major barrier in establishing and maintaining a serious energy management program. Among the reasons for lack of support are:

- The CEO, president and/or board of directors are unaware of the financial benefits that a corporate-approved energy management initiative will have on the balance sheet.
- Senior managers may not be convinced that new initiatives that are part of the company's strategic business plan will be of benefit.
- Previous initiatives have failed to deliver the targeted improvements.

The company's energy manager should consider the following:

- Is senior management being provided with factual and justifiable information upon which they can base their commitment?
- Does senior management receive reports on time and in the required format?
- Are the reports part of the company's Executive Information System (EIS)?

Remember, it is senior management that establishes policies, objectives and associated budgets, not middle management or a designated energy manager (see Sections 5 and 6, especially Section 6.5, "Obtaining Support From Decision-Makers").

3.1.2 Company Policies, Directives and Organization

To ensure that energy use efficiency becomes an integral part of a company's business plan and not just a side issue or ad hoc initiative, a clear set of policies, directives and organizational structure must be developed and approved at the most senior level. Specifically, there should be

- a clear energy use efficiency corporate or company policy statement that specifies energy goals and objectives

- an approved organizational structure and commitment to improving energy use efficiency
- a strategic action plan and time frame
- a strategy and plan to involve all employees by seeking their input and involvement

Energy management is first and foremost a management and organizational effort. Without proper attention, the program will have only marginal success or fail altogether.

3.1.3 Program Responsibilities

Because successful energy management is people-oriented (the more people involved, the more effective the program), the efforts of everyone involved must be structured and planned. The following can be considered a management equation for improving energy use efficiency:

Responsibility = Accountability + Authority

An assigned responsibility implies accountability. If these two parts of the equation are valid, then the person must have the authority (including an approved budget) to achieve company-approved objectives, goals and targets.

In smaller organizations, it may be that management is responsible for reducing energy consumption as part of its regular management duties.

In larger companies, an energy manager or coordinator must be assigned to be fully responsible for any initiative and be accountable to senior management for its success. Ideally, the individual should be an experienced line manager with some project management background and be people-oriented.

Although fully responsible for an organization's energy initiative, an energy manager obviously cannot work in isolation. The next step is to establish an energy management committee that should include staff from each major energy-using department, including representatives from operational staff, plant maintenance, engineering and finance. In most cases, the energy manager or plant energy coordinator chairs the committee.

3.1.4 Procedures and Systems

Who? What?
Where? When?
How? Why?

Procedures and systems are very important areas that must be challenged and reviewed. Often there can be significant initial low- or no-cost savings.

A well-structured EMIS will identify what areas should be reviewed, inspected and audited. It will also help managers and operational staff understand how answers to these questions will improve energy use efficiency. Challenge operational staff by asking, "If there were no financial or physical restrictions, what changes – operationally and financially justified – would you recommend?"

3.1.5 Project Selection and Focus

An efficiency initiative in one area or process will inevitably affect another.

3.1.6 Approved Budget

In today's business environment, there is significant internal competition for financial and human resources. An energy management program will be effective only to the degree that funds and personnel are available to develop and maintain it. It is therefore essential that the energy manager and the energy management committee develop a cost-effective business plan for senior management's approval.

3.1.7 Approved Investment Criteria

It is of little value to pursue initiatives or projects that require capital expenditures if the company's position is not clearly identified and understood.

- First cost: It may be company policy to obtain the best price for new or replacement capital equipment instead of also considering the long-term energy cost.
- Life-cycle cost: The company should consider the operating efficiency (cost) of the equipment during its life cycle.
- Payback period: If it is company policy to have an 18-month period for repayment of initial investment, it is unrealistic to prepare a proposal that has a payback period of, for example, three years.

3.1.8 Training

Training is often forgotten, under-emphasized and under-funded. Unless operational managers and plant staff receive adequate training on new techniques and equipment, many of the projected savings will not be realized.

For example, even though computers are now commonplace in today's working environment, not everyone is computer literate. Because equipment and controls involve computers, training in this area is important and will return value quickly. New techniques in other areas also require training.

3.1.9 Integrated Information Systems

Company information systems must be integrated so that data can be shared among departments. A company may maintain a number of databases, some of which may contain duplicate data. Managers and staff must not feel that if they share data it will somehow infringe upon their area of responsibility. The data belongs to the company, not to individual managers or departments.

3.1.10 Reports on Savings Achieved

Make certain that every saving achieved is recorded and reported to senior management. One of the major barriers to maintaining senior management support is irregular reporting. Relevant information should be forwarded to all company personnel relative to their area of responsibility or involvement. They contributed to the savings and should be apprised of what their efforts have accomplished.

3.1.11 Motivation

Motivation is a key factor in everyone's workday. Regular formal or informal communications of the objectives, goals, targets and achievements is a considerable factor in the success of an energy management program. Remember that energy management depends on people. Their participation and motivation to contribute to its success are essential – don't forget them!

3.1.12 Marketing

A company's image regarding energy and environmental issues is becoming increasingly important. Some companies are already reporting to governmental agencies what energy and CO_2 emissions reductions they have achieved, and they're also telling their customers and clients. They rightly take pride in documenting and publishing their success stories. Companies want the public to know that they are good corporate citizens – that they are improving their energy use efficiency and reducing greenhouse gas emissions that contribute to climate change.

3.2 Evaluation

It is important to evaluate a present Energy Management Program (EMP); this will also serve to distinguish between an EMP and an EMIS (see Section 2). Tables 2 and 3 will help with evaluating your organization's corporate energy management program.

Table 2. Success matrix

Factor	Assigned Value	Weighting Factor*	Present Assessment	Improvement Target
Management commitment	20			
Company policies, directives, organization	10			
Program responsibilities	10			
Procedures/systems	5			
Project selection and focus	15			
Approved budget – financial and other resources	15			
Approved investment criteria	3			
Training	5			
Integrated information systems	5			
Achieved savings are reported	5			
Motivation	4			
Marketing within and outside company	3			
Total	**100**			

*Weighting Factor Multiplier
No action: 0 percent
Weak initiative: 25 percent
Average initiative (including some weaknesses): 50 percent
Adequate initiative: 75 percent
Excellent initiative: 100 percent

Table 3. Evaluating a corporate energy management program

Scale	Energy Policy	Organization	Budget	Investment	Information Systems	Training and Motivation
4	• Signed and published policy • Detailed action plan • Evaluation and review process as part of corporate business plan and integral to corporate business strategy	• Energy management assigned to senior manager • Line manager's responsibility and reporting is part of job description • Senior management actively participates	• Energy deemed an operating cost, with specific corporate budget by responsibility or operational cost centres	• Favourable investment is applied to all new, replacement or upgrades of equipment, systems and procedures regarding energy • Environmental policies • Life-cycle cost analysis	• Comprehensive EMIS monitors consumption, faults, solutions and savings vs. budget • Integrated with corporate main information system	• Regular upgrading of staff's technical skills • Reports and marketing of results internally and externally via newsletter on other regular publication(s)
3	• Formal policy and action plan but is not part of corporate business plan • No active commitment from senior management	• Appointed energy manager reports to a senior manager • Energy committee of major energy users established and chaired by plant energy manager	• Funding approved on a project-by-project basis from general operating budget • Prioritized by energy committee and approved by plant energy manager	• Same payback criteria as for all company investments	• Monitoring and control systems based on sub-metering • No tie-in to corporate system • Savings not reported effectively to management and other staff	• Limited training/ awareness programs • Results are publicized internally and externally
2	• Unofficial policy established by energy manager or senior departmental manager	• Energy manager appointed and reports to ad hoc committee • Unclear line of authority	• Must compete with other company operating/ capital requests or initiatives	• Short-term investment only	• Cost reporting based on meter reading or utility reports retained by individual manager	• Some ad hoc training and awareness initiatives
1	• Unwritten policy or guidelines	• Energy management is a part-time responsibility • No line authority or real influence	• No specific funding available	• Low- or no-cost initiatives only	• No information system used to unofficially track energy consumption	• Limited and informal training
0	• No stated or implied guidelines	• No responsibility	• No funding	• None available	• No accounting for energy consumed	• No contact with staff

Real-Time Data Is Required

04

What Is Real-Time Data?

Real-time data is collected automatically at predetermined intervals. For a similar cost, measurements can be recorded every day or every second. To be useful, however, the frequency of data collection should

- be sufficient to allow problems and remedies to be identified in time to save energy (i.e., before the problem is over and the process has moved to another operating mode)
- be more frequent than the fluctuations in energy use that need to be understood (at least twice the frequency)
- should not be so frequent that changes are due to control system variations rather than true variations in energy performance

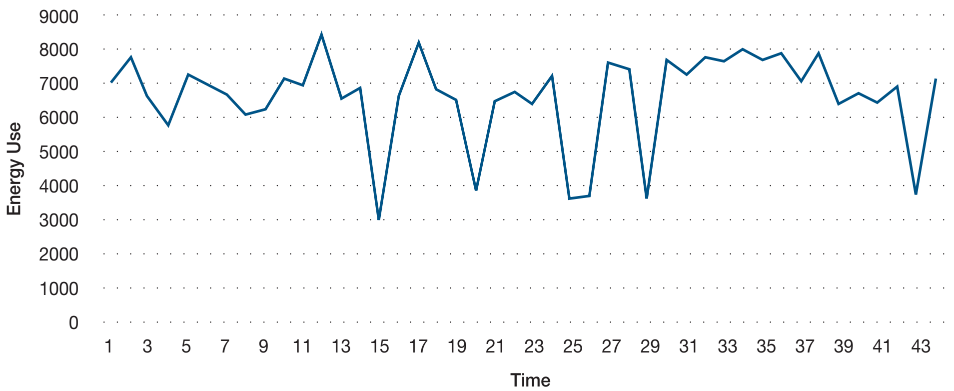
Low-frequency data produce crude targets and have caused some systems to fail. If a manager cannot see the effect of his or her actions on performance, system credibility will be lost. No savings will be achieved other than those that tend to follow the implementation of any EMIS and/or M&T system because of its sole focus on energy savings. These savings, however, are well below what is possible and typically will not be sustained. An EMIS should operate in real time for the following reasons:

- A real-time system will identify poor performance (i.e., a problem) sufficiently quickly for action to be taken.
- Real-time data can provide a better understanding of historical operations.
- Real-time data can produce better targets (models).
- Real-time information is better for activity-based costing.
- Real-time energy data is consistent with data collection to manage general process performance (energy, yield, etc.), and integration with these systems is key.

Identifying poor performance quickly allows staff to correct the problem and achieve energy savings. Contrast this with a system that simply tells the user that a problem occurred yesterday or last week; the operator is left knowing that an opportunity has been missed and is faced with the problem of making sure that the next problem is identified through real-time monitoring.

Contrast a profile of energy demand with a single value for total energy used. Figure 14 shows the various modes and blips, revealing important patterns and providing a basis for more comprehensive data analysis (see Section 8).

Figure 14. A profile showing blips in energy use



Arguments against using real-time systems include the following:

- Cost – Meters can be read manually, but what is the cost (i.e., personnel time) of manually collecting data? Readings **must** be taken at the same time each recording period (day/time) to be credible (this includes statutory holidays at premium overtime hourly rates).
- Less complexity – Systems that do not operate in real time are less complex, but what is their price in sacrificed energy savings?

How Can Action Ensure Improvements?

05

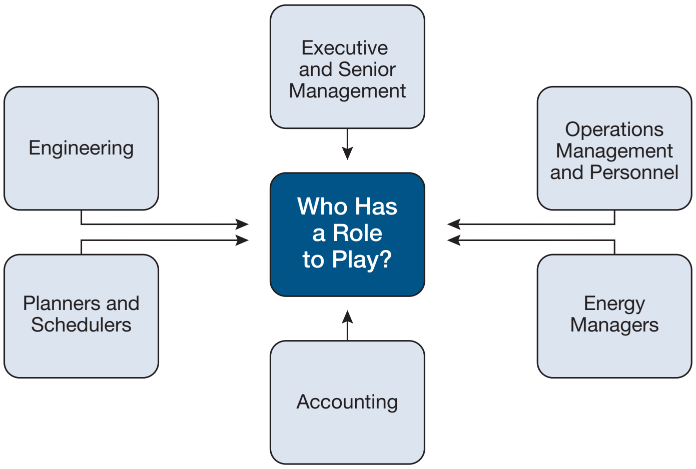
Overview

There is little value in initiating an EMIS if action is not taken on data analysis results. This section focuses on how to ensure that the EMIS is acted upon so that savings are achieved. Also outlined are who should take action, how and when they should act, and what they need to ensure that they take action.

5.1 Who Should Take Action?

Action to achieve improvements is best ensured by an organizational culture that encourages, rewards and sustains initiatives that reduce utility costs. Although an EMIS supplies useful information about a site's consumption patterns, "people skills" are needed in order to effectively communicate, encourage and involve personnel in effectively achieving results.

Figure 15. EMIS impact on organizational structure



As illustrated in Figure 15, using an EMIS as a support tool to encourage action affects a site's organizational structure. Depending on the company's type of business, management and personnel will each fulfil a different role when taking action. The downward and upward exchange of information and data between senior management and operations comprises an open structure that is crucial in order to ensure action and success.

Top management can ensure action by

- clearly stating its energy policy (i.e., define the organization's initiatives in energy use efficiency)
- informing the organization's employees and the general public of its commitment to energy use efficiency and associated cost reduction
- appointing a responsible authority (usually the energy manager) to ensure action

Operations management can best ensure action by involving those who have the most impact on energy consumption. Ultimately, it is operational personnel who take actions to meet energy use efficiency targets and who are accountable for the effectiveness of their efforts. An EMIS is based on transferring responsibility for performance efficiency from those who have limited influence on energy consumption (utilities and physical plant managers) to those who have the greatest influence on performance (the end-user who operates the process).

Actions taken to achieve energy savings will indirectly involve the planning and scheduling, accounting and engineering departments. Any proposed energy use efficiency initiative should be communicated to these groups as early as possible.

5.2 What Is Needed to Take Action?

Reliable and useful information is needed in order to take appropriate action.
Key aspects include

5.2.1 Energy data
5.2.2 Targets
5.2.3 Reports
5.3.4 Training
5.2.5 Decision support
5.2.6 Audited success
5.2.7 Motivation and recognition
5.2.8 Benchmarking and best practices

5.2.1 Energy Data

Good monitoring information provides a firm foundation to intelligently select measures to be implemented. Additional sub-metering may be needed to provide sufficient data and a basis for action. Data should not be "thrown at" an EMIS with immediate results expected; regard the EMIS as a tool to be engineered into a solution. The capabilities and limitations of an EMIS should be well understood before applying its findings.

5.2.2 Targets

Comparing current energy performance with targets prompts action to improve energy use efficiency. Simply monitoring energy use will only incur capital costs and will not result in cost avoidance.

Good target setting motivates; bad targets destroy confidence.

Targets are calculated from an equation that represents the link between monitored energy consumption and its influencing factors (outdoor temperature, operating hours, production rate, hours of occupancy, etc.). The target equation is derived from statistical analysis or from measured data. To be meaningful and reliable, targets must be

- regularly reviewed (at least quarterly)
- established in line with a definite action plan
- established only after the desired level of monitoring is in place and meaningful data has been confidently obtained
- realistic but not too easy to achieve

Consistently setting appropriate targets will ensure continuous improvement in results and help motivate personnel who influence energy use. Poor target setting can destroy confidence and lead to eventual failure of the EMIS. Several factors affect the target-setting process and the ability to translate information into action. These include the following:

- Identify and agree to desired targets. Keep in mind the justification for the application, and limit the effort to match the desired goals. Do not attempt to monitor the entire site if a preliminary evaluation anticipates that the major benefits will probably come from only one or two areas. Try to keep targets as simple as possible, but no simpler.
- Management personnel cannot support or commit themselves to something that they are not aware of and/or do not understand. Targets should be explained and be agreed to by senior management.

5.2.3 Reports

Reports should be circulated to advise when targets have been met or exceeded and when they have been improved upon. These can serve as motivation tools and should be clear, credible, timely, appropriate and informative. Don't overwhelm the intended audience with too many facts and figures.

The level of detail in reports must be tailored to the intended audience. Executives typically need only a performance overview. Senior management requires similar information that has slightly more detail and compares energy use with targets. Operational managers and their personnel need detailed information. Reports to them should include energy profiles and key influencing factors, which will offer more specific information and help them diagnose faults.

5.2.4 Training

The importance of training and documentation support

In order for appropriate actions to follow the implementation of an EMIS, personnel must understand the reports that are being generated and what actions they should take. This requires staff training and team building. Training must:

- impart a clear understanding to site personnel of the impact that utilities have on a plant's operation and that utilities represent a controllable cost
- use simple graphs, visuals and handouts to illustrate an overview of the site's utilities history and provide a reference to set future goals and targets
- help staff work together as a team and recognize opportunities to reduce energy costs throughout the site
- motivate staff to encourage their fellow employees to become actively involved in efforts to reduce energy use
- emphasize that when a problem occurs, it is regarded as a team problem that needs team support – individuals will not be left to sort out problems by themselves

5.2.5 Decision Support

As already stated in Section 3, effective implementation of energy use efficiency measures must involve various units within an organization. Creating a decision support committee for the responsible authority (i.e., the energy manager) can provide a framework for obtaining agreement on actions that may affect more than one operating unit. This committee could also foster communications between various departments and offer a stronger voice when approaching senior management for project approval.

5.2.6 Audited Success

Motivation will be sustained when a team has early successes with proven results, as validated by the EMIS. Credibility will also enhance motivation and obtain buy-in from all personnel.

5.2.7 Motivation and Recognition

Ways to reward good performance can be developed by an organization's human resources group. This may involve giving recognition through publicity (e.g., testimonial posters, newsletters, non-monetary awards at company events, etc.) or a modest cash award. Motivation will also be enhanced when staff is assured that help is available from the team to correct poor performance.

5.2.8 Benchmarking and Best Practices

Comparisons derived from a benchmarking exercise can provide a catalyst for taking action to improve energy performance and reduce costs.

Although the target review process will help a facility gain insight into its operations and utility cost performance, many organizations want to understand how their performance relates to other sites within the company or with their competitors. Benchmarking offers a tool for managers to measure their organization's performance in relation to others. It also provides an excellent learning opportunity. Improvements in utility consumption derived from EMIS knowledge can instigate a set of best practices. There are significant benefits from having all areas of an organization use best practices determined from another area of the organization or another industry player.

An organization that is interested in benchmarking must

- first decide which methodology it wants to use as a basis of comparison (e.g., energy consumption per total raw feedstock processed or energy consumption per total refined product)
- determine whose operations it intends to use as a benchmark
- do its homework and arrive well prepared (this is a prerequisite to getting other organizations to partner with you in a benchmarking effort)

Understand the data you need and the results you want – compare apples with apples.

Candidates for benchmarking can be determined through trade associations, journals and contact with colleagues. Most companies that are approached to share data are receptive to benchmarking, although some may be reluctant for competitive reasons.

Companies that understand that they are being approached because they are recognized as being best in their class will often agree to share information. Most companies, however, will not agree to an exchange of information with another company that has not looked at itself first.

How Is an Effective EMIS Designed and Justified?

06

Overview

This section outlines how to take a structured approach when designing an effective EMIS. Discussed are creating a vision, developing a case and gaining support to implement that vision. Key points are summarized at the end of this section.

6.1 Creating a Vision of an Effective EMIS

A company needs a clear vision if it is to invest in an EMIS. Factors that influence the decision to begin an EMIS project include

- a need to reduce greenhouse gas emissions
- the realization that utility costs are controllable and not fixed overhead expenses
- effective negotiation of utility contracts based on a sound understanding of a facility's or plant's energy use profile
- the need for real-time fault diagnosis, product quality control and the ability to challenge plant performance

The following points should be considered before designing an EMIS.

6.1.1 Address Site Needs

Implementation must address the needs of the site; otherwise the site is buying into a "system," not a management tool. This involves clearly identifying performance measurements that are relevant to the operating strategy of the site.

An EMIS must suit the site, involve process personnel and offer real-time data.

6.1.2 Usefulness of the System

It is necessary to clearly understand how the EMIS will be used and how it will directly or indirectly result in utility cost avoidance. The EMIS must be useful if it is expected to remain in service for several years. This means that it must gather the collective and accumulated experience of a site's operations without having to relearn it. This involves

- gathering and storing a considerable amount of information, organizing it logically and making it accessible with limited effort within reasonable response times

- being flexible enough to accommodate the requirements of a main site in a multi-site organization but also address a unique requirement of a remote site if the load is sizable and represents a constraint on the overall operation
- encouraging collaborative activity and assisting analysis and decision making

6.2 Beginning Design: Consider Measurement Issues

Once a clear vision of how the EMIS will be used is established, details on energy use measurement need to be worked out. To ensure that an effective system is implemented, an EMIS design should be based on two key facets:

- prominent involvement of the person who is in charge of the process
- the presentation of performance measurements in real time

There is little value in designing a sophisticated energy monitoring system that measures consumption too coarsely. Similarly, measurements will be of no help if they are so detailed that it is difficult to determine what historical energy consumption was for a specific area and why it differed from previous values. In practical terms, the person who is in charge of the process best answers this. An effective system also provides tools to the people who are actually processing the product so that they can receive performance indicators during the process and respond appropriately.

The essence of an EMIS is to compare real-time utility consumption with historical records and set targets (e.g., the energy consumption of the present process batch vs. the previous one). Until these two attributes are designed into an EMIS, the site will ultimately be left with a "rearview mirror" syndrome that offers information that no one will have time to go back and review.

It makes sense for the person who is responsible for the process to be assigned the tasks of collecting energy and process data and explaining the performance in real time. Alternate personnel are not likely to have the required knowledge, and they would have to consult closely with the process person in any case.

The degree to which energy use is measured must be factored into the design of the EMIS, and this is subject to the usual trade-off of cost vs. need. If, as a result of insufficient measurement, energy use is not broken down into the same size "pieces" on which the process is managed, the plant will have difficulty introducing the accountability required to effectively manage energy use.

To counter any concerns that an EMIS means needless micro-managing, experienced process operators generally recognize the difficulty of managing a process simply by looking at the total feed-in and comparing it with the total product out every month. It is not unusual for a process vessel to be instrumented with equipment, valued at a range of $100,000 to $200,000 and dedicated to micro-managing that part of the process. This is inherent in process control; yet, this approach is rarely applied to energy control with the same regard. If the plant is serious about developing metrics, challenging current practices and reviewing energy consumption as part of the regular cost review process toward energy management, it should know its energy consumption per unit of product for every process area, at least on a daily basis.

6.3 The Next Step: Consider Integration Into Existing Systems

Use existing infrastructure as much as possible.

Careful consideration of how the EMIS will fit into existing management systems on-site must be part of the overall design process. The continuing reduction in the cost of data processing, the increase in available communication bandwidth, and the ongoing improvements in search-engine software encourage the integration of an EMIS within existing IT systems. Many sites already employ a variety of DCS and SCADA systems, enabling a large portion of existing hardware and infrastructure to be used in the design of a new EMIS.

Since the requirements of an EMIS are likely to be broader than an existing IT system, implementation will probably require additional input or output variables. This could be accomplished with relative ease by adding supplementary field (end) devices such as sensors, tying the signals to spare input cards and applying some reprogramming.

Beyond data acquisition and monitoring and control issues, the design must evaluate which attributes of the management systems, ISO requirements, procedures, etc. that are presently in use can be linked to a new EMIS. The purpose of this evaluation is to gain insight into how the existing systems are used within an architecture that typically integrates data, functions (e.g., analysis, document management, simulation tools, search engine, etc.) and presentation. An understanding must also be gained of the operation of the corporate networks that support this architecture, including intranets, extranets for utility and supplier connections and links to the Internet.

Since all plants have cost accounting systems, the EMIS must effectively mesh with what is currently in place to ensure that energy management is integrated within the core of the business and not relegated as a sideline issue.

Consider the interaction of technology and people.

It is important to realize that barriers to implementation usually have more to do with cultural and organizational issues than technical issues. Creating a knowledge-based team will require more than supplying software, large databases of information and hardware. Issues that should be addressed when considering the interaction of people and technology include the following:

- Existing data that is inconsistent throughout the company should be reconciled before designing an EMIS. Uniform data is a key requirement in a data-sharing environment.
- It will be difficult to encourage people to share information when an organization's culture ranks their employees strictly on individual performance. Foresight will be needed in order to deal with common perceptions that capturing and disseminating knowledge will reduce one's future value to the organization ("Why will I be needed?"

or "Will someone else get all the credit if I share information?"). A collaborative attitude can be fostered within an enterprise when knowledge-sharing contributions and team efforts are recognized in performance appraisals.

- Focusing on technology alone cannot overcome an unwillingness or inability to communicate information across boundaries in hierarchical structures. Plant management must consider who should have complete access to information so that informed decisions can be made during plant operations.

6.4 Prepare a Supporting Case: Cost/Benefit

It is difficult to estimate with certainty the annual utility cost savings that will result from implementing an EMIS. Over the past 15 years, significant development work has been undertaken in the UK. Results indicate that, when properly implemented, an EMIS can save 5 to 15 percent of annual energy costs. As an initial approximation, 8 percent appears to be a reasonable estimate. A more refined estimate of savings can be developed by conducting a "front end" energy survey to assess the extent of a site's controllable loads and potential reductions through improved operating practices as a result of meaningful, timely information. The results of the survey can be used to identify the areas of greatest energy use and potential savings should it be decided to implement a targeted pilot project with reduced scope before full implementation. In this case, EMIS software (database, graphics, reports, historical archiving and trending) and hardware components (processing power, network bandwidth, disk and memory, and printing) should be designed with sufficient expansion capability for future requirements without requiring a process interruption.

What amount of expenditure can be justified?

The amount of expenditure that can be justified to implement an EMIS should be proportional to the site's annual utility costs. This forms the reference point from which the potential energy cost savings can be estimated. Although there are no definitive rules for arriving at a justifiable expenditure, the ranges of cost (based on experience in the UK) outlined in Table 4 can be used as a guideline.

Table 4. Approximate justifiable EMIS capital cost

Annual Utility Costs	Approximate Justifiable EMIS Capital Cost
$125,000	Up to $25,000
$250,000	Up to $40,000
$600,000	Up to $50,000
$1,250,000	Up to $150,000
$2,500,000	Up to $200,000+

The order of magnitude range of costs outlined in Table 4 will cover various levels of hardware and software purchasing. For example, expenditures of up to $150,000 would encompass a modest number of meters, analysis spreadsheets and perhaps basic data acquisition software and hardware at the upper cost range. Expenditures of greater than $200,000 will cover a greater degree of metering, data acquisition software and hardware, data analysis tools and networked systems, etc.

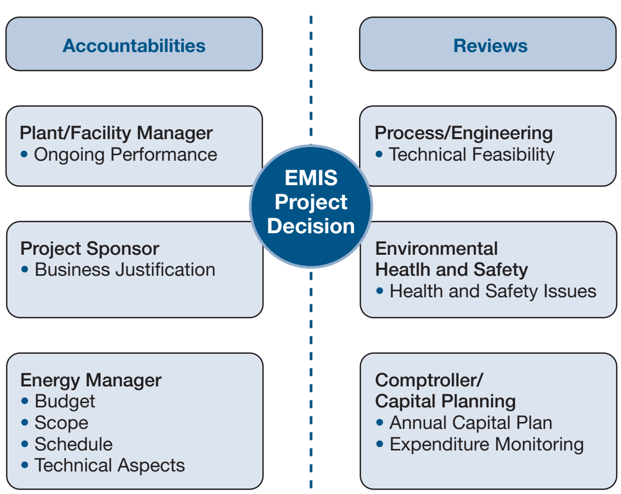
It should be emphasized that beyond the initial installation costs, there is also an operating cost associated with an EMIS (including time and maintenance costs) that should be considered when justifying a project. In addition, capturing lessons learned from the data-gathering process and keeping them current with changes in the business environment will entail ongoing support costs, requiring time and money that should be anticipated and budgeted for.

Having considered aspects of cost/benefit analysis and refining the design development to achieve the required payback period, non-monetary benefits should also be part of the justification. For example, one important benefit of implementing an EMIS is that the organization can retain critical information that could otherwise be lost when personnel leave the company.

6.5 Obtaining Support From Decision-Makers

As outlined in the previous section, implementing an EMIS will involve many different operations and management units within an organization. The final stage in turning the initial vision into reality is to obtain support from key decision-makers. Because of the many players involved in the process, coordination is vital. The energy manager (or project manager) is usually the ideal person to coordinate and organize the submission that will be presented to senior management. Figure 16 illustrates the decision loop, including its key players and their corresponding objectives and drivers.

Figure 16. Decision loop accountabilities and reviews



6.6 Designing and Implementing an EMIS: A Checklist

The following summarizes a structured approach toward designing and implementing an effective EMIS. This checklist is intended to guide readers in finding their own solutions.

Yes	No		
❍	❍	Is there a clear definition of what the plant or facility wants to achieve?	Be clear on how the EMIS is to be used, how it will improve the management of utilities, and whether it will be financially viable.
❍	❍	Has it been determined how the EMIS will integrate with existing energy management and IT systems?	Consider what existing infrastructure can be used. This will require taking stock of the state of the plant's software, hardware, field devices, employee knowledge base, operations culture and hierarchy.
❍	❍	Have all the reports that are needed to meet the objectives and those to whom they will be directed been identified?	What do line staff and management each require? Identify what the reports should contain. What should the presentation format be (paper-based, DCS display, Web-based, etc.)? Beware of information overload, which could deter use of the system.
❍	❍	Is identification of data collection requirements necessary in order to meet reporting needs complete?	This is not limited to collecting energy consumption data. Focusing on influencing factors (degree-days, production levels, operating hours) and real-time data collection is important and encouraged. This will allow proper analysis of the factors that affect energy use and help diagnose faults. As much as possible, energy data should be collected by the same systems (SCADA, DCS and PLC) that collect process data.
❍	❍	Has it been determined how the data will be properly analysed?	There is no point in collecting data if it is not going to be properly analysed. Data analysis techniques (such as data mining) should reveal information about the relationships between the influencing factors and energy use and help to identify faults that are affecting energy costs. Predictive analysis could also be considered as an advanced feature. Increased efficiency is sure to result if the data analysis software can enable a process control system to reduce deviation from a desired set-point, increase throughput, decrease energy consumption or predict or rapidly diagnose faults.

Designing and Implementing an EMIS: A Checklist (continued)

❍	❍	Will the EMIS be marginalized as a sideline issue?	An EMIS should be integrated into existing monitoring and control systems and general IT systems. Information derived from the system should be presented to management along with business performance, production performance, etc. Considering energy alone will result in the EMIS being sidelined.
❍	❍	Has a budget allowance for support services been prepared and approved?	Ensure that the budget estimate includes an allowance for support services such as site commissioning, testing, training and site documentation, periodic technical assistance and troubleshooting.
❍	❍	Has a front-end energy survey followed by cost-benefit analysis been completed?	The eventual success of an EMIS will be gauged by its cost-benefit performance. A reasonable estimate of simple payback can be developed by completing a front-end energy survey to determine probable annual energy cost savings and budget grade estimates of capital expenditure (can be obtained by consulting with vendors).
❍	❍	Is there flexibility to refine the design as required?	Be prepared to refine the design in line with management's budgetary expectations. Extraneous metering, data analysis capability, data storage and report production capability may have to be pared back to reduce costs. Before committing significant capital expenditure and staging the implementation, begin with a pilot project so that expected savings can be proven and increase support for the project. Initial payback can be enhanced by selecting system applications in only those areas that have a high likelihood of yielding significant savings.
❍	❍	Is the preparation of a sound justification completed?	The capital allocation request process for most organizations will demand that a well-presented written and verbal case is made to senior management. This presentation should be factual, focusing on business goals, not technology.

Effective Energy Reporting

07

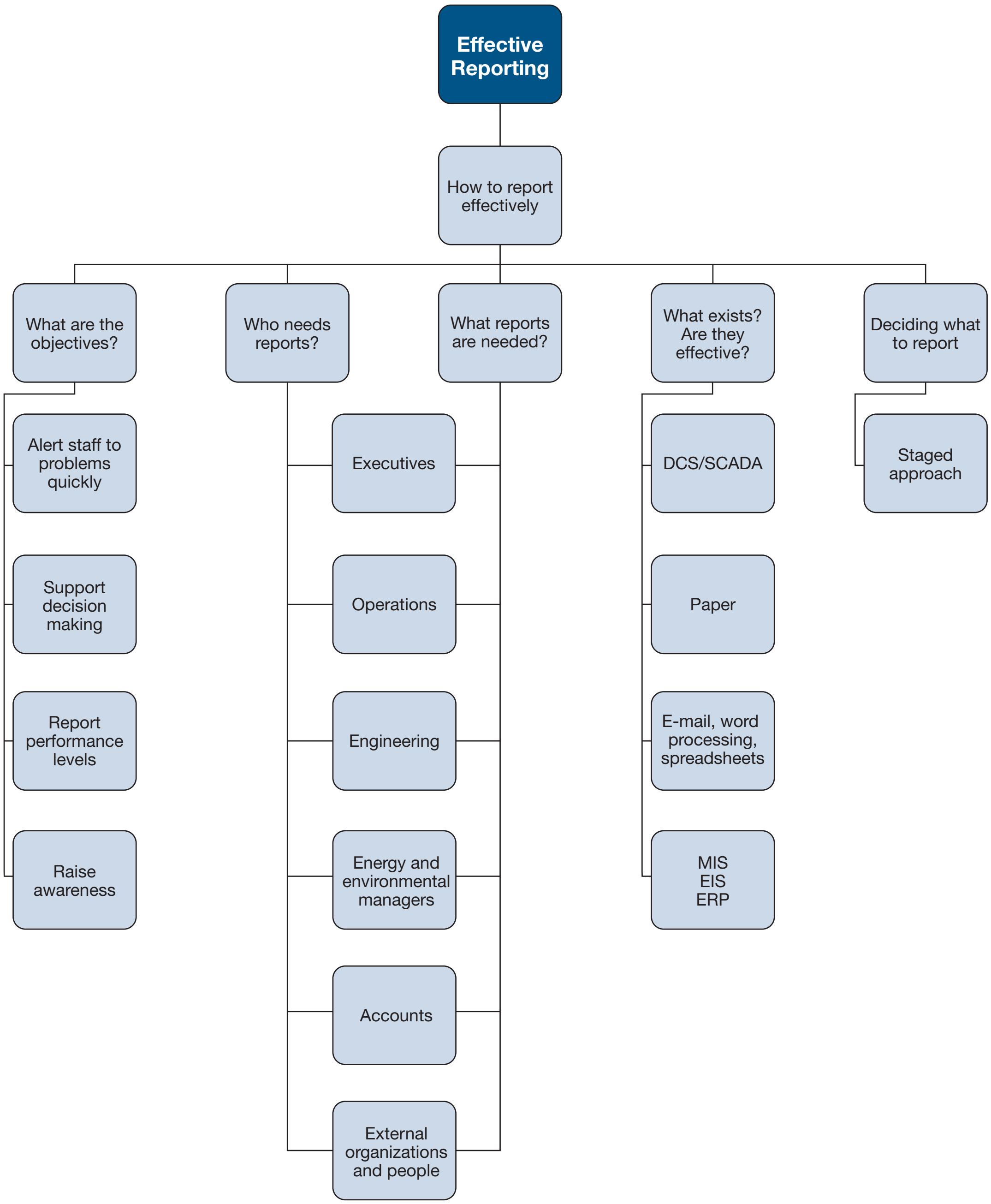
Overview

Effective energy reporting is an essential element of a successful EMIS. Reports are required for a range of individuals and departments in an organization, from operations personnel to the CEO. Each report must include relevant information in an easily understood format, and all data should be consistent.

The reports must provide information to enable the user to act. Operational staff needs to know when a problem has occurred as quickly as possible and know what they should do about it. Senior management, on the other hand, needs summary information to know that procedures and systems are working well. In order to design reports, it is important to understand who needs reports and why.

Existing reporting infrastructure should be used where possible. Graphical techniques can be used with company intranets and the Internet, and the Web can facilitate access to reports anywhere, anytime. Figure 17 summarizes the topics addressed in this section.

Figure 17. Effective energy reporting: Questions and answers



7.1 What Is an Effective Report?

The EMIS should include effective performance reporting to relevant personnel. This is to

- ensure that staff are alerted to problems in a timely manner
- support effective decision making
- report performance levels internally and externally
- raise awareness and win support for energy management initiatives

A comprehensive EMIS will be targeted to a range of individuals and groups. These might include

- executives
- operations management
- operations personnel
- engineering
- accounting
- energy and environmental management
- external advisors
- planners and schedulers
- ad hoc users

Reports will differ for each user, but all should be founded on sound data regarding actual process performance, a robust analysis and performance targets.

Data presented must be consistent, and often it makes good sense for all reports to be available to all staff (unless there are significant issues with confidentiality). However, the reports designed for each user should be limited to what he or she needs in order to effectively act. Avoid information overload; staff can consult reports that are more detailed if they choose.

Ideally, reports should be readily available where and when they are needed. A Web interface made available on the corporate/company intranet/network can be highly effective.

As a rule, reports should be tightly integrated into existing performance monitoring and management systems. For example, if operations staff relies on DCS or SCADA systems for information, display the results using these systems. If executives have an Executive Information System (EIS) that is used effectively, use it to communicate results. Similarly, use the corporate energy Web site if one exists.

Moreover, energy reports should be subsets of general performance reports. Energy is seldom, if ever, the sole improvement objective and should be considered with other factors such as output, quality and reliability. Companies exist to make profit, not to save energy, but the two are usually consistent with each other.

Understand who needs reports and what existing systems are in use.

Before designing reports and selecting reporting methods, it is important to

- understand who needs reports and why
- understand what existing reporting systems are used and where energy reports could be integrated
- understand that needs will differ from one organization to another

7.2 Who Requires Energy Reports?

Some of the individuals and groups that may require energy reports are discussed in the following, along with possible reasons and the use the reports will be put to.

7.2.1 Executives

Senior executives will have overall responsibility for energy performance and may well need to report on and explain performance levels to the board or to senior management. They will have delegated the task of managing energy performance and will want to measure the effectiveness of the performance of the responsible individuals.

The availability of sound data that is well presented and, ideally, that demonstrates a successful energy improvement initiative will keep energy high on the executive and management agenda and facilitate approval for expenditure and initiatives.

The executive will typically have little time to spend on energy issues and will require data presented clearly and simply that can be immediately understood. Detail will not generally be necessary. A standard format is a good idea – the chair of the executive board will become used to the information and will understand and expect it. The information might include

- a summary of last year's costs, broken down into key areas
- a summary of the current year's performance on a monthly basis
  - against budget
  - against the previous year
  - against targets
- a note of the savings (or losses) achieved to date and how they were achieved
- a note of additional savings opportunities and what actions are ongoing to address them

A new report should be issued each month and be available in time for board meetings (with time for the executive to include figures in his or her own reports and ask any questions).

The reporting method will vary from paper-based reports or electronic documents that can be easily incorporated into board reports, to computer-based systems. The executive may be using an EIS, be familiar with Web browsers or be familiar with a spreadsheet program or similar software.

7.2.2 Operations Management

Operations management will be responsible for operating processes and plant efficiency. They will need to know on a shift, daily, weekly or monthly basis (depending on the nature of the process and the level of energy use) what energy has been used and how this compares with various targets. The information will be used to

- measure and manage the effectiveness of operations personnel and process plant and systems
- identify problem areas quickly
- provide a basis for performance reporting (to executives)

The operations manager will typically require simple reports either via a Web interface, a word-processed document, a spreadsheet program or through an existing management reporting system. The information may need to be incorporated into existing process and plant performance reports.

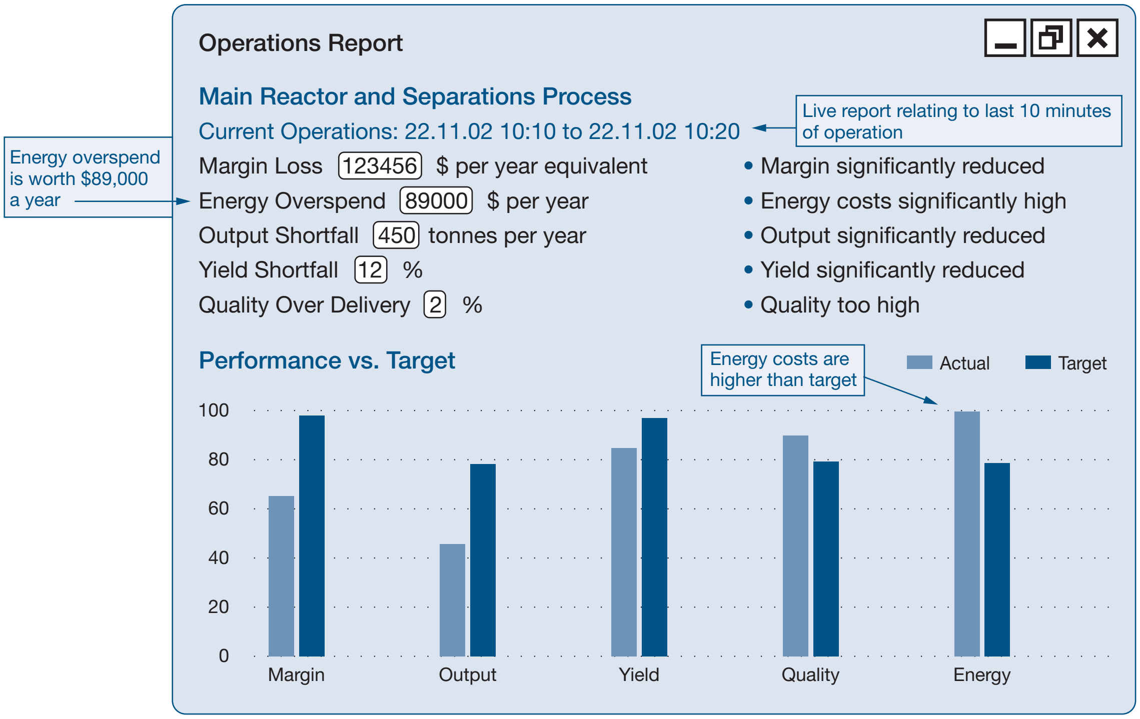
7.2.3 Operations Personnel

Operations personnel need to know when a problem has occurred and what needs to be done to rectify it. This information needs to be

- provided in a timely manner, which might mean within a few minutes of the event for a major energy-using process, or within a day or a week
- reported using a system that is easy to use and readily accessible (typically the DSC, SCADA or a Web browser interface)

Figure 18a illustrates an alert that energy performance has been poor over the last 10 minutes.

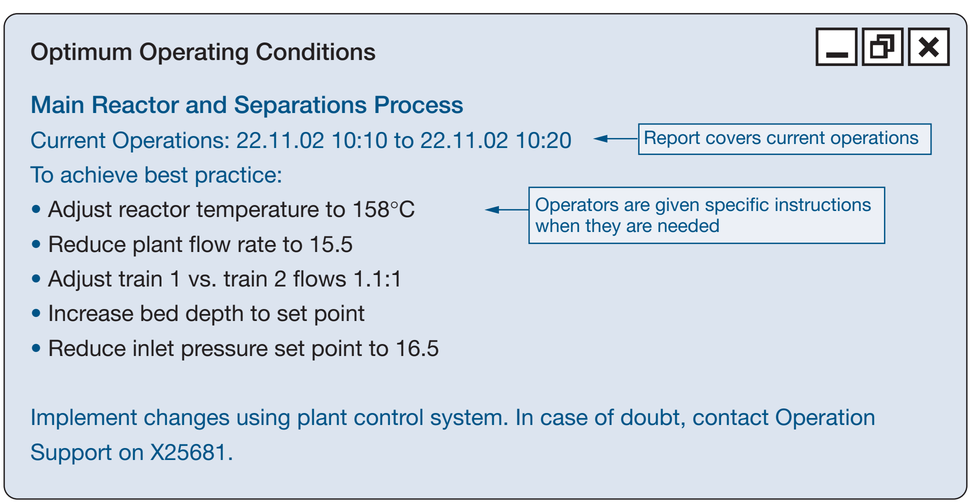
Figure 18a. Example of an operations report alert



The energy information should be presented alongside other key performance factors, as illustrated in Figures 18a and 18b.

Decision support solutions may also be required in order to instruct operators on how to respond to poor performance.

Figure 18b. Another example of an operations report alert



7.2.4 Engineering

Engineering staff has a number of roles, including operations, support and projects.

Engineers associated with operations will need reports similar to those for operations personnel (described in Section 7.2.3). Engineers may typically be involved with problems where there is more time to act (compared with process operators), for example, cleaning heat exchangers, solving a control problem or removing air from a refrigeration condenser.

Engineers who are not directly in operations but who provide support will need more detailed historical information. Typically, these individuals will be involved in analysing historical performance, developing targets and modelling. They will require access to the plant data historian and will use analysis tools, ranging from commonly available spreadsheet software to advanced data mining and similar software.

Engineers that are involved in projects will need supporting data, for example, levels of energy use, process operating conditions, etc. They will also need access to the raw data in the historian and access to analysis tools.

Energy data and associated analysis tools need to be well documented and supported.

7.2.5 Accounts

The accounts department may be interested in actual energy usages and costs to compare with budgets. They will need information that is broken down by department so that costs can be allocated to related activities. Accurate costing of operations and the cost of producing goods can improve decisions regarding product pricing, for example, and the allocation of resources.

7.2.6 Energy and Environmental Managers

Energy and environmental managers will need summary data that identifies the performance achieved and trends, much like what executives and operations managers require. Like engineers, they may require more detailed information for specific analysis.

The environmental department may want energy consumption expressed as equivalent CO_2 emissions, and the energy reports may need to be integrated into environmental reports that are more general. Summary information may be required for annual energy and environmental reporting and may be needed more frequently by regulatory bodies.

The energy manager may be involved in energy purchasing as well as efficiency. He or she may need information about the profile of energy use (using a half-hourly graph, for example), peak usage, nighttime usage, etc. The energy manager will also need access to the raw data in order to allow evaluation of purchasing options and to check bills.

The energy manager may also be responsible for managing tax rebates (e.g., the Accelerated Capital Cost Allowance provision 43.1 has a cogeneration performance requirement that must be assessed for regulation applicability).

7.2.7 External Advisors

External advisors such as consultants will need access to raw data for detailed analysis and to summary data.

7.3 A Staged Approach

Consider the following approach in order to design effective reports.

Identify the target personnel – these are people whose involvement can help to save energy. Determine their specific needs:

- understand the existing performance reporting systems in use
- evaluate the effectiveness and suitability of existing systems for energy information
- discuss and agree on the format, content and timing of the reports with the users
- focus especially on reports to operations personnel, including on-line monitoring and decision support
- implement reporting, making use of existing monitoring and data infrastructure
- ensure adequate testing and ongoing support for the reporting systems
- continuously revise and refine reports

Defining reporting needs will determine data analysis and monitoring/metering needs. It is an essential early stage task when developing an EMIS and follows the determination of EMIS deliverables (see Section 2.3).

Energy Data Analysis

08

Overview

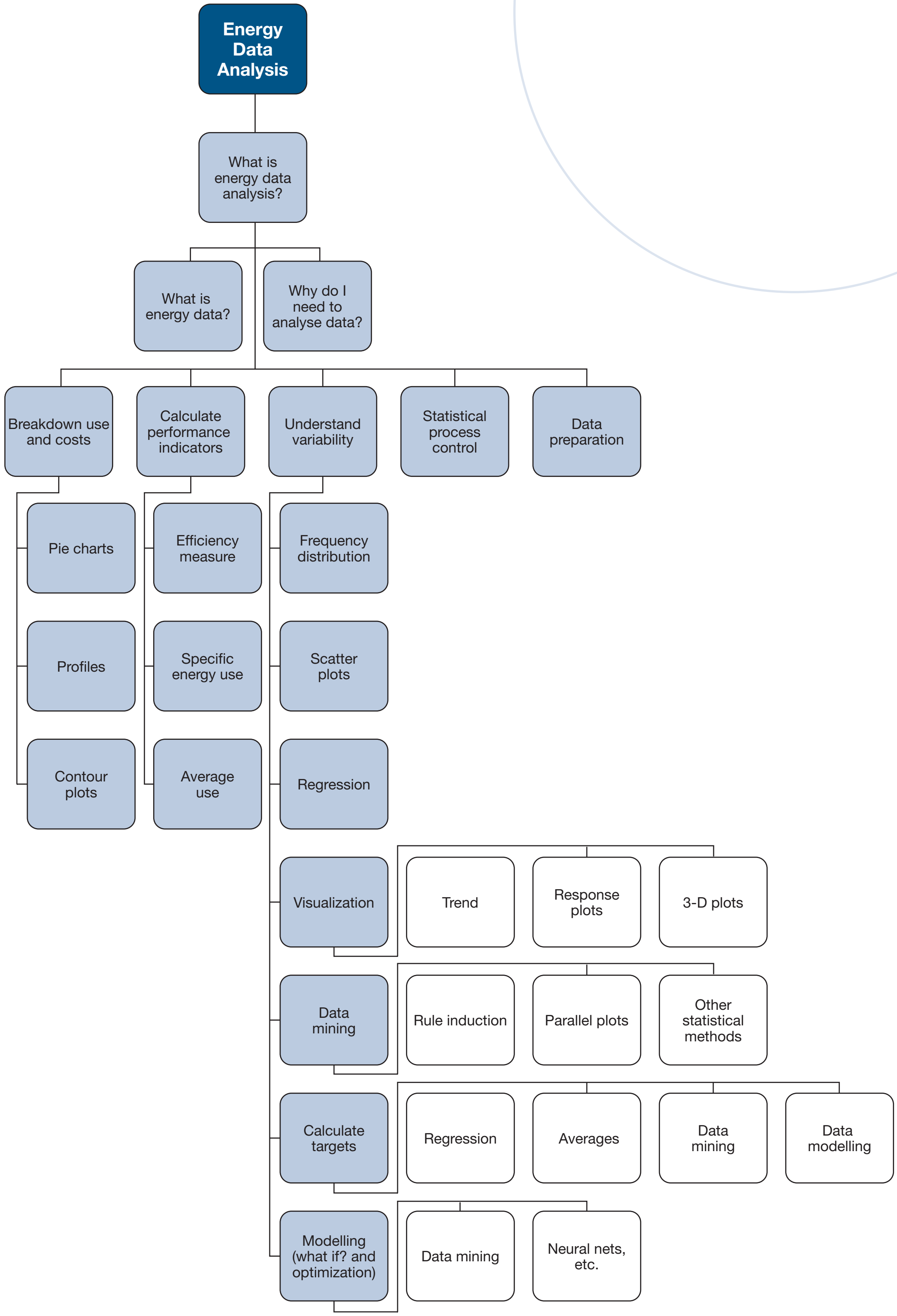
The following discusses the analysis of energy data and is a key section of this handbook. Effective data analysis is essential but is often not given appropriate priority. In fact, poor analysis of data can destroy the operation of an EMIS and result in misleading messages.

Energy data includes not only energy usage but key influencing factors as well. Data must be collected at a higher frequency than any variations that are being studied.

The objectives of data analysis are to better understand energy use and costs, calculate performance levels, calculate targets and model energy use. A range of techniques can be utilized, from simple to complex. These should be selected to suit the problems being addressed (rather than selecting an analysis technology and then finding a problem to suit).

The block diagram shown in Figure 19 summarizes the topics covered in this section.

Figure 19. Block diagram showing elements of energy data analysis



8.1 What Is Energy Data?

Energy data includes

- direct measures of energy use (electricity, gas, steam, etc.)
- measures directly associated with energy use, for example, heat rate, cooling rate or compressed-air flow
- influencing factors measured or recorded variables that may affect energy use

Direct and indirect measures of energy use are essential. Ideally, the energy use of each significant processing area should be measured separately. Such an area can be defined as

- an area where the energy use is largely determined by actions within that area, process or plant item
- one that has a significant level of utilities consumption
- one where there is potential for under-performance or where performance is variable
- an area that is managed by one person or group to whom responsibility for performance can be allocated

Table 5 provides examples of areas that require utility metering.

Table 5. Examples of areas that require utility metering

Area
Individual process energy consumptions (steam, electricity, etc.)
Energy use by individual unit operations (e.g., dryer, evaporator)
Boiler energy use
Heat rate (from cogeneration units)
Refrigeration energy use
Compressed-air flow
Cooling flow (from refrigeration)
Energy use by main buildings

It is essential to have data on influencing factors. Without this, analysing energy use is limited to quantifying use and cost and comparing current values with historical values. Relying on this alone will severely limit achievable savings. With data on influencing factors, it is possible to

- understand the causes of variable energy use
- set targets against which current performance can be compared
- model energy use

Table 6. Examples of influencing factors

External disturbances
• ambient temperature
• production rate
• feed conditions
Controllable factors
• selection of plant
• control settings
• operating practices
• repair of faults

8.2 Objectives of Energy Data Analysis

Objectives of an energy data analysis can be defined as follows:

- break down energy use and cost
- calculate performance levels
- understand the reasons for variable energy use and performance
- calculate targets for energy use and efficiency to be used to identify poor performance and track progress
- model energy demands

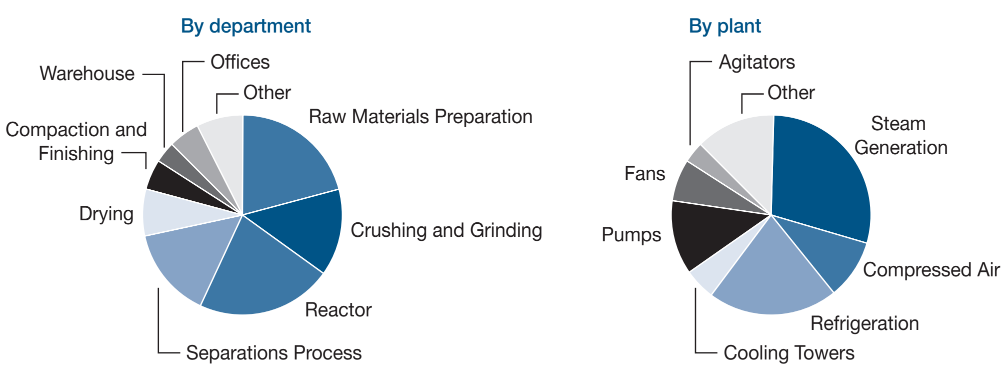
Techniques for data analysis range from simple to complex. The choice depends on the size and complexity of the operations, available capital and software tools, capabilities and interests of staff, and time available.

8.3 Breakdown of Energy Use and Costs

Dividing the total energy consumption (and cost) of a facility into sub-areas has a number of benefits:

- it allocates costs to relevant departments
- it highlights key areas
- it triggers discussion and ideas

Figure 20. Breakdown of energy use

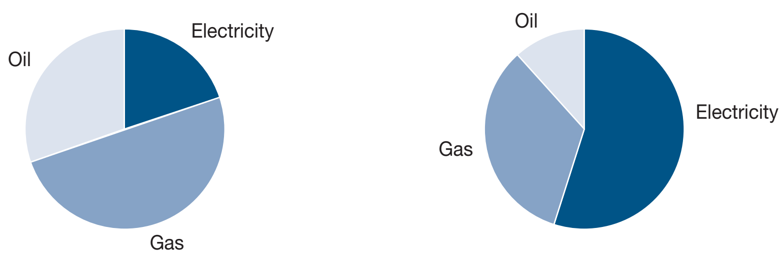


In the examples in Figure 20, utilities (electricity, gas, oil, steam, etc.) have been combined, typically shown on a cost basis.

Charts based on energy use (MJ, kWh, etc.) or CO_2-equivalent emissions may also be useful. It can be instructive to show the various utilities use and costs graphically. All of these graphs are essential in energy management and are typically based on a year's worth of data.

Figure 21 shows utilities broken down by energy and cost (cost is shown at right), showing the relatively high cost of electricity and the impact this has on energy use efficiency priorities.

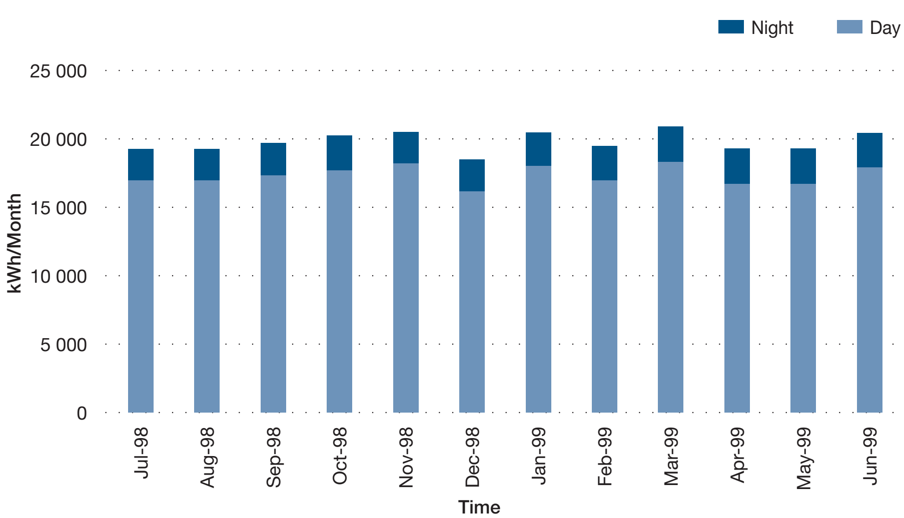
Figure 21. Breakdown of utilities' use and cost



Charts such as these can easily be produced using standard spreadsheet packages or similar software and can be easily published, for example, as part of an energy Web site on the corporate intranet.

In some cases it can be useful to subdivide energy use by time. For example, determining average energy use during non-productive periods (e.g., nighttime, holiday periods) can be highly informative, revealing poor control of plant operations (e.g., poor isolation of compressed air).

Figure 22. Monthly breakdown of electricity use showing day and nighttime units



Determining peak demands can also be informative. Where possible, a demand profile should be studied.

Figure 23a. Typical half-hourly demand profiles (as a line graph)

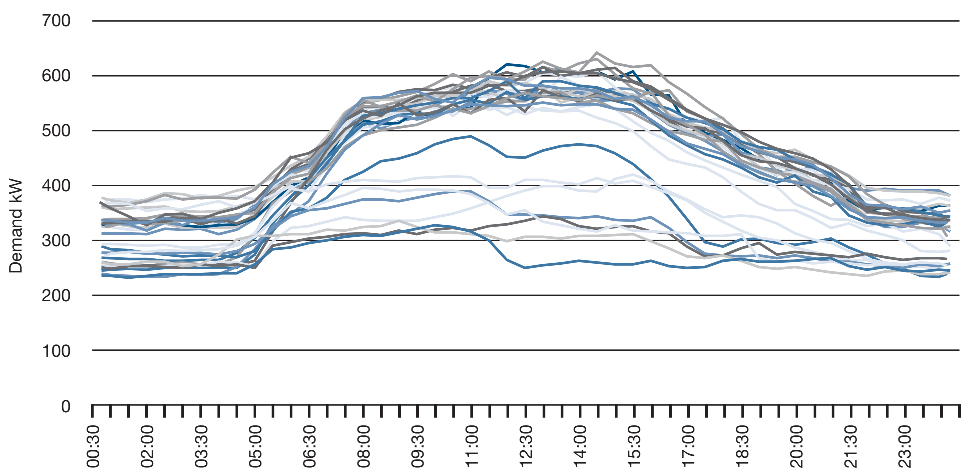
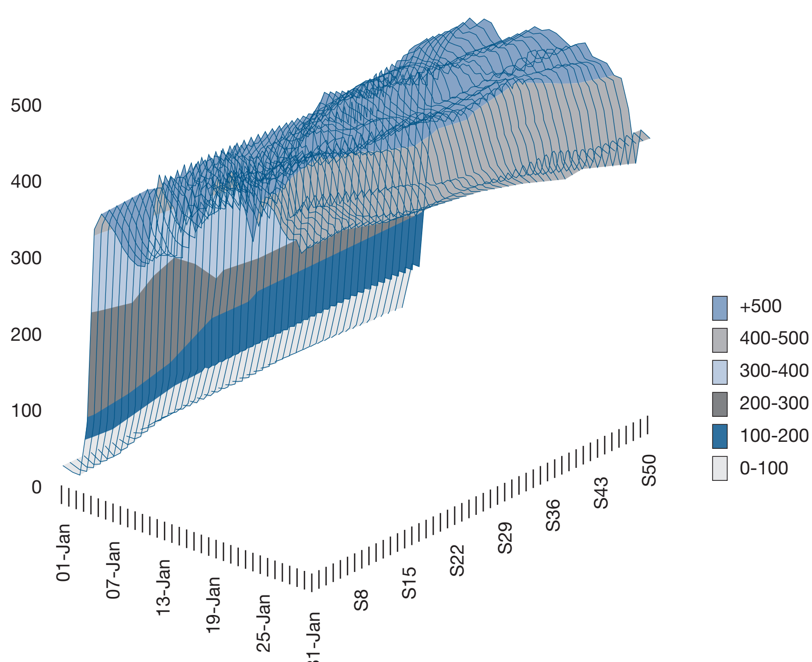


Figure 23b. Typical half-hourly demand profiles (as a contour plot)



8.4 Calculation of Performance Indicators

Energy performance can, in some cases, be a simple measure, such as the energy use of an area or process. However, energy use is often affected significantly by external factors, such as production rate, in which case organizations may use "specific energy use," i.e., energy use divided by the production level.

These and similar measures should be interpreted very carefully! A process that has a high base-load energy demand, for example, will have a lower specific energy use at higher production rates, even if the underlying efficiency of operations remains unchanged.

Other measures of efficiency can be used, such as the efficiency of a boiler or the coefficient of performance (COP) of a refrigeration system. These values would also be expected to vary (boiler efficiency, for example, with steam loading and COP with ambient temperature).

Performance indicators are useful; however, they should be compared with targets, including

- targets derived from a model of operations
- targets based on the achievement of similar plant/processes under similar conditions (either the same plant/process in the past or another process that is very similar)

8.5 Understanding Performance Variability: Simpler Techniques

There are a number of simpler techniques that can be used to understand variability in energy use. Variability can be displayed as a frequency distribution, which shows the average value, spread (or standard deviation) and the shape of the distribution.

Figure 24. Example of frequency distribution

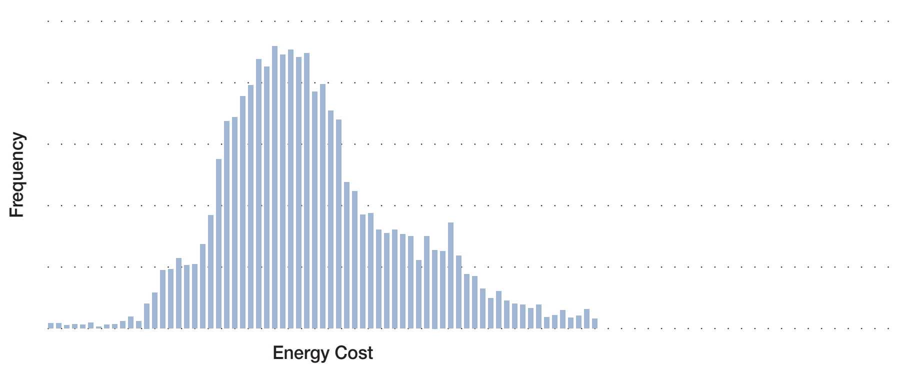
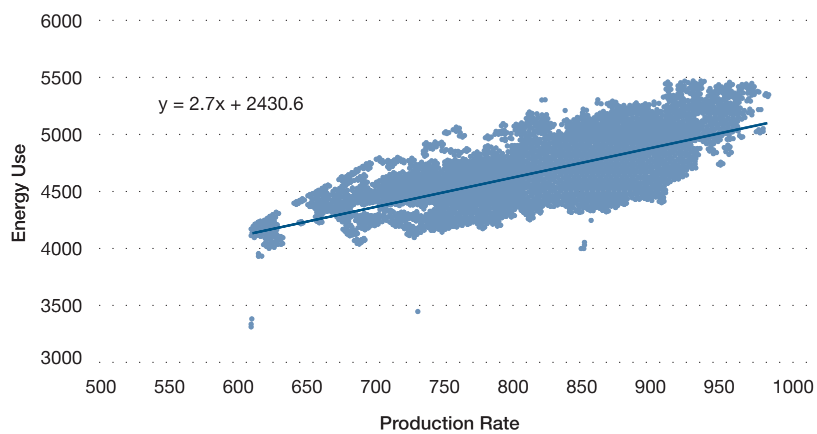


Figure 24 shows a typical example of the specific energy cost of a process operation. There is a significant spread, which an analysis would aim to explain. Is the spread due to external factors or a decision made by operations?

Plotting energy use vs. influencing factors can help to establish relationships. For example, energy use can be plotted against production to reveal a clear relationship (see Figure 25).

Figure 25. Energy use vs. production



The graph shown in Figure 25 also identifies

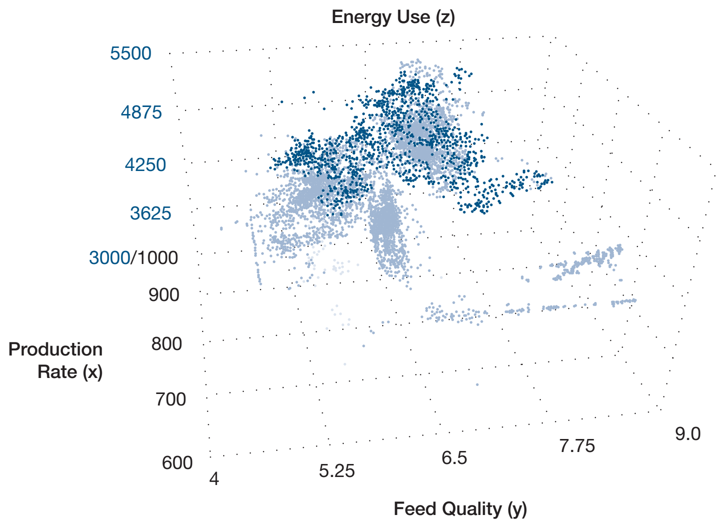
- a base load consumption of 2430.6 units
- residual variability – the production rate does not fully describe the variations in energy use (in fact, there is a significant residual variability)

A linear regression analysis can capture the relationship as an equation of the form:

	y	=	mx + c, y = 2.7x + 2430.6
where	y	=	energy use
	x	=	production level
	m	=	gradient of the line
	c	=	intercept

This approach can be extended to three dimensions (see Figure 26).

Figure 26. Example of three-dimensional plot, showing energy use vs. production and feed quality



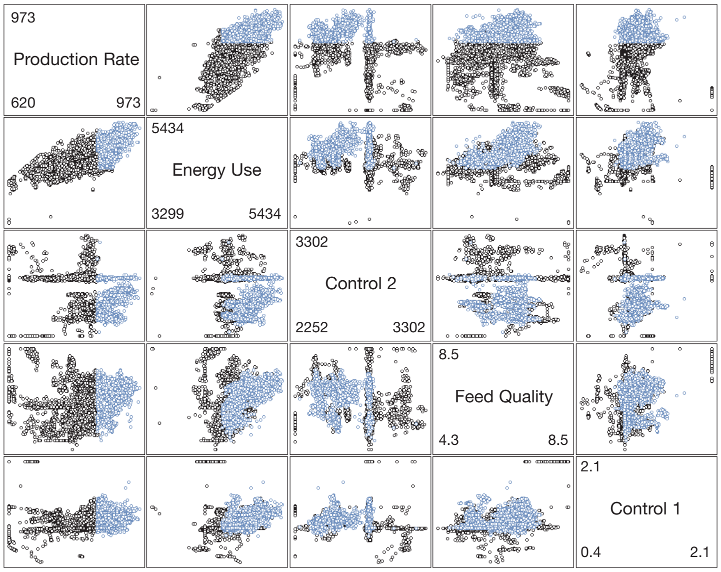
Multiple regression techniques can produce extended equations to describe the relations.

$$y = m_1 x_1 + m_2 x_2 + m_3 x_3 + \ldots + c$$

Software tools are readily available to facilitate these graphs and calculations; commonly available spreadsheet programs have most or all of the capabilities needed.

Trying to decipher patterns from numerous single plots of many variables can be very cumbersome. Multiple two-dimensional scatter plots offer a means of finding relationships between multiple variables (matrix plots) by illustrating, at a glance, the patterns that are inherent in the data. In Figure 27, the shaded cells identify the axis labels for each variable that is plotted. The first non-shaded cell in the top row plots production rate on the y-axis vs. energy use on the x-axis. The first cell on the bottom row plots the controllable value "Control 1" on the y-axis vs. "production rate." High-energy-use data is coloured light blue. As an example of the patterns that may be spotted in this multiple two-dimensional scatter plot, the relationships between energy use and feed quality are clear. Another example of high energy use is associated with lower values of the controllable value "Control 2."

Figure 27. Multiple scatter plot



8.6 Understanding Performance Variability: Data Mining

In some circumstances, a more detailed analysis is appropriate

- for major energy users
- where energy is a complex issue affected by multiple influencing factors
- where there is access to substantial historical data, for example from a data historian

Data mining has the following characteristics:

- it handles massive databases
- it finds patterns automatically
- it expresses the patterns as a set of rules

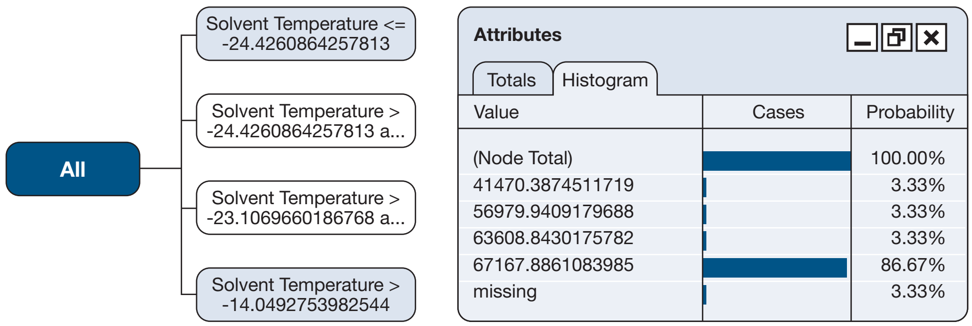
The decision tree shown in Figure 28 represents a set of rules generated in a data-mining analysis. The rules identify the key driver for the energy use of a refrigeration system and quantify the impact of that driver. The highlighted “route” through the tree is characterized by the following rule:

If the solvent temperature is > −23°C and < −14°C

Based on the 86.67 percent probability that is identified under “Attributes” on the right-hand side of Figure 28, the energy use is determined by the analysis to be 67 167 units under these conditions.

Rules are generated automatically in such an analysis. The user defines only the objectives and influencing factors. The process essentially subdivides historical operations into modes; where energy use is different, the modes are characterized by rules.

Figure 28. Simple decision tree

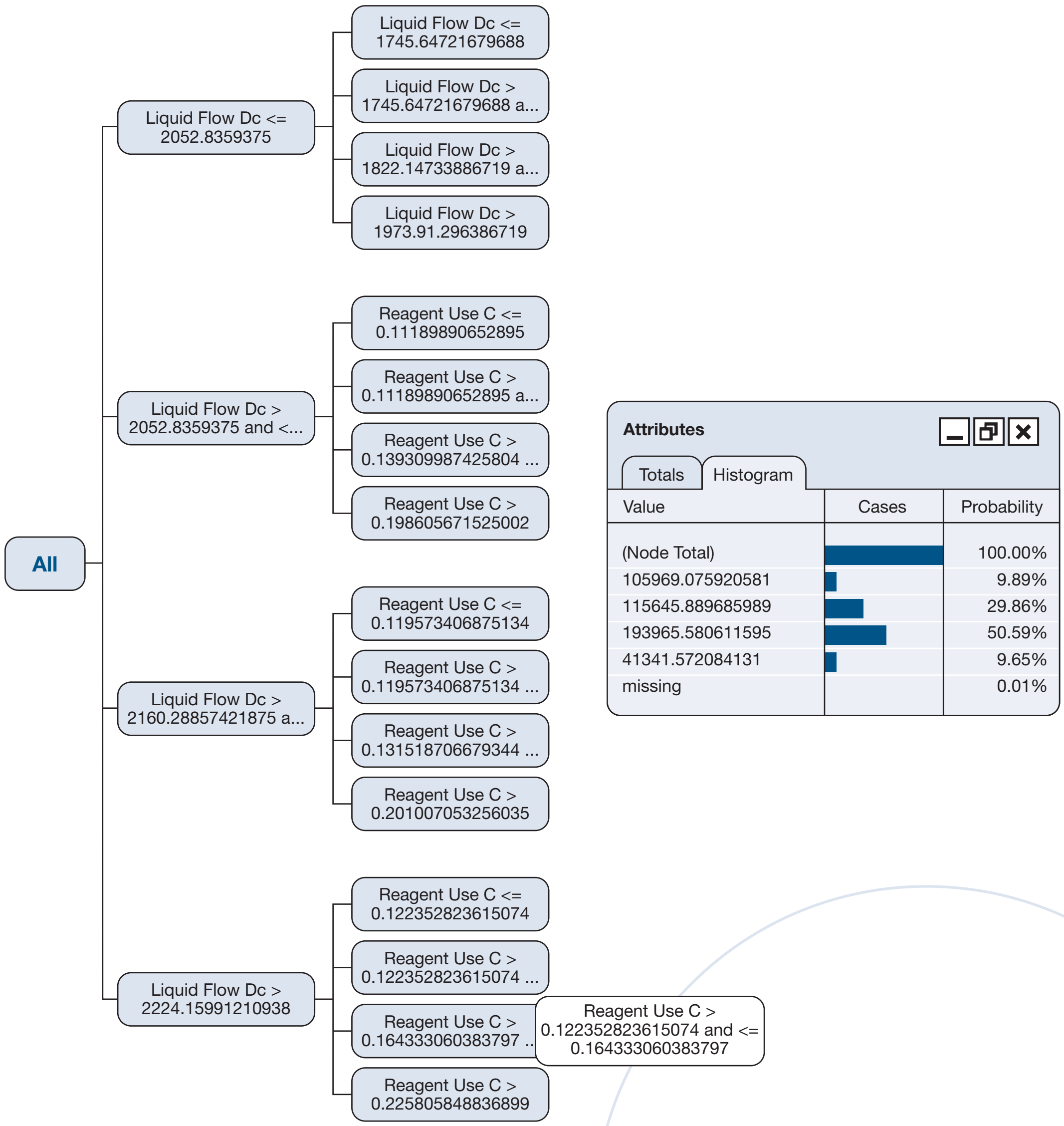


A real analysis will create substantially more complex decision trees (there are more complex rules), such as the one illustrated in Figure 29. Such a tree will

- identify key drivers
- quantify the impact on energy use
- identify the best operating modes

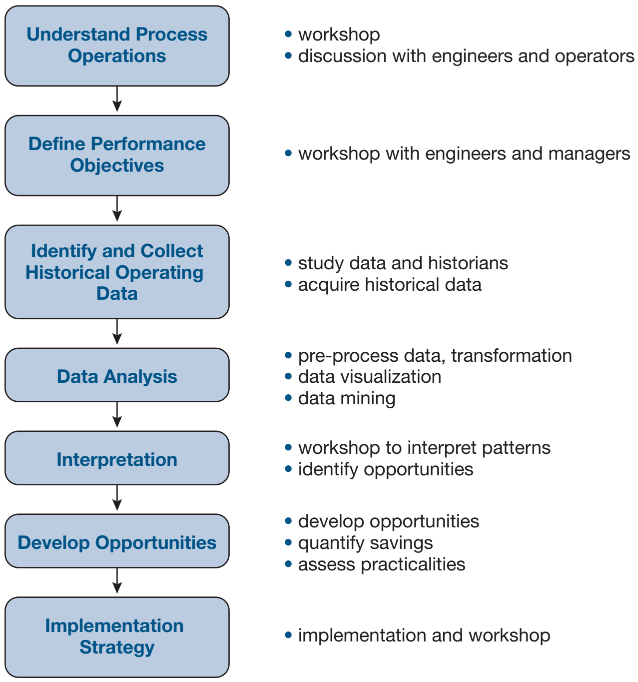
Figure 29 identifies a node path for the liquid flow and reagent use that determines a 50.59 percent probability that energy consumption will be 193 965 units under these conditions.

Figure 29. Complex decision tree



Data-mining tools are readily available and widely used. Figure 30 shows the typical stages of such an analysis.

Figure 30. Stages of an initial data-mining analysis



These stages apply to any comprehensive data analysis project.

Example 2: High-Pressure Boiler Plant Performance

An analysis of the efficiency of a high-pressure boiler plant was completed. The plant houses three boilers, two of which are normally in service at any one time. The boilers are capable of dual-fuel firing on natural gas or oil and generate steam at a maximum pressure of 1600 psig (11 Mpa) to supply steam turbines and other loads at reduced pressure.

Data was collected from the plant following modification of the site-monitoring systems and mined, with operating cost per unit of steam being the main focus.

Figure 31. Boiler manifold steam pressure

Attributes included the selection of boilers into the operating sequence, loads, pressures, temperatures and turbine bleed steam flows.

Figure 31 illustrates the boiler manifold steam pressure over a half-hour period.

The impact of manifold header pressure (mpress) on the operating cost is illustrated in the decision tree that is partially illustrated in Figure 32. In this case, a higher steam pressure reduces the operating cost per unit of steam produced. In comparison, Figure 33 illustrates that simply relying on plots of cost vs. manifold steam pressure would not clearly show the influence of manifold steam pressure. This is due to the changes within the data set that are happening for many other factors that affect performance.

Figure 32. Impact of manifold pressure on operating cost – partial decision tree

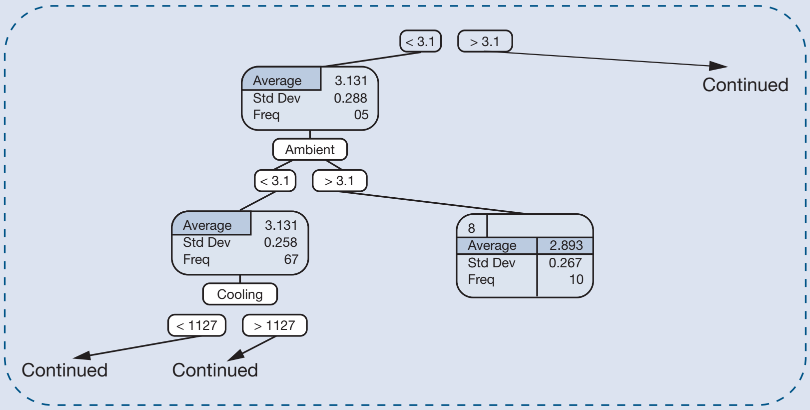
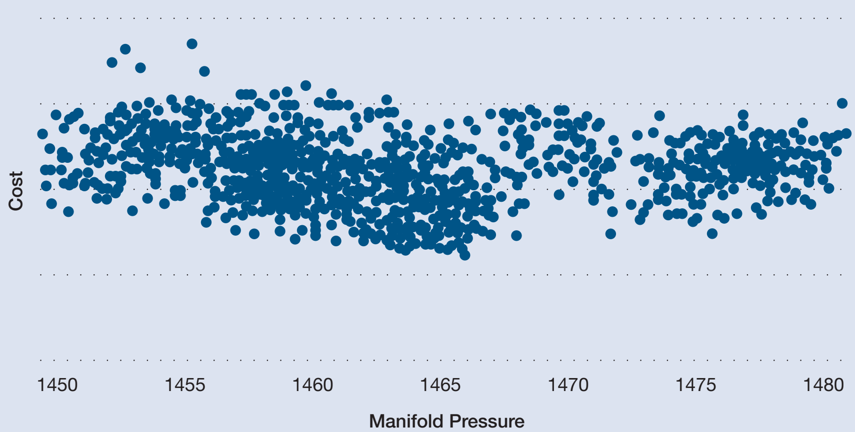


Figure 33. Cost vs. manifold pressure



In total, annual cost avoidances of 4 percent were identified (valued at approximately $500,000), yielding a simple payback period of approximately one year.

8.7 Calculating Targets

Targets are expected performance values that can be compared with actual performance to discover whether a plant or process is performing well or not. Targets take several forms, including the following:

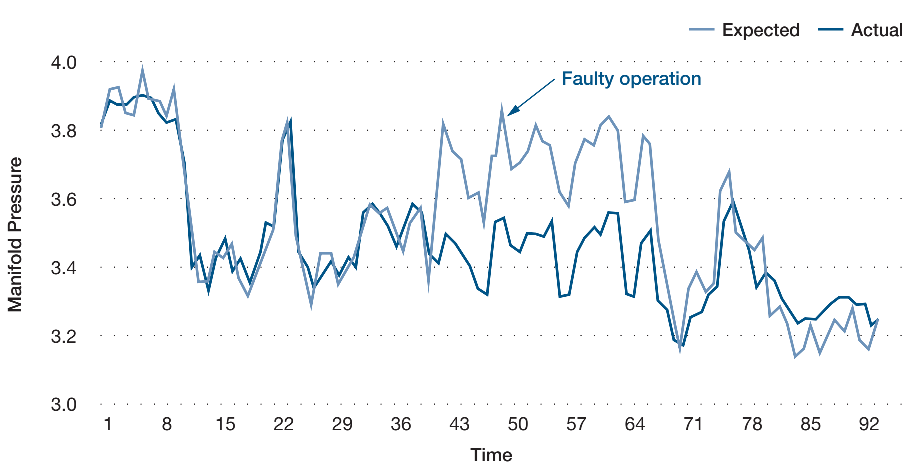
- Historical average performance is a commonly used target. These can be used to alert operations staff when performance is below average.
- The simplest form of such a target is the average energy use during an earlier period, for example, the last year or the last month.
- Often, targets will have some adjustment for external influencing factors, such as production rate or ambient temperature. Typically, this adjustment is based on a regression or multiple-regression analysis.

In some cases, the target is adjusted to reflect a desire to improve. For example, the target may be adjusted to further reduce energy use by 5 percent across the board.

The accuracy and robustness of targets is vitally important. An incorrect target will mislead; improvements may not be reflected in the calculations or poor performance may not be identified. Poor targets result in a loss of confidence in monitoring and ultimately failure to achieve energy savings.

A more sophisticated historical target can be developed using data mining and similar techniques. More data can be analysed, more influencing factors can be accounted for, and non-linear relationships can be handled effectively.

Figure 34. Actual vs. target performance



A target produced from a detailed analysis of data collected (for example, hourly or every 15 minutes) can be sufficiently accurate to implement on-line in real time. The benefits of this include more rapid identification of operating problems. Such an approach should be seriously considered for major energy users.

The historical average performance can be considered a benchmark against which future performance can be compared. It represents what typically would have happened had no changes (improvements) been made.

A best-practice target identifies what a process or plant could achieve if it were operated well. It differs from average historical performance and a desired improvement since it is based on facts about the improvement potential.

Best practice can be calculated from first principles, in which case it represents what theoretically can be achieved. Computer models are applied widely in major processes such as oil refining and petrochemicals and are becoming more common in other sectors. Models of utility systems such as boilers and refrigeration plants are also in use.

Alternatively, best-practice targets can represent the best performance achieved in the past, given the particular (external) conditions. This can be discovered from historical operating data using data mining and similar techniques.

A best-practice target is discovered by identifying periods of operation in the past where external conditions were similar to those currently in place and then selecting the best performing period as the target. Software tools are available to automate this process.

Performance against targets can be represented in a number of ways. Poor performance as compared with the target can be reported as it becomes known and expressed, for example, in terms of the annual cost if the faults are not fixed.

Figure 35a. Performance reporting

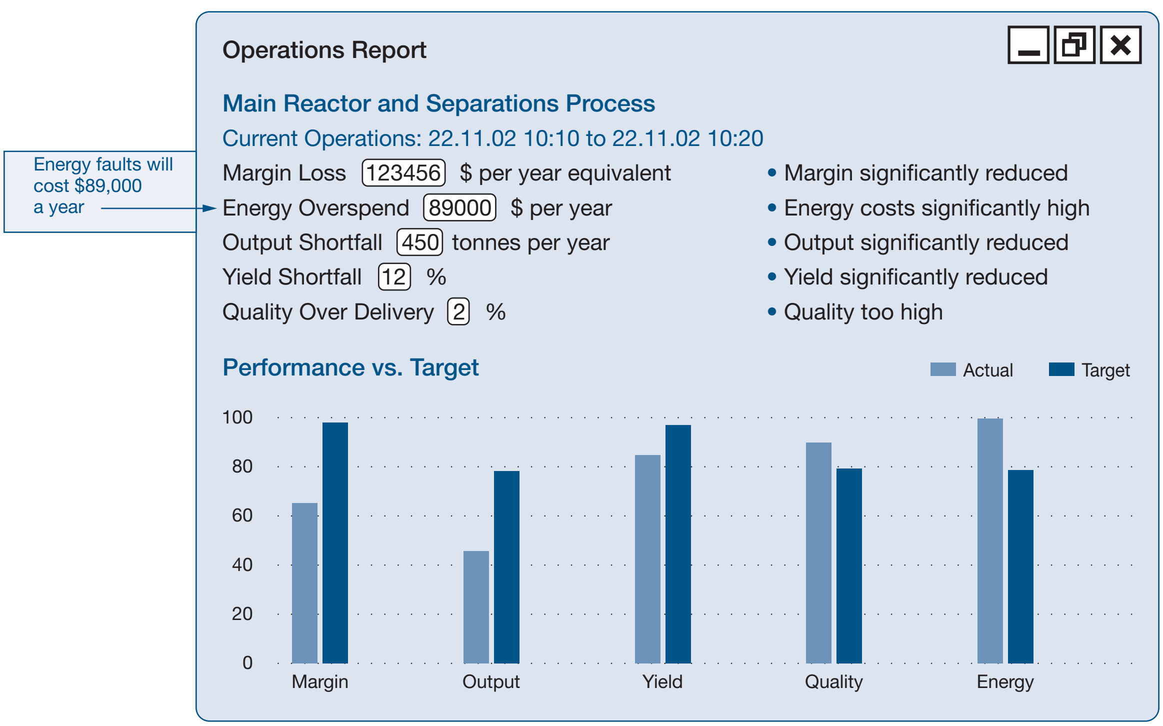


Figure 35b. CUSUM reporting (as a line graph)

Operations Report

Main Reactor and Separations Process - Energy Cost

Last Eight Hours: 22.11.02 16:00 to 22.11.02 24:00

Energy Overspend $\boxed{123456}$ $ per year equivalent

- Improving trend
- Recent performance good

Performance vs. Target

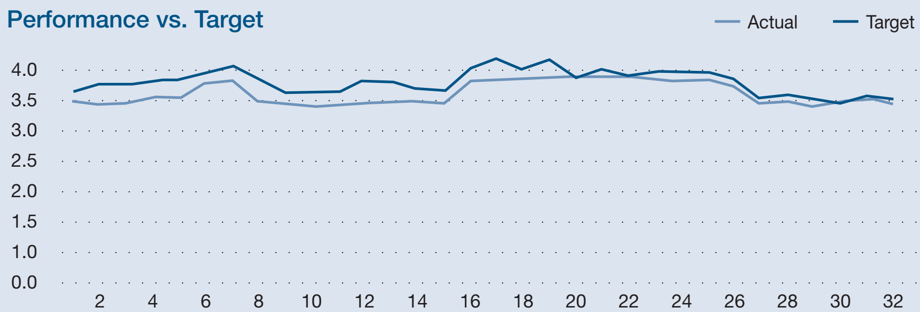


Figure 35c. CUSUM reporting (as monthly, weekly or yearly summaries)

Executive Report

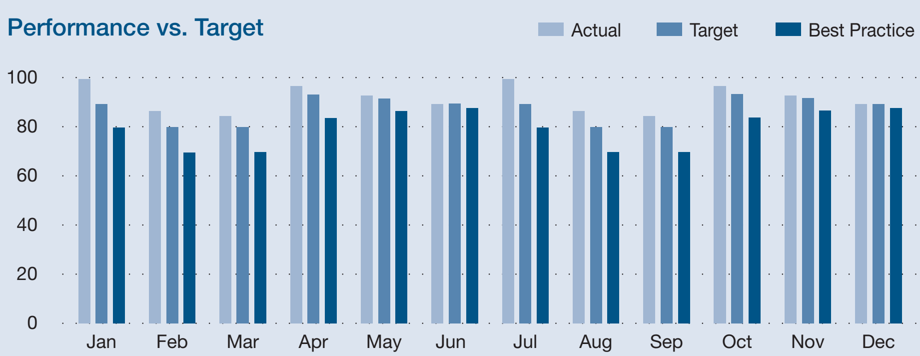
Entire Manufacturing Facility

Monthly: January to December 2002

Margin Loss $\boxed{123456}$ $ per year equivalent

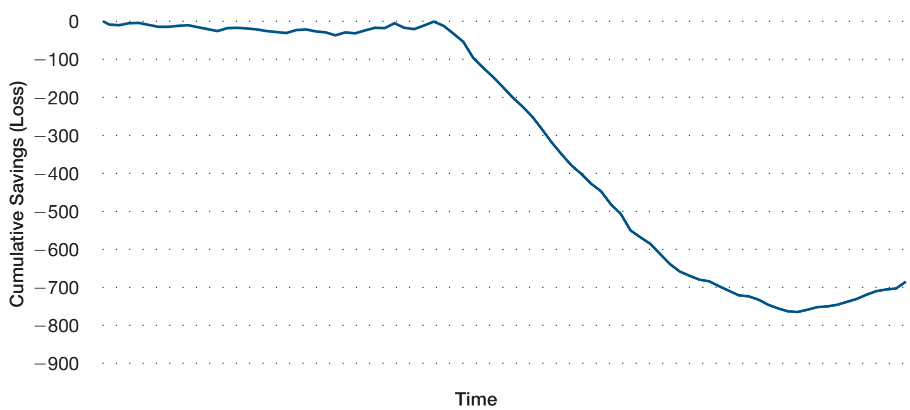
- Significant margin loss
- Improving trend
- Recent performance good
- Worst performance January and July
- Best performance November and December

Performance vs. Target



Cumulative sum (CUSUM) techniques show the cumulative savings made over a period. Figure 36, for example, shows cumulative savings over a period of eight weeks.

Figure 36. CUSUM reporting



CUSUM figures are calculated by adding the savings of each period to produce a running total. If the process is on target, the savings will on average be zero, and the CUSUM line will be horizontal. Off-target performance will "lose" each period, and the slope of the CUSUM line will be negative. Above-target performance will produce a positive slope. A change of gradient on a CUSUM graph signifies an "event" – a change in the performance of the process.

8.8 Data Modelling and "What If" Analysis

Targets are calculated by producing a model of operations using historical operating data (or a first-principles model).

Other modelling techniques can be considered, including neural networks, case-based reasoning and other statistical and mathematical techniques. These techniques should be applied carefully – modelling process operations requires a good understanding of the relationships between variables on the part of the analyst. Rule induction facilitates that understanding.

In spite of the pitfalls, data modelling can be an effective basis for monitoring control and optimization solutions, and the models can be used to study the impact of altered conditions – a "what if" analysis.

Metering and Measurement 09

Overview

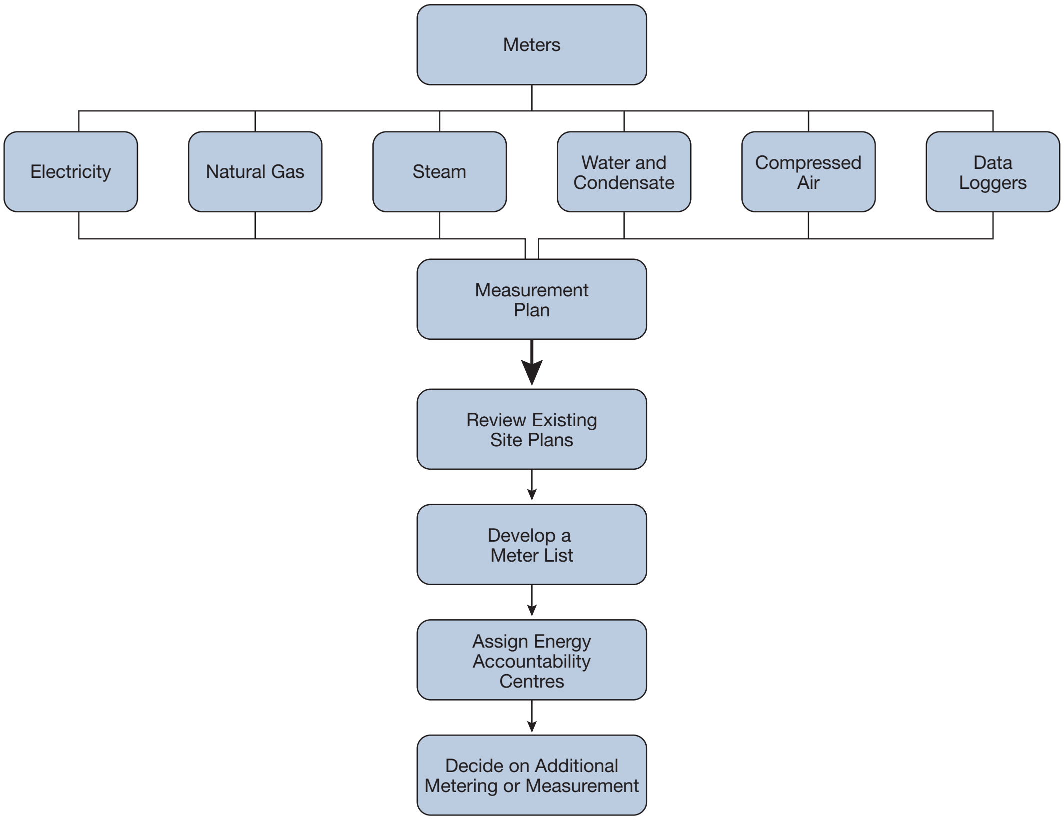
This section discusses the characteristics of available metering and the required infrastructure to collect and store data.

Outlined in the following is an approach to guide the end-user toward implementing a metering and measurement system, bearing in mind the following key questions:

- Do I need any additional meters to manage energy use?
- How do I decide where to install meters?
- What meters should I use?
- How do I link these meters to my monitoring systems?
- Can I afford them? If not, what are the priorities?
- What are the practical and other issues I need to know about?

A structured approach to developing a measurement plan is illustrated in Figure 37.

Figure 37. Measurement plan – A structured approach



9.1 Introduction

If something can be measured, it can be managed.

Metering and measurement represent a key component of the overall EMIS. Timely measurement of utility consumption, ambient conditions and process variables allow your plant or facility to

- provide cost-centre accounting
- identify problem areas before they become out of control
- verify utility billing
- assist in energy purchasing
- assist in maintenance and troubleshooting
- aid in identifying and monitoring energy projects
- offer meaningful data toward sizing and design for capital installations and improvements

It must be emphasized that whatever is being measured, the output data will not in itself reveal why something happened. At this point, the end-user is encouraged to note changes and deviations in the data's patterns and look for possible causes. On another cautionary note, the difficulty in measuring everything at once makes it necessary for the end-user to select a few key areas and monitor these with particular attention to the sudden change or unusual event and other warning signals. Having acquired the data, the end-user may be guided by the following when interpreting the measured results:

- Since measurements do not "stand alone," use comparisons to determine if a result is under or over budget, better or worse than the last similar time period, above or below the industry average, or better or worse than one product or another, to name only a few considerations. Perform benchmarking according to internal and external comparisons.
- When making comparisons, words can be too vague to be useful; use numbers (e.g., "100 kg of product/MWh is an improvement over 85 kg/MWh" is more specific than "we are better than we used to be").
- Normalize the data in order to ensure realistic comparisons. Account for seasonal difference changes in use and occupancy or process (e.g., m^3 natural gas vs. m^3 natural gas heating degree-day).

9.2 The Need for Metering

An energy management plan or strategy should be developed before contemplating the expansion of metering capability and selecting sensors, meters and other monitoring instruments. This plan will provide a foundation for considering the intended purpose of installing meters beyond the utility's revenue metering. Reliance on main utility meters, except in the cases of small plants or facilities, is inadequate for determining utility consumption profiles in these areas. The end-user must clearly understand whether the metering is being installed strictly for savings verification and whether the installation is to be permanent or temporary. Sub-metering allows for energy use accountability to be introduced at the level of the end-user, who has the greatest influence on driving operating costs downward, unlike plant or facility utility personnel.

Forecasting for utility purchase contracts is another driver for increased metering and measurement capability. In some regions, retail power rates have become more time-sensitive, and the average price will change over time and use. Load profile shapes will influence pricing in this situation, with flatter profiles usually resulting in a lower average cost.

Energy marketers may offer simplified rates that level out these time-based variations, but this may not necessarily offer the best deal. Variable rates may provide the lowest average price when selected in conjunction with strategies that reduce, level or shift peak demand. Knowing the shape of your aggregate typical daily load profile and that of your major sub-metered loads could reveal opportunities to reduce present and future price and thus total cost. Increased knowledge of your energy use will help your energy supplier offer the most optimum and secure pricing.

The same rationale in the foregoing may be applied to natural gas fuel forecasting and purchasing. From the point of view of producers, transporters and suppliers, a level load throughout the day and year is most desirable. As a result, variations in demand tend to increase these costs significantly. Having a detailed knowledge about gas use, enhanced by sub-metering, will allow the purchaser to determine the amount of base-load firm and interruptible gas requirements for contracted purchases.

In summary, energy purchase contracts may be sensitive to peak use that exceeds maximum levels specified in the purchase contract, making close monitoring and control of plant or facility loads necessary. Lack of knowledge about an organization's consumption or usage peak profiles will be detrimental to negotiating the best available purchase contract in an open market.

Be sure to know the following:

- when the energy is consumed (time of day and seasonal use)
- what loads can be controlled (shifted, levelled and/or reduced)

9.3 Deciding Where to Locate Meters and Sensors

Having established the need for metering and measurement, the next step is to develop a measurement plan that outlines a road map for installing monitoring equipment. This plan should identify

- all monitoring points
- types of sensors and their locations
- signal cable routes and wireless communications
- necessary documentation

The measurement plan precedes the preparation of a data acquisition plan and subsequent analysis. The end-user must ultimately define the frequency of measurements (e.g., 15 minutes, hourly, etc.) and whether monitoring will be for a short or long term.

9.3.1 Step 1: Review Existing Site Plans

A structured approach to a measurement plan

If up-to-date site plans are available, single-line diagrams should illustrate natural gas and electrical distribution to major loads. The electrical schematics will illustrate the power distribution to transformers, motor control centres and major loads. The schematics, having revealed the configuration of the energy distribution and metering, will provide valuable insight as to whether the existing distribution systems readily lend themselves to metering for cost allocation purposes.

In many instances, many of the main gas metering points or motor control centres could supply loads in different plant or facility cost centres. Installing additional metering for all these loads would likely be cost-prohibitive or at odds with the site's budgetary constraints. The steps listed in the following will help rationalize the decision as to the number and location of meters that will strike a balance between the site's objectives and budgetary constraints.

9.3.2 Step 2: Develop a Meter List

A list of meters that will be included in the overall cost allocation strategy should be developed. A simple example of such a metering list is illustrated in Table 7.

Table 7. Metering list

Metering Point	Metered Load
CA 1	No. 1, No. 2 air compressors
E 1	115 kV sub
E 2	Administration building
W 1	Municipal water service
NG 1	Main site entrance
NG 2	Dryers
E 3	Parking lot car block heaters and lighting
W 2	No. 1, No. 2, No. 3 service water pumps
S 1	Utility boilers No. 1, No. 2
E 4	HVAC units No. 1, No. 2, No. 3

9.3.3 Step 3: Assign Energy Accountability Centres

After completing the metering list, energy accountability centres can be assigned in accordance with the plant or facility's business units. Table 8 illustrates an example as to how the energy accountability centres may be configured in accordance with the metering list presented in Table 7.

Table 8. Energy accountability centres

Business Unit	Energy Accountability Centre	Performance Variable	Metered Load
Site services	Administration	Tonne of product	E 2
Site services	Parking lot	Tonne of product	E 3
Site services	Building heating	Outdoor air temperature	NG 1 – NG 2
Site services	Air conditioning	Outdoor air temperature	E 4 – Calculated Factor
Site services	Domestic water	Tonne of product	W 1
Process	Materials handling and production	Tonne of product	E 1 – (E 2 + E 3 + E 4)
Process	Process heating	Tonne of product	NG 2
Process	Compressed air	Tonne of product	CA 1
Process	Process water	Tonne of product	W 2
Process	Process steam	Tonne of product	S 1

9.3.4 Step 4: Decide on Additional Metering or Measurement

Adopting a systematic approach to tabulate a metering list and energy accountability centres reveals areas where metering and measurement can be improved.

For example, major process loads such as pumps, motor drives, etc. could be electrically sub-metered to gain more knowledge on usage rather than having to rely on a coarse measurement from meter subtraction for process, as illustrated in Tables 7 and 8.

Also, there is a gap in potential useful information to be gained from the compressed-air system, which is not power metered according to the metering list. At the moment, compressed-air flow (m^3/sec) can be "ratioed" against total production (tonne of product). Electrically sub-metering the bank of air compressors (No. 1 and No. 2) would enable the performance of the air compressor equipment to be tracked – (m^3/sec)/kW – yielding valuable diagnostic information. If Metering Point E 5 were added in this regard, the energy accountability centre tabulation would be amended with the following addition:

Business Unit	Energy Accountability Centre	Performance Variable	Metered Load
Process	Compressed air	Total airflow	E 5

9.4 Deciding on What Types of Metering to Use and Practical Considerations

9.4.1 Electrical Metering

In many cases, power quality and feed protection issues represent the driving force for sub-metering electrical power instead of energy management considerations. In moving to an energy management and cost control justification for installing additional metering capability, the following should be considered when reviewing the types of commercially available metering equipment and subsequent selection.

As a start, existing utility revenue metering should be utilized to the fullest possible extent, particularly to gain an appreciation of a site's total electrical load profile or for billing verification. Special concerns related to using existing revenue metering include the following:

- Because the revenue meter is the property of the utility and is a regulated device, utility personnel should make any modifications.
- Modifications typically include retrofit with a pulse initiator or installation of a pulse splitter on an existing pulse initiator.
- It is key that the pulse value is obtained from the meter or the utility.
- When existing facility panel meters cannot be refitted with pulse initiators or when voltage levels prohibit cost-effective installation of new meters, new 5-amp current transformers could be installed on the secondary side of existing meter current transformers, which would in turn be connected to new metering equipment. This metering approach is not as accurate as direct metering because measurements based on secondary current introduce a second measurement error.

Tying into existing power utility revenue metering

Power meters owned by the site for monitoring total power to a major load centre would typically be located at the point of delivery (sub-station) and monitor the watts and Q-pulse from the utility revenue meters. Total kVA, kW and kVAR readings would then be calculated from these signals. A typical digital power meter for this application would offer a digital readout display and a maximum sampling rate of 128 Hz. A standard version may allow for a maximum of four channels. In comparison, a premium, more advanced version of this power meter would include most of the same features but have a video display terminal and allow for a maximum of 42 channels. The premium version is generally more suited to revenue grade metering and would offer power quality analysis, event-triggered data storage and logging.

An economical power measurement unit for sub-metering could typically offer a digital readout display and a maximum sampling rate of 32 Hz. Typical power measurement would include apparent power (VA), reactive power (VAR) and power factor (PF), as in the more premium models previously referred to. This unit would typically be ideal for use as a power transducer for DCS, EMS, SCADA and PLC systems.

A deregulated power market application may impose certain metering requirements. The following Web sites are included for reference, representing power-metering products that are deemed to conform to the requirements of some open markets:

- Conforming list for an Independent Electricity Market Operator in Ontario: www.iemo.com/imoweb/metering/meterlist.asp
- IEMO Wholesale Revenue Metering Standard: www.iemo.com/imoweb/pubs/metering/mtr_wrmStdHw.pdf

End-users are encouraged to research the particular requirements that apply to the region in which their plant or facility is located.

9.4.2 Natural Gas Metering

In most cases, natural gas sub-meters with dial indicators are used. Although equipped with pulse output capability, this feature is rarely used, largely due to perceived cost considerations. Larger areas of natural gas consumption may have meters that make use of the utility's pulse signal.

Natural gas meters range in size and capacity from 2-in. (50-mm) flanged connections at 800 CFH (22.6 m^3/hr.) capacity to 56 000 CFH (1600 m^3/hr.) rating. For small commercial loads of up to 15 psig (1 bar), compact line-mounted meters with a dial-face or odometer-type index can be purchased. For higher-volume industrial loads, a full range of meters that are rated for working pressures of up to 300 psig (24 bar) are available.

Many site-owned meters remain uncorrected for temperature and pressure, bringing the accuracy of many site-metered volumes into question. Compensation for temperature effects can be accomplished by a mechanical computer with a spiral bi-metallic thermocouple probe, positioned at the meter inlet within a sealed temperature well. Natural gas volume readings may be corrected to a 60°F (15°C) basis to yield readouts in standard cubic feet (SCF) or normal cubic metres (Nm^3) between flowing temperatures of −20°F to 120°F (−29°C to 49°C).

Ensure that pressure/temperature compensation is applied to natural gas meters.

Pressure correction factors may be calculated according to the following formula:

$$\frac{\text{Utility delivery pressure + Site atmospheric pressure}}{\text{Atmospheric pressure at sea level}}$$

For example, if the utility delivery pressure is 50 psig (345 kPa), estimated site atmospheric pressure is 14.6 psi (100.66 kPa) and atmospheric pressure at sea level is 14.73 psi (101.56 kPa), then the pressure correction factor would be

$$\frac{50 + 14.6}{14.73} = 4.39$$

As such, the metered volume would be multiplied by 4.39 to obtain a "true" reading in this case.

Temperature- and pressure-compensated meters are commercially available from major vendors. Some meters are available with battery-powered microprocessor-based correction for temperature and pressure effects. The corrector may be integrally mounted within the body of the meter or externally mounted on a wall, pipework or standard instrument drive.

Thermal-dispersion-type flow meters offer relative simplicity of measurement through a single-pipe penetration, thus eliminating temperature and pressure transmitters and density compensation calculations required by differential pressure, vortex and turbine type metering. As such, less hardware is needed for a metering system, and this flow meter offers an alternative and accurate means of gas-flow measurement. Communication between the flow meter and signal processor assembly is over two-wire pair. Linear output signals of 0-5 V DC or 4-20 mA can interface with either RS 232 or RS 485 communication.

It must be remembered that because gas service entrances and meters are usually located outdoors, a $1,000 metering point can incur a final cost of $10,000 when the costs of trenching, buried conduit and structural penetrations through buildings for pipework are considered. In these cases, wireless data communications may present a viable alternative.

Much like electrical meters, a pulse initiator could be installed on existing natural gas meters by the utility to provide shared signals. For cases where a pulse initiator is already present on the meter, a pulse splitter may be installed. Important points to consider in using shared signals for natural gas metering include

- allocate enough coordination time with the utility
- obtain from the utility the correct scale factor for the meter
- temperature and pressure compensation of the output from the pulse initiator

It should be emphasized that although sharing signals with utility meters can be cost-effective, sharing signals with existing facility meters can entail unforeseen calibration and repair expenses. Related concerns include

- all the inaccuracies of the existing metering system are assumed
- existing facility meters could potentially be improperly sized
- calibration documentation could be limited or unavailable
- impracticality of removing meters from a live system could leave no alternative but field calibration, with its associated approximations

9.4.3 Steam Metering

Orifice plate meters are in common use throughout plants. Calibration data would have to be obtained either from the facility's calibration records or from a meter's nameplate data. Steam flow is proportional to the square root of the pressure difference across the measuring orifice plate. At low flows, significant changes in flow may not generate significant changes in differential pressure, leading to measurement error. This is a concern if steam generation falls below the turndown ratio for rated accuracy of the orifice plate measuring device, leading to inaccurate data logging.

Another caution regarding the use of orifice plate steam flow meters relates to when steam pressure is lowered. Steam flow readings extracted by differential pressure orifice plate devices are usually affected when steam pressure is lowered due to a corresponding reduction in steam density. This in turn results in a greater pressure drop at the orifice plate for a given flow, yielding a proportionally higher steam flow reading. Calculated mass flow correction factors must be applied to steam flow readings in this case to obtain a true reading. Discussions with site personnel reveal that automatic pressure compensation is rarely applied.

An example of mass flow correction as applied to orifice plates for saturated steam is outlined as follows:

Given a flow reading of 13 607 kg/hr. of saturated steam, an operating pressure of 690 kPa and an orifice plate design pressure of 862 kPa, what is the actual corrected mass flow?

The correction formula is: $C_m = \sqrt{(dD/dA)} \times (dA/dD)$

Where dA = steam density at actual pressure
dD = steam density at design pressure
C_m = mass flow correction factor

From steam tables: dD = (1/specific volume) = 1/0.201 = 4.976 kg/m^3
dA = (1/specific volume) = 1/0.243 = 4.120 kg/m^3

$$C_m = \sqrt{(4.976/4.120)} \times (4.120/4.976) = 0.9098$$

Therefore, the actual steam flow is 0.9098 × 13 607 = 12 380 kg/hr.

Differential pressure is usually measured by a differential pressure transmitter and conditioned into a 4-20 mA or other industry standard signal to an energy management and control system.

Beware of calibration for orifice plate steam metering.

Vortex flow meters, although more costly, offer greater accuracy compared with orifice plate flow meters and have over three times the "rangeability." Another alternative to flow measurement by orifice plate is offered by annubars, which consist of diamond-shaped sensors that are inserted in the flow stream. Annubar flow sensors generate lower permanent pressure loss due to reduced flow restriction and require less labour to install. As an example, an annubar installed on an 8-inch (200-mm) pipe requires only 4 linear inches (20 cm) of welding compared with an orifice plate, which requires 50 inches (125 cm) of welding for the same pipe. Installed cost savings range from 25 percent on smaller pipes to 70 percent on larger pipes. As in the case for orifice plates, manufacturer's data must be consulted to determine the appropriate temperature and pressure compensation factors. Rangeability will be similar to orifice plates.

9.4.4 Water and Condensate Metering

Pulse head retrofit is usually required for water meters.

Unless a meter is very old, existing turbine, rotating disc, vortex and magnetic flow meters can usually be retrofitted with a pulse head. Final confirmation of this should be made with the meter manufacturer. Although rarely calibrated, most of these flow meters probably have reasonable accuracy if the meters are in serviceable condition. Be aware that the costs of meter removal, replacement of worn parts and recalibration could often equal the cost of a new meter. It is suggested that any pulse-head retrofit should be accompanied by the installation of a local register to provide a check reading.

If the metering pipework includes a check valve to stop the flow of condensate or water through the meter, and if the check valve fails, the flow may be correctly metered on the local register but metered multiple times by the pulse head.

Numerous types of venturi, annubar and orifice plate meters that use differential pressure transmitters will be encountered in the field. These are susceptible to numerous operational and calibration issues.

Non-intrusive type flow meters offer a means of performing spot checks for liquid flow measurement. These include magnetic, transit time and doppler-type sonic flow meters. The main advantage of this metering equipment is that it offers portability of measurement and unobstructed flow with no pressure drop in the pipework. Important points to consider in selecting non-intrusive meters include

- magnetic flow meters are relatively expensive but offer high rangeability (30:1) and are suitable for dirty fluids and bi-directional flow measurement
- transit-time-based sonic flow meters offer high accuracy for relatively clean flows but are adversely affected by bubbles or particles in the flow stream and internal deposition on pipe walls, and require full pipe flow with moderate turbulence
- the accuracy of doppler-type sonic flow meters depends on the presence of suspended particles or bubbles in the liquid flow stream

9.4.5 Compressed-Air Metering

Although widely used, orifice plates are inappropriate for compressed-air systems because they offer limited turndown capability (3:1), and they generate relatively high differential pressures. It is suggested that Pitot-tube-based instruments offer improved turndown and relatively negligible differential pressure. Selection of a Pitot-tube-based measurement should include temperature and pressure compensation in order to produce true flow readings. Both the Pitot tube and Type J thermocouple should be installed in an undisturbed section of the compressed-air line from each compressor.

Lack of pressure gauges or uncalibrated gauges in the system restrict measurement of differential pressures on critical components such as filters, coolers and separators. Installation of test taps at selected locations would enable the use of one calibrated precision instrument to obtain reliable pressure readings and avoid maintaining and calibrating a number of gauges.

9.4.6 Data Loggers

The role of data loggers

In situations where access is cumbersome (e.g., motor and fan housings, electrical junction boxes, air vents, etc.), data related to temperature, relative humidity, voltage, amperage, pressure and CO_2 can be monitored by data loggers. Since they are stand-alone devices, they can also be re-used for other assignments. Relative cost is low compared with more permanent data-acquisition systems.

Most data loggers can interface with a PC. Some have external input capabilities that may be wired to existing gauges and sensors that are equipped with voltage output terminals, also enabling these devices to be monitored and recorded.

Data loggers offer an alternative measurement application for opportunities where a small number of simple retrofit measures (e.g., lighting) are replicated in great quantity and only a representative sample requires metering. Knowing the operational profile of a motor or lighting system that has a flat amperage-draw profile enables energy consumption to be readily computed.

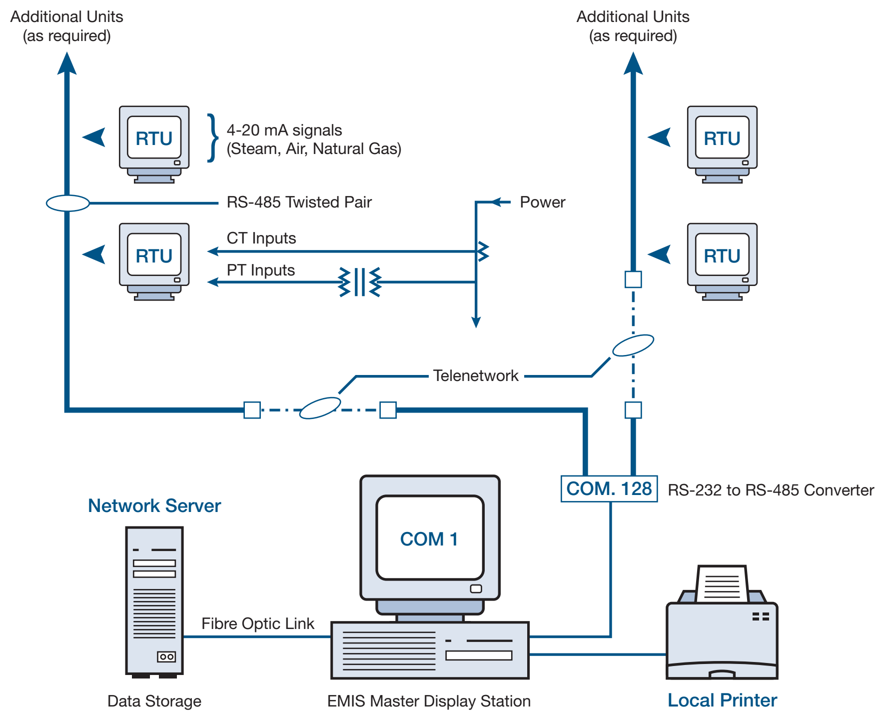
9.5 Linking Meters to Monitoring Systems

Following the selection of metering equipment, the architecture of the system that links the data collected in real time from various remote electronic meters (natural gas, power, compressed air, steam and water) to the EMIS software must be configured.

Currently, most meters have analogue output options (4-20 mA), serial digital interface options (direct RS 232) and network bus communication interface capability, for example, Ethernet, Modbus remote terminal unit (RTU), etc. As such, although most meters can be initially used on a stand-alone basis, these can be integrated within a complete plant or facility-wide system for monitoring and control through a common communication link, offered through open architecture.

Figure 38 illustrates a commonly used system that utilizes RTUs mounted in the field to monitor energy use in various areas of a plant or facility. The RTUs are interconnected via a local area network (LAN) to a main EMIS computer.

Figure 38. Common EMIS configuration



9.6 Cost Considerations

Cost is always a prime consideration, and having planned for measuring and data acquisition, a decision must be made as to whether the existing metering infrastructure should be used or whether new metering equipment should be purchased. It should be cautioned that the avoided cost of using an existing meter can be offset by the costs of converting to meet new metering requirements, in addition to inspection, repair and calibration costs. Other considerations include technical requirements of the project, whether the meter still has to fulfil its original duty and whether a permanent installation is required.

The cost-effectiveness of metering depends highly on the economies of scale of the end-use. For example, metering of a 200-hp motor is comparable to a 20-hp motor, but the 200-hp motor has the potential for yielding 10 times the savings for similar cost.

Costing is difficult to estimate for the purposes of this handbook in the absence of detailed engineering and the susceptibility of costs to market conditions.

9.7 Concluding Remarks

It is better to be roughly right than precisely wrong.

The expectation of absolute precision for all of a site's measurements and the difficulty of achieving this is often perceived as a barrier to implementing improved metering capability. This should not deter the site from upgrading metering systems before it implements an EMIS. Staged implementation applied within budgetary constraints is a practical way to get started. At this point it is important to realize that, in practice, measurements will not be perfect.

Reward good performance and help poor performance.

Action to achieve improvements is best ensured by an organizational culture that encourages rewards and sustains utility cost-reduction initiatives. The EMIS is intended to supply useful information and data about the site's utility consumption patterns. Effectively communicating, encouraging participation and involving personnel across all levels of the site requires people skills. Motivation will be sustained when a team experiences early success with proven results, as validated by the EMIS. Credibility will also enhance motivation and buy-in from all personnel. Methods of rewarding good performance should be developed with an organization's human resources group. This may involve giving recognition through publicity (e.g., testimonial posters, company publications such as newsletters, non-monetary awards at company events, etc.) or a modest cash award. Motivation will also be enhanced when staff is assured that help is available from the team to correct poor performance.

Although procedures and standards such as ISO serve a useful purpose, beware of overreliance on these as a driver for improving energy use efficiency. For example, ISO 14000 is widely regarded as a proven international standard for effective and comprehensive environmental management. Although it is broad enough to encompass energy use efficiency, this broad focus may miss some unique aspects of energy management. For example, strategic energy purchasing is a complex and key requirement when operating within a deregulated environment. The key focus of ISO 14000 is on environmental conformance and compliance. As such, this standard offers no guidance on energy purchasing because purchasing is not normally related to conformance compliance. Undeniably, there is a direct link between energy and the environment, and an EMIS can serve as a useful complementary tool to environmental issues.

Overreliance on a single energy champion is risky.

Another area that can be a problem is relying too much on a single energy champion. Many organizations have been in situations in which information could not be found because "only a certain person knew" or because that person was absent. An effective EMIS will capture the collective knowledge of a site's energy use and make it broadly available. In addition, by reducing data-collection time, personnel can devote more time to developing solutions.

10 Do You Have an Effective EMIS? A Checklist

The following can help assess an EMIS and compare it with the structured approach presented in this handbook. This checklist may indicate that many of the elements of an EMIS as presented are there, but are under-utilized or not utilized at all. Several desirable elements may be able to be implemented at minimal cost. At the very least, this checklist will indicate what is missing vs. what is achievable and can lead to greater profitability through improved energy use efficiency.

An effective EMIS should include the items listed in the following checklist. Implementing these items should reduce annual energy costs by at least 5 percent.

Deliverables: Does the EMIS Deliver the Following?

Yes	No		
❍	❍	Early identification of poor performance	Excess energy use in key areas of the process is identified quickly enough to allow remedial action to be taken (identifying performance in the past that could have been better is not enough!).
❍	❍	Support for decision making	The EMIS user is provided with information (paper-based resources or software tools) to help him or her act when poor performance is identified.
❍	❍	Effective energy reports to all decision-makers:	Energy performance is reported to key decision-makers. The reports address all personnel involved in the management of business and energy performance.
❍	❍	• Executives	
❍	❍	• Senior managers	
❍	❍	• Operations management	Reports include only relevant data and are designed for the individuals concerned.
❍	❍	• Engineering	
❍	❍	• Operations personnel	
❍	❍	• Planning and scheduling	Reports are integrated into existing reporting systems.
❍	❍	• Accounts	
❍	❍	• External bodies	Reports are timely and accessible.
❍	❍	• Other relevant staff	
❍	❍	Audits of historical performance	Provides details of past performance, including breakdown of energy use, trends in key performance indicators, and comparisons of energy use and key performance indicators with robust target values.
❍	❍	Support for identifying savings measures	Quantifies energy use of individual processes and the plant. Supports the quantification of the impact of changes in key process parameters on performance.
❍	❍	Provides evidence of improved energy performance	Shows improved performance against agreed benchmarks for the entire site, individual processes and the plant.
❍	❍	Provides assistance with energy budgeting and contract negotiations	Provides relationships between influencing factors (production levels, product qualities, product mix, ambient conditions, etc.) to enable future energy demands to be predicted with confidence.
❍	❍	Provides energy data to other business and process IT systems	Provides relevant data and relationships to planning and scheduling systems, to management accounting and similar corporate IT systems, and to process and plant performance monitoring and management systems. Feeds relevant data to central data historians/ warehouses.

Features: Does the EMIS Include the Following Key Features?

Yes	No		
❍	❍	Effective storage of energy and related data	A modern database, historian and warehouse.
❍	❍	Ready access to relevant data by all relevant staff:	Data easily accessed by relevant staff using standard tools (spreadsheet, executive information system, enterprise resource planning, management information system, applications programs, DCS, SCADA, etc.).
❍	❍	• Executives	
❍	❍	• Senior managers	
❍	❍	• Operations management	
❍	❍	• Engineering	
❍	❍	• Operations personnel	
❍	❍	• Planning and scheduling	
❍	❍	• Accounts	
❍	❍	• External bodies	
❍	❍	• Other relevant staff	
❍	❍	Calculation of effective targets from historical data or plant simulation	Incorporates modern data analysis tools to create effective targets that take account of multiple influencing factors (beyond multiple, linear regression) and/or includes first principles models of plant operations as targets.
❍	❍	Comparison of actual performance against targets	Compares the actual values of energy use and key performance indicators and influencing factors against target values.
❍	❍	Historical data analysis	Tools to identify patterns in historical data, ranging from simple graphics to visualization and data mining.
❍	❍	Graphical reporting	Reports include simple but effective graphics (line, scatter, bar, CUSUM, three-dimensional, etc.).
❍	❍	Data validation	Heat and mass balances, range checks, etc.

Elements

Yes	No		
❍	❍	Energy meters	Energy meters in sub-areas of the site automatically read.
❍	❍	Measurement of influencing factors	Measurement of influencing factors automatically read.
❍	❍	Measurement of key performance indicators	Measurement of KPIs automatically read.

Elements (continued)

❍	❍	Automated data acquisition	Automated data collection is a key requirement of an effective EMIS.
❍	❍	Data historian	A database that can store and effectively serve.
❍	❍	Data analysis tools	A suite of data analysis tools from regression to data mining.
❍	❍	Reporting tools	Ideally, tools are already used to report process and business performance.
❍	❍	Decision support tools	Software tools or paper-based.
❍	❍	Interfaces	To enterprise resource planning, management information system, DCS, SCADA, spreadsheet, etc.

Support

Yes	No		
❍	❍	Energy management program	A comprehensive energy management program of which the EMIS is one element.
❍	❍	Management commitment	Support and commitment for the energy management program from the CEO and senior management.
❍	❍	Allocated responsibilities	Responsibility for energy performance allocated to relevant production, operations and department management, not the energy manager.
❍	❍	Procedures	Procedures to ensure the tasks necessary to operate the EMIS and to achieve savings are understood and adopted.
❍	❍	Training and support	Technical training, training in using software, support to EMIS users.
❍	❍	Resources	Financial commitment and personnel appropriate to the achievable benefits.
❍	❍	Regular audits	To check system performance, adherence to procedures and benefits realized.

Appendix A: Abbreviations

CFH	Cubic feet per hour
CIPEC	Canadian Industry Program for Energy Conservation
CO_2	Carbon dioxide
DCS	Distributed control system
EIS	Executive information system
EMIS	Energy management information system
EMP	Energy management program
ERP	Enterprise resource planning
HVAC	Heating, ventilating and air conditioning
ISO	International Organization for Standards
IT	Information technology
KPI	Key performance indicator
M&T	Monitoring and targeting
MCF	Thousand cubic feet
MIS	Management information system
Nm^3	Normal cubic metres
PLC	Programmable logic controller
psig	Pounds per square inch gage pressure
SCADA	Supervisory control and data acquisition
SCF	Standard cubic feet

Appendix B: Figures and Tables

Canadian Industry Program for Energy Conservation

CIPEC

For more information or to receive additonal copies of this publication, write to

Canadian Industry Program for Energy Conservation
Office of Energy Efficiency
c/o Natural Resources Canada
580 Booth Street, 18th Floor
Ottawa ON K1A 0E4
Tel.: (613) 995-6839
Fax: (613) 992-3161
TTY: (613) 996-4397 (teletype for the hearing impaired)
E-mail: cipec.peeic@nrcan.gc.ca

Leading Canadians to Energy Efficiency at Home, at Work and on the Road

The Office of Energy Efficiency of Natural Resources Canada strengthens and expands Canada's commitment to energy efficiency in order to help address the challenges of climate change.

Canada

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 6
Schedule 9
Appendix H
Filed: 2011 Apr 1
(51 pages)

MARKET PROFILE AND OPPORTUNITY ASSESSMENT OF THE COMMERCIAL AND INSTITUTIONAL SECTORS IN THE GREATER TORONTO AREA

[Project ID #: 28013]

– Final Report –

Submitted to:

Toronto Hydro Energy Services

Submitted by:

Marbek Resource Consultants Ltd.

May 27, 2008

Marbek Resource Consultants Ltd.
300-222 Somerset Street West, Ottawa, ON K2P 2G3
Tel: 613.523.0784 ⬩ Fax: 613.523.0717 ⬩ www.marbek.ca

EXECUTIVE SUMMARY

The objective of this study is to provide Toronto Hydro Energy Services (THES) with a market assessment of the commercial and institutional sectors in the Greater Toronto Area (GTA). This includes the identification and examination of sub-sectors that present the greatest opportunities in terms of energy efficiency gains. Several key factors, such as overall floor space, energy use, and energy intensity, were used to identify these sectors. Each of these priority sub-sectors was profiled in order to assess factors such as regional distribution and identify key players and their contact information. Specifically, the contact information of individuals responsible for energy and/or facilities management was sought.

The following sub-sectors were profiled:
- Offices
- Warehouses/Wholesale
- Non-Food Retail
- Universities
- Elementary and Secondary Schools
- Colleges.

Through the use of a model that was developed in-house, this study also assesses the magnitude of the energy savings opportunities in the commercial and institutional sectors through the implementation of various energy conservation technologies. Measures related to building envelope, lighting, and HVAC were assessed and options that result in both electrical and natural gas savings were considered.

An economic scenario was used for this analysis; thus, all measures that passed an economic screen were applied. This process results in an optimistic estimate of the energy conservation potential but provides a good indication of which sub-sectors and end-uses show the most potential for energy efficiency in the GTA. The following findings were made:
- Overall, nearly two thirds of the energy savings potential is represented by electricity savings
- Offices have the largest energy savings potential, representing over a third of the estimated total
- Over 50% of the potential is represented by measures related to HVAC
- The energy savings potential through lighting improvements is also significant, especially if only considering electricity
- Over three-quarters of the energy savings potential is in existing buildings.

From these observations, the following program recommendations can be made:
- Office buildings should be the first priority for program offerings
- Other major sub-sectors should be targeted in the following approximate descending order of priority: non-food retail, wholesale and warehousing, schools, and universities and colleges
- HVAC energy efficiency programs should be the highest priority, followed by lighting
- Program offerings should include both electricity and natural gas savings
- Although existing buildings offer the largest potential, program offerings should also include new construction in order to avoid missing opportunities that will not recur for decades.

Table of Contents

List of Exhibits

1. INTRODUCTION

Marbek Resource Consultants was retained by Toronto Hydro Energy Services (THES), to provide a market assessment of the commercial and institutional sectors in the Greater Toronto Area (GTA).

The objectives of this market assessment are to identify and profile the sub-sectors that present the greatest opportunities in terms of energy efficiency gains. The investigation includes several key factors, including overall floor space, energy use, energy intensity, and ownership and occupancy patterns.

The remainder of this study will assess the magnitude of the energy savings opportunities in these sectors through the implementation of various technologies related to building envelope, lighting, and HVAC. This provides THES with key market and technical information that is essential to the expansion of effective conservation programs in the commercial and institutional sectors of the GTA.

1.1 DEFINITION OF COMMERCIAL AND INSTITUTIONAL SECTORS

For the purposes of this study, the following sub-sectors within the commercial and institutional sectors were analyzed at the regional level:

- Offices (excluding public administration)
- Public administration buildings
- Non-food Retail
- Food Retail
- Wholesale and warehousing
- Information and cultural industries
- Elementary and secondary schools
- Community colleges
- Universities
- Ambulatory health care services
- Hospitals
- Nursing and residential care facilities
- Social assistance facilities
- Accommodation services
- Food services and drinking places
- Religious organizations
- Other.

As discussed in Appendix A, these sector definitions are based on segmentation and codes within the North American Industry Classification System (NAICS). For modeling purposes, some of these sub-sectors are combined into larger categories with similar energy consumption patterns (e.g. offices and public administration buildings), or split to reveal building segments with differing energy use patterns (e.g. large offices and small offices).

The region included in the analysis is illustrated on the map of the GTA shown in Exhibit 1.1. As can be seen in this Exhibit, the GTA is made up of 24 municipalities that are grouped into 5 regions.

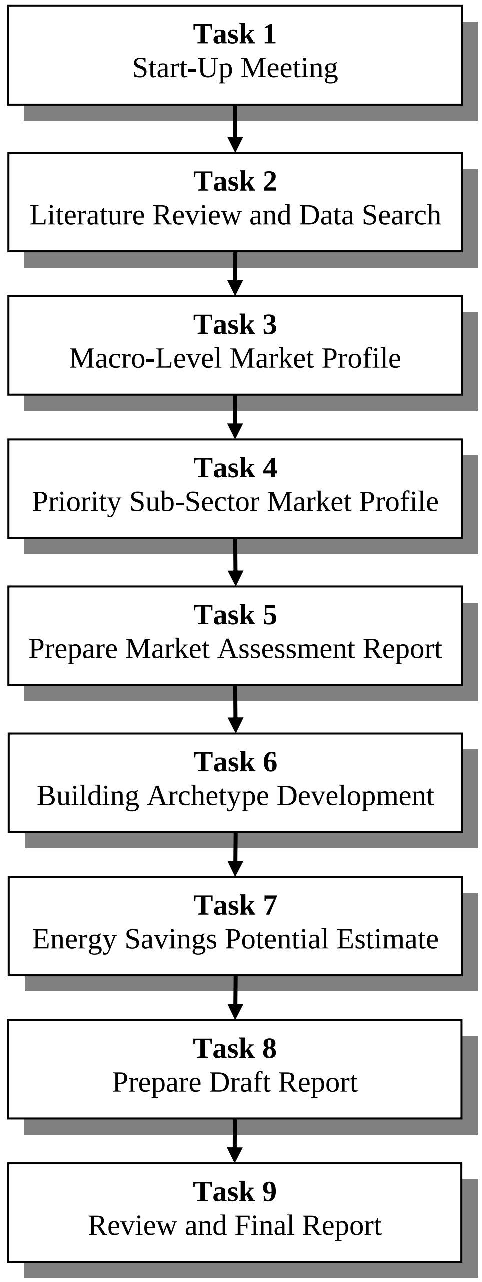
Exhibit 1.1: A Map of the Greater Toronto Area (GTA)

(Source: **www.greatertorontoarea.org**)

1.2 STUDY APPROACH & METHODOLOGY

The work plan for the entire study is presented in Exhibit 1.2.

Exhibit 1.2: Project Work Plan



1.2.1 Market Assessment Phase

This portion of the work began with a literature review of the best available information sources. Sources were found through internet research, real estate market publications and by contacting real estate and market professionals.

Based on the outcome of our review, a profile of the GTA's commercial and institutional sectors was developed. In this macro-level profile, the study team sought to understand market segmentation by facility type and to recognize the overall size of the various market sub-sectors, as well as overall energy consumption in those sub-sectors. The primary purpose of the macro-level market profile was to identify priority sub-sectors that warrant further investigation.

A comprehensive profile of the market for each priority sub-sector was then developed. This preliminary profile segments the market by region and facility type and to the extent that secondary data permit, addresses elements such as the following:

- How big is the market?
- Where are the facilities?
- Who are the main players?
- What is the profile of their regional distribution and head office locations?
- How is the market sub-segmented?

This report presents the results of the macro-level market profile and showcases more detailed profiles of the priority sub-sectors that have been selected as a result of this process.

1.2.2 Energy Modeling Phase

The second phase of the project involved the preparation of a number of building archetypes for use in the energy savings modeling exercise. These archetypes were adapted from work performed in other jurisdictions. The building energy end-use profiles were applied to the market data through the use of an MS Excel spreadsheet model.

The energy consumption model for each market and energy end-use was applied to derive potential energy savings across various end-uses. The savings estimates were applied through the development of a number of energy savings measure bundles that would notionally save a certain percentage of energy from each energy end use. Savings results were presented by market segment, energy end-use, and measure bundle type.

1.3 REPORT PRESENTATION

The remainder of this report is presented as follows:

- **Section 2 – Market Overview:** This section presents the market profile objectives and macro-level market profile results.

- **Section 3 – Market Profiles of Priority Sub-Sectors:** This section presents detailed assessments of the markets for the priority sub-sectors.

- **Section 4 – Energy Management Opportunity Assessment:** This section presents the potential for energy efficiency improvement.

- **Section 5 – Conclusion and Recommendations.**

2. MARKET OVERVIEW

This section presents an overview of the key characteristics of the commercial and institutional sectors in the GTA. The market overview is used for two primary purposes:

- To provide key parameters such as building floor area and energy consumption to be used in later stages of the study

- To identify priority sub-sectors to target for further data collection and profiling at the sub-sector level

The discussion is organized and presented in the following sub sections:

- **Building Inventory**, which presents an analysis of the number of buildings and the gross floor space of buildings in the commercial and institutional sectors

- **Energy use**, which presents the total energy consumption and energy intensity of the various sub-sectors

- **Interpretation of Results**, which outlines the method and reasoning that is used in the selection of the priority sub-sectors

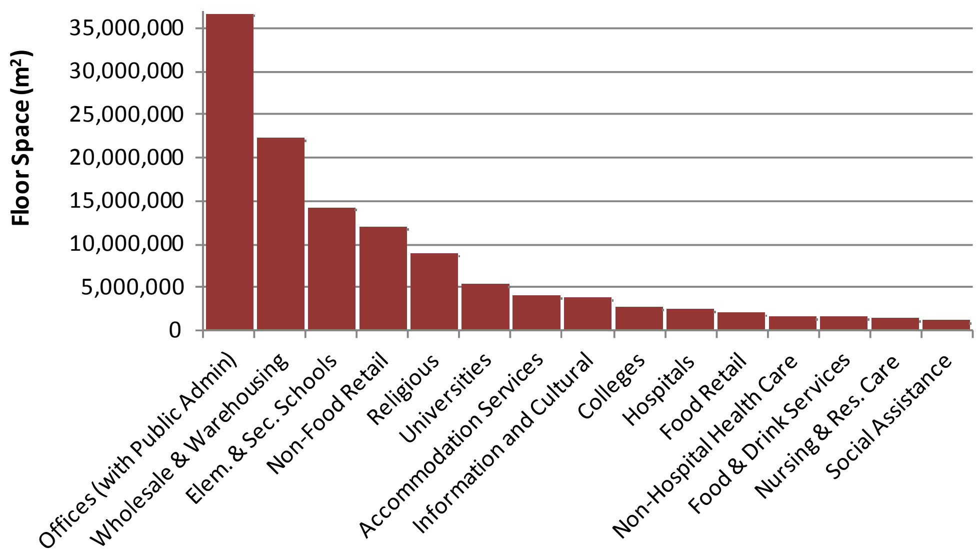
- **Caveats,** which discusses some of the limitations of the available data.

2.1 BUILDING INVENTORY

The data for the total building floor space of the commercial and institutional sector in the GTA are presented in Exhibit 2.1. The approach used to estimate these data based on CICES data for Canada and Ontario is outlined on page A-1 of Appendix A.[1] From Exhibit 2.1, it is clear that offices represent a large proportion of the total floor space, followed by warehouses, elementary and secondary schools, and non-food retail. Combined, these four sectors account for approximately 65% of the commercial and institutional floor space in the GTA.

[1] CICES provides data on the total number of establishments as well as the total building floor space for each of the specified sub-sectors. However, the current definition of establishments allows for each establishment to represent several buildings. Although this discrepancy will be resolved in future versions of the survey (based on personal communication with a CICES representative from NRCan OEE, Jan. 8, 2008), it results in the establishment data in CICES 2005 being of little value for this study.

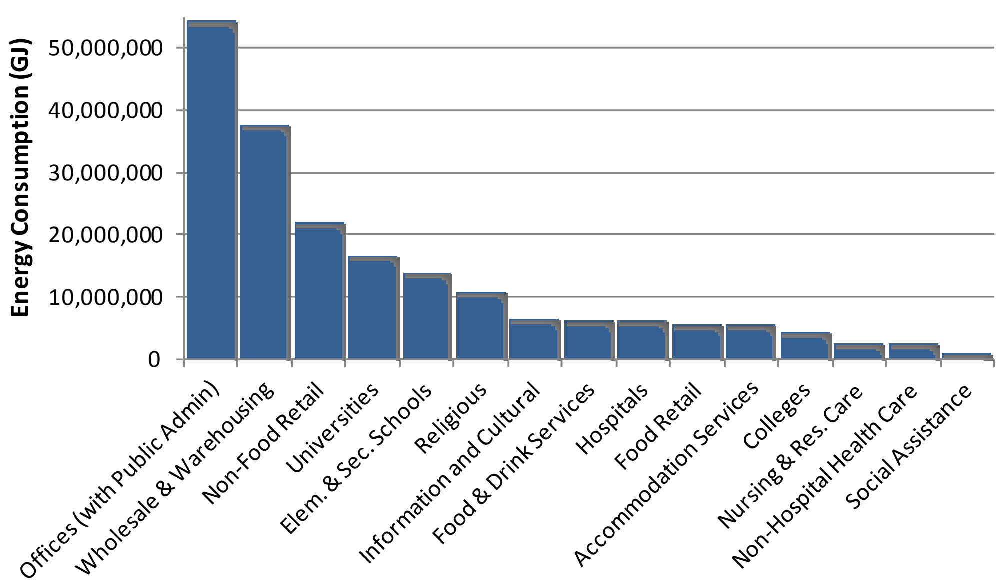
Exhibit 2.1: Floor Space of Commercial and Institutional Sector Buildings in the GTA



2.2 ENERGY USE AND PERFORMANCE

CICES 2005 data provide the total energy, electricity, and natural gas consumption by building activity for Ontario and Canada as a whole. However, the uncertainties in the estimates for electricity and natural gas use are significantly higher. Estimates for the total energy consumption of the commercial and institutional sectors in the GTA are presented in Exhibit 2.2 and Exhibit 2.3.

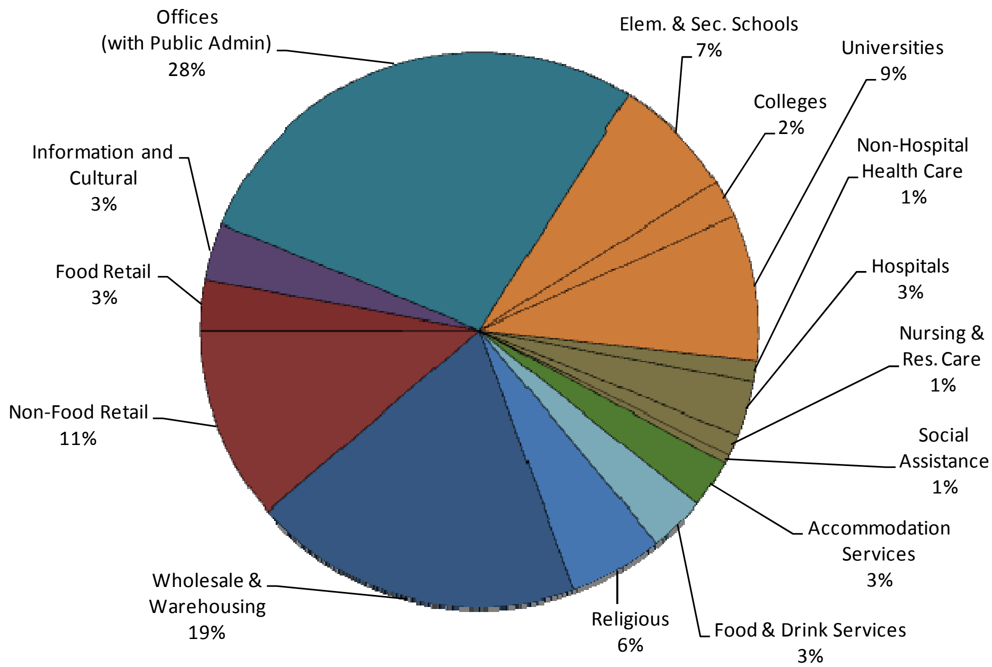
Exhibit 2.2: Energy Use of the Commercial and Institutional Sub-Sectors in the GTA



These exhibits indicate that offices are the top energy consumer by a large margin. Warehouses, non-food retail, universities, and elementary and secondary schools round out the top five.

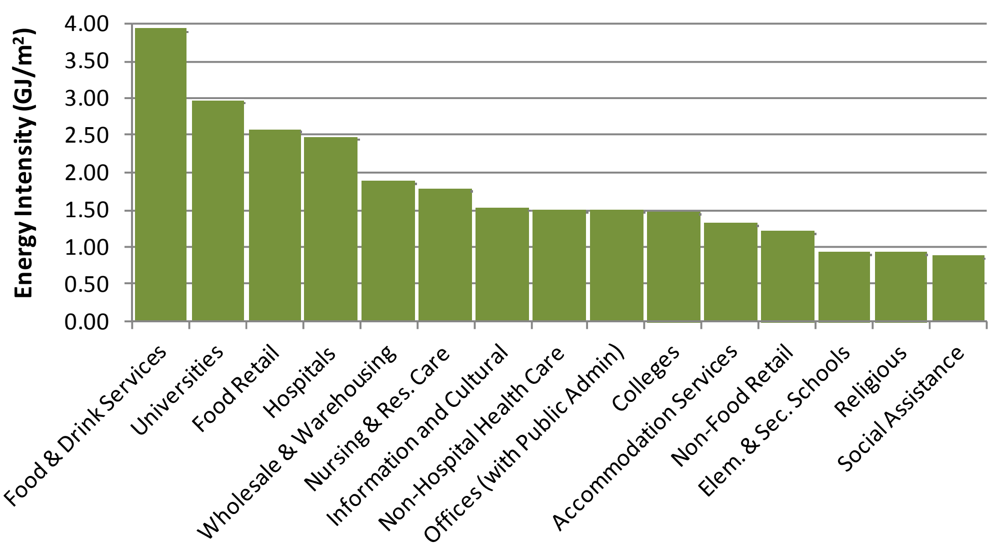
Together these five sectors account for approximately 65% of the total energy use of commercial and institutional buildings in the GTA.

Exhibit 2.3: A Breakdown of Energy Use in Various Sectors in the GTA



CICES also provides data on the energy intensity of the market sub-sectors in Ontario. Based on reduced heating loads, it was assumed that the energy intensity for the GTA is approximately 5% lower than these estimates. Energy intensity data for the GTA are presented in Exhibit 2.4.

Exhibit 2.4: Relative Energy Intensity of C&I Sectors in the GTA



Analyzing and comparing the energy intensity of the various commercial and institutional sectors is instructive but one must exercise caution since some of the sub-sectors are highly energy intensive by nature. Based on Exhibit 2.4, food and drink services are the most energy intensive sector being analyzed, followed by universities, food retail, and hospitals.

An interesting feature in this exhibit is the relative energy intensity of universities and colleges; the energy intensity of universities is estimated to be almost twice as high as colleges. Although not intuitive at first, this discrepancy is also noted in the CICES 2005 summary report. This publication states that "this difference may be due to several factors; namely, the difference in operating hours for each type of establishment or the levels of activity and student enrollment, which are greater for university campuses. To a lesser extent, the differences may also be due to the specific mandates of these two types of institutions: community colleges may focus primarily on teaching, while universities may expend more energy on research".[2] This is especially true in buildings with labs.

2.3 IDENTIFICATION OF PRIORITY SUB-SECTORS

This section identifies the commercial and institutional sub-sectors that should be targeted for energy efficiency improvements in the GTA. This conclusion is based on an initial assessment of their overall size and energy use, and the energy intensity figures presented above. A ranking scheme was used to identify the top five priority sub-sectors, as presented in Exhibit 2.5.

Exhibit 2.5: Ranking of Sectors by Energy Consumption, Floor Space, and Energy Intensity

Sector or subsector	Energy Rank	Space Rank	Intensity Rank
Wholesale & Warehousing	2	2	5
Non-Food Retail	3	4	12
Food Retail	10	11	3
Information and Cultural	7	8	7
Offices (with Public Admin)	1	1	9
Elem. & Sec. Schools	5	3	13
Colleges	12	9	10
Universities	4	6	2
Non-Hospital Health Care	14	12	8
Hospitals	9	10	4
Nursing & Res. Care	13	14	6
Social Assistance	15	15	15
Accommodation Services	11	7	11
Food & Drink Services	8	13	1
Religious	6	5	13

[2] Natural Resources Canada, Office of Energy Efficiency, "CICES Summary Report – June 2007", pg. 10, http://www.oee.nrcan.gc.ca/Publications/statistics/cices06/pdf/cices06.pdf

Based on this analysis, the following sub-sectors are recommended for more detailed analysis:

- Wholesale and Warehousing
- Offices (including Public Administration)
- Universities
- Non-Food Retail
- Elementary and Secondary Schools.

2.4 CAVEATS

The two primary available sources of data on the building inventory in the GTA are the Commercial and Institutional Consumption of Energy Survey (CICES) and the Commercial and Institutional Building Energy Use Survey (CIBEUS). Each has limitations, as discussed further in Appendix A. CICES has provided most of the data used in this phase of the study. The limitations of this data source have the following key implications for the study:

- CICES data are mainly provided at the Ontario level. To estimate the floor space of buildings in the GTA, assumptions must be made to apportion the Ontario buildings in each sub-sector. In some cases, this was based on the ratio of populations (likely to be a good estimate for sub-sectors such as schools). In other cases, such as universities, it was possible to use a ratio based on university student enrolment.

- CICES categories are based on NAICS (North America Industry Classification System) codes, and do not line up perfectly with the sub-sectors of buildings used in previous Marbek studies of commercial and institutional buildings in Ontario and other provinces. Some CICES categories were combined into larger sub-sectors for the modeling phase of the project.

3. MARKET PROFILES OF PRIORITY SUB-SECTORS

This section profiles each of the priority sub-sectors that were identified in Section 2.3. This includes an examination of facility size, regional distribution, and an identification of key players and their contact information. The general method for acquiring the contact information of individuals who deal with energy management for each of the key players is described in Appendix A.

3.1 OFFICES

Office buildings, including both commercial and some institutional office space, make up 28% of the floor space of commercial and institutional buildings in the GTA. This sub-sector ranks first in both floor space and annual energy consumption. In energy intensity, the sub-sector ranks only ninth. Other sub-sectors with longer operating hours, such as restaurants, or more intensive energy end uses, such as food retailers with their high refrigeration loads, use more energy per unit of floor area.

3.1.1 Data Sources

Data for the GTA office sector were obtained through an agreement with CB Richard Ellis (CBRE), a GTA-area realty firm with an extensive knowledge of the size and distribution of these types of facilities. The size of the building stock which was reported by CBRE was found to be significantly smaller than the estimated floor space from CICES data. However, CBRE office space data do not include any government facilities and only showcase office space that is rentable. Nonetheless, it is believed that the CBRE data give a good indication of the distribution of office space in the GTA area. Contact information for the key players in this sector was also provided by CBRE.

Data on buildings owned by the three levels of government were gathered through internal research. Sources of information include nine federal departments, the Ontario Realty Corporation (ORC), and internet resources, such as the City of Toronto’s website.

3.1.2 Regional Distribution

Data on the regional distribution of privately-owned office space are provided in Exhibit 3.1. This table is based on data provided by CBRE but is scaled to an overall value equal to the office floor space estimate in Section 2. From this table, it can be seen that Toronto represents over 70% of the office space in the GTA, with the Greater Downtown, the Financial Core, the Downtown East and West, and the Midtown areas representing over 50% of this space. The downtown area, bound by Lake Ontario to the south, Wellesley Street to the north, Jarvis Street to the east, and University Avenue to the west is the largest single contributor, representing over a third of the office space in the GTA.

The majority of the publicly-owned office buildings in the GTA are also located in the City of Toronto. The City of Toronto itself is the largest public owner of buildings in the GTA. Among provincially-owned buildings, approximately half of the ORC buildings in the GTA are in the City of Toronto, accounting for approximately two-thirds of electricity consumption. All but one of the GTA buildings owned by the Public Works and Government Services Canada (PWGSC), the largest federal building owner, is located in the City of Toronto.

Exhibit 3.1: The Regional Distribution of Private Office Space in the GTA

Region	City/Area	Total Office Space (m^2, % of Total)	
Toronto	Greater Downtown[1]	5,976,000	17.7%
	Financial Core	5,688,000	16.8%
	Midtown	3,465,000	10.3%
	Downtown East and West	2,652,000	7.8%
	North Yonge Corridor (North)	1,839,000	5.4%
	Don Valley Pkwy South (South-East)	1,338,000	4.0%
	Don Valley Pkwy North (North-East)	1,291,000	3.8%
	Hwy 427 Corridor (West)	980,000	2.9%
	Scarborough	859,000	2.5%
	North York West (North-West)	479,000	1.4%
	SUB-TOTAL	**24,569,000**	**72.7%**
Peel	ACC & Airport	2,056,000	6.1%
	Mississauga (City Centre)	885,000	2.6%
	Hwy 10/401	885,000	2.6%
	Meadowvale	623,000	1.8%
	Mississauga South	455,000	1.3%
	Brampton	226,000	0.7%
	SUB-TOTAL	**5,130,000**	**15.2%**
York	Markham/Richmond Hill	2,308,000	6.8%
	Vaughan	358,000	1.1%
	SUB-TOTAL	**2,665,000**	**7.9%**
Halton	Burlington	741,000	2.2%
	Oakville	455,000	1.3%
	SUB-TOTAL	**1,196,000**	**3.5%**
Durham	Oshawa, Whitby, Pickering	239,000	0.7%
	SUB-TOTAL	**239,000**	**0.7%**
TOTAL		**33,798,000**	

[1] Excludes Financial Core and Downtown East and West

Data on the regional distribution of public office space in the GTA are presented in Exhibit 3.2. The City of Toronto represents just under half the population of the GTA. It is the largest public owner of buildings in the GTA, with approximately 1.6 million m^2. Other municipalities are also important building owners, but on a considerably smaller scale. Mississauga, the next largest city, has 325,000 m^2 of buildings. The Ontario Realty

Corporation is another key player, with approximately 950,000 m^2 of office space in the GTA. The PWGSC is the largest owner of federal buildings, with approximately 230,000 m^2 of office space. The other federal departments are much smaller players. The RCMP, for example, owns less than a tenth as much office space in the GTA as the PWGSC.

Exhibit 3.2: Publicly-owned Office Space in the GTA

Government Entity	Population	Buildings	
		Floor Space (m^2)	Electricity Use (GWh/yr)
Municipal Governments			
Toronto	2,500,000	1,600,000	1,000[3]
Mississauga	670,000	325,000	N/A
Brampton	430,000	N/A	N/A
Peel Region (net of Miss. & Brampton)	<100,000		
York Region (no cities > 300,000)	890,000		
Durham Region (no cities > 200,000)	560,000		
Halton Region (no cities > 200,000)	440,000		
Provincial Government			
Ontario Realty Corporation	N/A	950,000	200
Federal Government			
PWGSC	N/A	230,000	31
RCMP	N/A	20,000	3.6
TOTAL	**~5,500,000**		

3.1.3 Key Players

Data on the overall holdings of individual owners of office space in the GTA area aren't easily available. However, it is possible to gauge who the top players in this sector are. Exhibit 3.3 provides contact information for the principal owners of office space in the GTA based on CBRE's expert knowledge in this area.

[3] The 17 million sq. ft. includes all City facilities, not just office buildings. The electricity consumption is the approximate total for the city, including the TTC, street lighting, etc. Since THES has a major contract for energy efficiency work with the City, it would be most efficient to use THES figures here, rather than duplicate efforts.

Exhibit 3.3: Top Holders of Private Office Space in the GTA

Holding Company/Owner, Address	Contact Name, Title	Contact Information
Brookfield Properties Corporation 181 Bay St., Suite 330, P.O. Box 770 Toronto, ON M5J 2T3	Richard Pike Head of Operations and Environmental Services	416.369.2613 rpike@brookfieldproperties.com
Cadillac Fairview Corporation Ltd. 220 Yonge St., Suite 110, P.O. Box 511 Toronto, ON M5B 2H1	Dan Pisani, Director of Office Property Operations	416.862.3657 dan.pisani@cadillacfairview.com
Oxford Properties Group Inc. 130 Adelaide St. W., Suite 1100 Toronto, ON M5H 3P5	Frank Hawkins, Manager of Technical Services (National Programs)	416.868.3788 fhawkins@oxfordproperties.com
	David Giddings, Director of Technical Services	416.865.5357 dgiddings@oxfordproperties.com
GWL Realty Advisors Inc. 50 Burnhamthorpe St. W., Suite 1500 Mississauga, ON L5B 3C3	Mike Karmazyn Director of Technical Services	905.275.6681 michael.karmazyn@gwlra.com
Bentall Real Estate Services* 10 Carlson Court, 5th Floor Etobicoke, ON M9W 6L2	Ken Madden, Energy Management	416.674.3586

* A contact for this corporation could not be finalized. Thus, the contact presented here may not be the individual who deals with energy and/or facilities management.

The key players in terms of public office space can easily be identified based on a scan of total floor space above. The five top players are the Cities of Toronto, Mississauga and Brampton, the Ontario Realty Corporation, and the PWGSC. Contact information for officials within these institutions is provided in Exhibit 3.4.

Exhibit 3.4: Contact Information of Public Office Building Owners/Managers

Entity	Contact Name, Position	Contact Information
City of Toronto	Jim Kamstra, Manager Energy and Waste Management Office	416.392.8954 Jim.Kamstra@toronto.ca
City of Mississauga	Rajan Balchandani, Manager Energy Management	905.615.3200 Rajan.Balchandani@mississauga.ca
City of Brampton	Dave Kenth Energy Management	Dave.Kenth@brampton.ca
Ontario Realty Corporation	Erwin Massiah, VP Property Operations and Land Management	416.327.9520 Erwin.Massiah@orc.gov.on.ca
PWGSC	Silvano Mason, Asset Manager Crown Properties	416.512-5908 Silvano.Mason@pwgsc.gc.ca

3.2 WAREHOUSES/WHOLESALE

Among the commercial and institutional sectors in the GTA, warehouse and wholesale buildings ranks second in both floor space and total energy consumption, accounting for approximately 17% of each. This sub-sector also ranks fifth in terms of energy intensity.

3.2.1 Data Sources

Data for the GTA warehouse/wholesale sector were obtained through an agreement with CB Richard Ellis (CBRE), a GTA-area realty firm with an extensive knowledge of the size and distribution of these types of facilities. The size of the building stock which was reported by CBRE was found to be significantly larger than the estimated floor space from CICES data. The majority of this difference is due to the inclusion of some industrial facilities in the CBRE data. Nonetheless, it is believed that this data give a good indication of the distribution of warehouse/wholesale facilities in the GTA area.

3.2.2 Regional Distribution

Data on the regional distribution of warehouse space in the GTA are presented in Exhibit 3.5. This table is based on data obtained from CBRE but it is scaled down to an overall value equal to the warehouse/wholesale floor space estimate obtained from CICES in Section 2.

Based on these data, the areas in the GTA representing the largest proportion of office space (in order of size) are Mississauga, North York, Etobicoke, Brampton, Scarborough, and Vaughan. Combined, these cities account for 73% of the office space in the GTA.

Exhibit 3.5: The Regional Distribution of Warehouse Space in the GTA

Region	City/Area	Total Floor Space (m^2, % of Total)	
Halton	Burlington	628,000	2.8%
	Oakville	557,000	2.5%
	Milton	307,000	1.4%
	SUB-TOTAL	**1,492,000**	**6.7%**
Peel	Mississauga	4,718,000	21.1%
	Brampton	2,353,000	10.5%
	SUB-TOTAL	**7,071,000**	**31.7%**
York	Vaughan	1,940,000	8.7%
	Markham	1,087,000	4.9%
	Richmond Hill	363,000	1.6%
	Aurora	154,000	0.7%
	Newmarket	140,000	0.6%
	Stouffville	29,000	0.1%
	SUB-TOTAL	**3,714,000**	**16.6%**

Region	City/Area	Total Floor Space (m^2, % of Total)	
Toronto	North York	2,671,000	12.0%
	Etobicoke	2,525,000	11.3%
	Scarborough	2,111,000	9.5%
	Downtown	718,000	3.2%
	East York	248,000	1.1%
	York	233,000	1.0%
	SUB-TOTAL	**8,506,000**	**38.1%**
Durham	Pickering	283,000	1.3%
	Ajax	224,000	1.0%
	Whitby	181,000	0.8%
	Oshawa	840,000	3.8%
	SUB-TOTAL	**1,527,000**	**6.8%**
TOTAL		**22,310,000**	

3.2.3 Key Players

Exhibit 3.6: Contact Information of Top Warehouse Space Owners in the GTA

Holding Company/Owner, Address	Contact Name, Title	Contact Information
Orlando Corporation 6205 Airport Road Mississauga, ON L4V 1E3	Peter Sloof, Property Manager	905.677.5480 sloofp@orlandocorp.com
	Dennis Pasut, Senior Property Manager	905.677.5480 pasutd@orlandocorp.com
H&R Developments Inc. 3625 Dufferin Street, Suite 500 Toronto, ON M3K 1N4	Dave Moir, Manager of Technical Services	416. 635.7717 X268 dmoir@hr-dev.com
Bentall Real Estate Services* 10 Carlson Court, 5th Floor Etobicoke, ON M9W 6L2	Ken Madden	416. 674.3586
GWL Realty Advisors Inc. 50 Burnhamthorpe Rd. W., Suite 1500 Mississauga, ON L5B 3C2	Mike Karmazyn, Director of Technical Services	905.275.6681 michael.karmazyn@gwlra.com
Morgaurd Real Estate Investment Trust* 55 City Centre Drive, Suite 1000 Mississauga, ON L5B 1M3	Larry Gallagher	905. 281.4794

* Contacts for these corporations could not be finalized. Thus, the contacts presented here may not be the individuals who deal with energy and/or facilities management.

Data on the overall holdings of individual owners of warehouse space in the GTA area aren't easily available. However, it is possible to gauge who the top players in this sector are. Exhibit 3.6 provides contact information for the principal owners of warehouse/ wholesale space in the GTA based on CBRE's expert knowledge in this area.

3.3 NON-FOOD RETAIL

The non-food retail sector ranks fourth in terms of floor space and third in terms of energy consumption among commercial and institutional sectors in the GTA. However, the energy intensity of this sector is among the lowest in the sectors being profiled. This may be due to a lower density of electrical equipment, such as refrigeration equipment and computers, compared to other sectors. There are over 1200 non-food retail chains in Ontario, the majority also being present in the GTA.

3.3.1 Data Sources

Data on non-food retail chains were obtained from the Monday Report Directory of Retail Chains in Canada, which was last updated in October 2007. This source provided data on the number of locations and the average size of retail chains across Canada, broken down by province. Information on the parent companies and contacts within the retail chains was also provided. Although this provided a fairly reliable estimate of overall retail floor space in Ontario, it was necessary to estimate the proportion of retailers that are present in the GTA based on these results.

3.3.2 Regional Distribution

Although data on the regional distribution of non-food retailers in the GTA are not easily available, it is assumed that retailers are distributed similarly to population.

3.3.3 Key Players

Information on the top 20 non-food retailers in the GTA in terms of overall floor space is presented in

Exhibit 3.7. This exhibit also indicates the number of stores and their average floor space, both for the GTA region, which were used to derive the total floor space estimates. These estimates are largely based on data from the Monday Report of Retail Chains in Canada. Since data were not explicitly available for the GTA, some assumptions had to be made to estimate the number of stores that were present in this area. Ontario data were usually available but, in some cases, estimates are based on Canada-wide data. Average floor space numbers were also not always available; where necessary, internal research was conducted to provide estimates for these.

Exhibit 3.7: Non-Food Retailers in the GTA, Sorted by Descending Total Space

Retailer	Parent Company	Stores *	Avg. Space (m^2)*	Total Space (m^2)
Zellers	Hudson's Bay Company	60	7,000	415,000
Home Depot	Home Depot Inc.	38	10,800	410,000
Wal-Mart	Wal-Mart Stores Inc.	49	8,100	395,000
Sears, Sears Home	Sears, Roebuck and Co	57	6,000	341,000
Canadian Tire	Canadian Tire Corp. Ltd.	99	3,300	320,000
The Bay, Home Outfitters, Designer Depot	Hudson's Bay Company	19	12,500	283,000
Winners, Homesense	TJX Companies Inc.	73	2,200	163,000
Home Hardware, Home Building Centres	Home Hardware Stores Ltd.	214	700	158,000
Costco	Costco Ltd.	12	12,500	151,000
Rona (Build. Centre, Home and Garden, Cashway, Hardware)	Rona Inc.	51	3,000	150,000
Shopper's Drug Mart	Shopper's Drug Mart Inc.	138	800	115,000
Mark's Work Wearhouse Ltd.	Canadian Tire Corp. Ltd.	62	1,900	114,000
GoodLife	GoodLife Fitness Centres Inc.	58	1,900	108,000
Staples Business Depot	Staples Inc.	48	1,900	89,000
Sport Chek, National Sports, Sport Mart, Sports Experts	The Forzani Group Ltd.	60	1,500	88,000
TD Canada Trust	TD Bank Financial Group	302	300	84,000
Chapters, Coles, Indigo Books, Smithbooks	Indigo Books & Music Inc.	60	1,400	83,000
Future Shop, Best Buy	Best Buy Co. Inc.	38	2,200	81,000
Giant Tiger	North West Company Inc.	54	1,500	80,000

***** Note that all estimates are rounded. Thus, multiplying the store number and average floor space estimates together may not yield the total floor space estimate in all cases.

Based on the floor space estimates derived from CICES data, the top six non-food retail chains listed above represent almost 20% of the total floor space in this sector. Contact information for these retailers is presented in Exhibit 3.4. The Hudson's Bay Company and the Canadian Tire Corporation are also identified as each being the parent company of two of the top retailers in terms of floor space in the top 12.

Exhibit 3.8: Contact Information of Key Players in the Non-Food Retail Sector

Retailer/Canadian Parent Company	Contact Name, Position	Contact Information
Hudson's Bay Company (Toronto, ON)	Brian Benson, Director Facility Maintenance and Energy	416.861.4294 Brian.Benson@hbc.com
Canadian Tire Corp. Ltd. (Toronto, ON)	Steve Pickett Facility Management	416.480.8831 Steven.Pickett@cantire.com
Home Depot Canada (Toronto, ON)	Don Jacyshyn Facility Energy Management	416.412.4990 donald_s_jacyshyn@homedepot.com
Wal-Mart Canada (Mississauga, ON)	Chris Leo Facility Energy Management	905.821.2111 x4425
Sears Canada (Toronto, ON)	Gerry Mazonetto Facility Energy Management	416.941.3759

3.4 UNIVERSITIES

Universities represent less than 5% of the floor space of commercial and institutional buildings in the GTA but they rank second in terms of energy intensity and fourth in overall energy use. The high energy intensity may be due to prolonged hours of use and a large number of labs.

3.4.1 Data Sources

Student enrolment and data and university official contact information were obtained from the Association of Universities and Colleges in Canada (AUCC) and individual university websites.

3.4.2 Regional Distribution

There are three large universities located in the GTA; the University of Toronto, York University and Ryerson University, all of which are located primarily in Toronto. The University of Toronto is composed of several schools and campuses while York University is made up of two. Ryerson University is located on a single campus. There are also two smaller universities; The University of Ontario Institute of Technology (UOIT), located in Oshawa, and the Ontario College of Art and Design (OCAD), located in Toronto. This summary demonstrates the degree of concentration of universities in the GTA, with most of the facilities being located within the city of Toronto itself.

3.4.3 Key Players

Universities in the GTA represent only 38% of university student enrolment in Ontario, almost 8% lower than would be suggested based on population. **Exhibit 3.9** presents a breakdown of student enrolment in universities in the GTA, broken down by full-time and part-time attendance in undergraduate (UG) and graduate programs.

Exhibit 3.9: Student Enrolment of Universities in the GTA

University/College	Full-time		Part-time		Total	
	UG	Grad	UG	Grad		
University of Toronto	**53,000**	**11,000**	**6,500**	**2,000**	**72,500**	**44.6%**
Main Campus (St. George)	26,501	10,048	3,334	1,780	41,663	25.6%
Scarborough Campus	8,719	322	828		9,869	6.1%
Mississauga Campus	8,990	420	1,458		10,868	6.7%
University of St. Michael's College	3,970	140	400	170	4,680	2.9%
University of Trinity College	1,540	70	120	50	1,780	1.1%
Victoria Univ. and Emmanuel College	3,280	0	360	0	3,640	2.2%
York University	**39,100**	**3,300**	**7,100**	**1,800**	**51,300**	**31.5%**
Main Campus (Keele)	36,791	3,300	7,100	1,800	48,991	30.1%
Glendon College	2,309				2,309	1.4%
Ryerson University	**16,260**	**770**	**13,680**	**320**	**31,030**	**19.1%**
Univ. of Ontario Inst. of Technology	**4,150**	**20**	**150**	**10**	**4,330**	**2.7%**
Ontario College of Art and Design	**2,767**		**700**		**3,467**	**2.1%**
TOTAL	**115,277**	**15,090**	**28,130**	**4,130**	**162,627**	

Three key players can easily be picked out based on a scan of university student enrolment. These three top players, the University of Toronto's St. George Campus, York University's Keele campus, and Ryerson University, represent almost 75% of university students in the GTA. Contact information for officials within these institutions is provided in Exhibit 3.10.

Exhibit 3.10: Contact Information of University Officials

University	Contact Name, Position	Contact Information
University of Toronto (St. George Campus)	Bruce Dodds, Director of Utilities and Buildings Operations, Sustainability Office	416.978.2319 bruce.dodds@utoronto.ca
York University (Keele Campus)	Tracey Forrest, Director, Energy Management	416.736.5216 tforrest@yorku.ca
	Edwina Scott, Admin. Coordinator, Facilities Planning and Renovations	416.736.2100 x66017 escott@yorku.ca
Ryerson University	Ian Hamilton, Director, Campus Planning and Facilities	416.979.5000 x6272 ihamilto@ryerson.ca
	Shiv Tangri, Supervisor, Energy and Automation	416.979.5000 x2775 shivtangri@ryerson.ca

3.5 ELEMENTARY AND SECONDARY SCHOOLS

Elementary and secondary schools are identified as a priority sub-sector due to their large contributions in total floor space and energy usage. This sector ranks 3rd in total floor space and 5th in total energy consumption among the commercial and institutional sectors in the GTA. However, the energy intensity of these types of schools ranks among the lowest in the sectors that are profiled. This is likely due to the operating hours for most schools being shorter than for most commercial and institutional buildings.

3.5.1 Data Sources

Data for the elementary and secondary school sector were obtained by contacting Ontario's Ministry of Education, from individual school board websites, and by contacting school board officials.

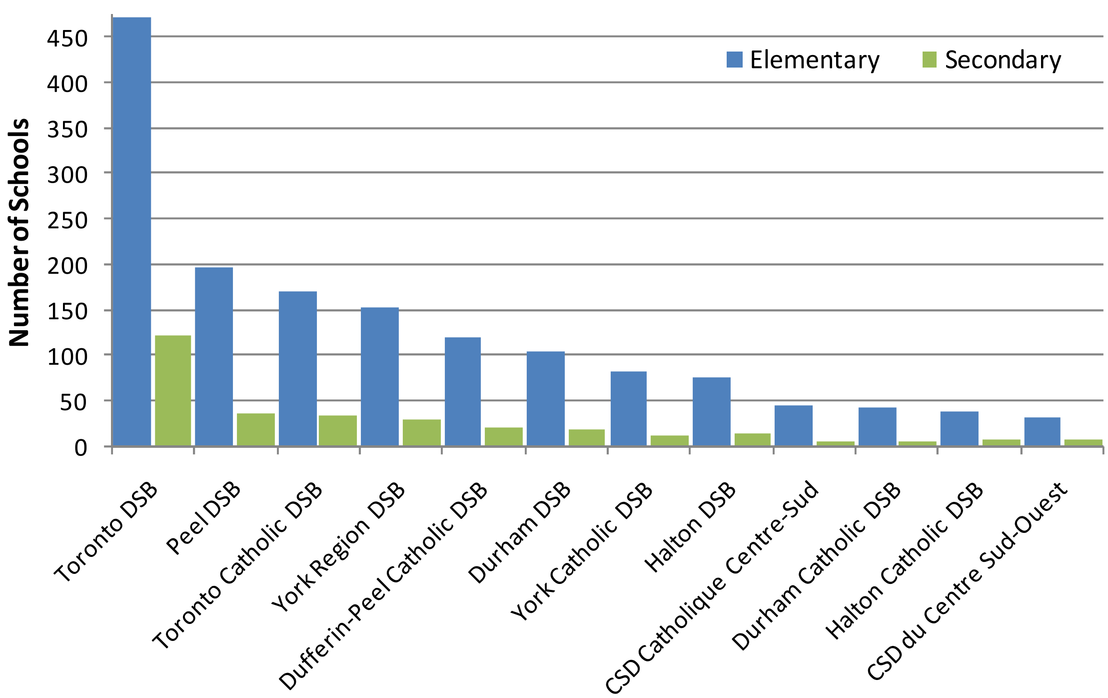
3.5.2 Regional Distribution

There are twelve school boards in the Greater Toronto Area, six of which are catholic and six of which are non-denominational. The majority of these school boards are English but there are also two French-language boards. The boundaries for the school boards generally follow those of the five regions that make up the GTA; namely Toronto, Halton, Peel, York, and Durham (see Exhibit 1.1 for a map).

3.5.3 Key Players

The following exhibits provide a breakdown on the number of schools and students in elementary and secondary schools and the relative floor space data for each of the school boards that make up the GTA. Note that DSB signifies District School Board, while CDSB signifies Catholic District School Board, and CSD stands for Conseil scolaire de district.

Exhibit 3.11: Breakdown of the Number of Schools in Each School Board in the GTA



From these exhibits, it is clear that the Toronto School Board is by far the largest in terms of schools, students, and floor space. In fact, this school board represents 32% of schools, 27% of students, and 36% of the elementary and secondary school floor space in the GTA. The top five school boards represent about 75% of the schools, student enrolment, and school floor space in the GTA. All of these school boards are located in the Toronto, York, or Peel regions. Contact information for officials within these school boards is presented in Exhibit 3.14.

Exhibit 3.12: The Total Student Enrolment of School Boards in the GTA

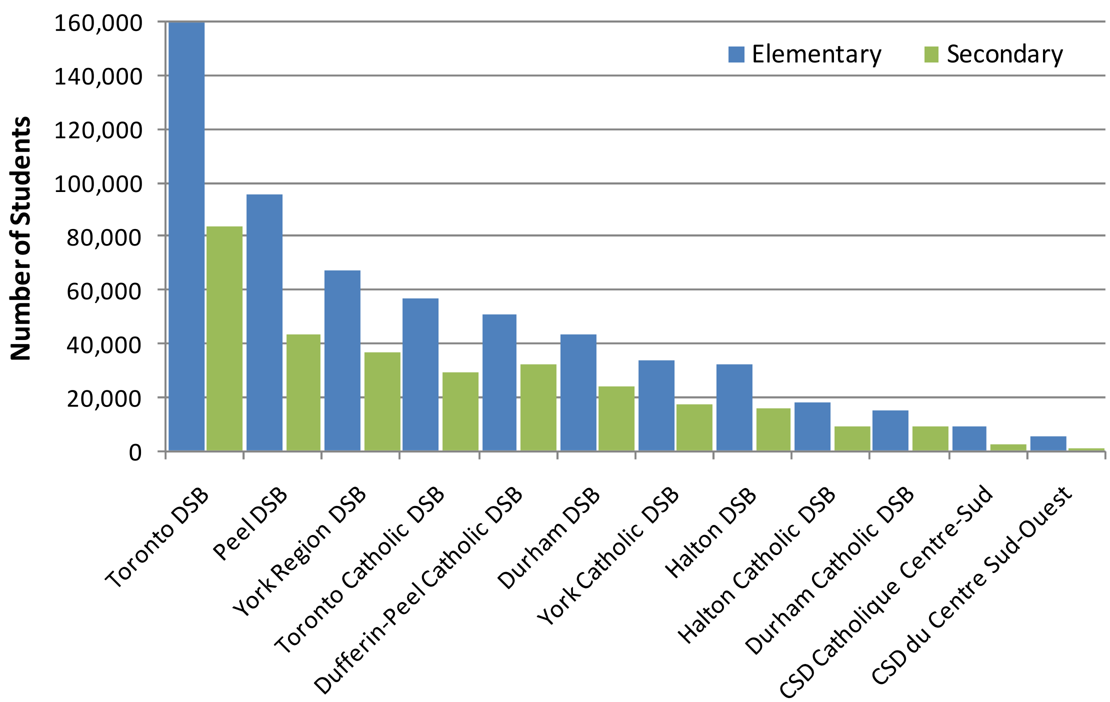


Exhibit 3.13: A Floor Space Comparison of the School Boards in the GTA

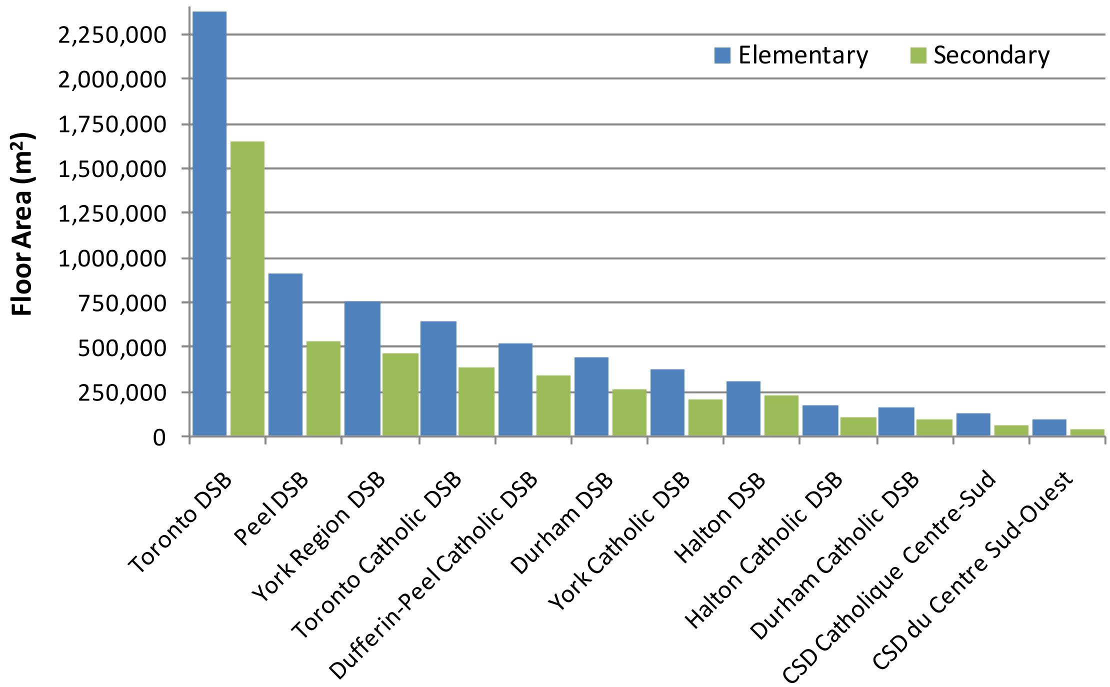


Exhibit 3.14: Contact Information of School Board Officials in the GTA

School Board	Contact Name, Position	Contact Information
Toronto DSB	Mary Lovett EcoSchools Specialist	mary.lovett@tdsb.on.ca
	Ecoschools Program Office	416.394.7276 ecoschools@tdsb.on.ca
Peel DSB	Wayne McNally, Ass. Director Operational Support Services	905.890.1099 x2180
	Communications Department	905.890.1099 x2212 communications@peelsb.com
York Region DSB	Michele Scott Communications Officer	905.727.0022 x2520 communication.services@yrdsb.edu.on.ca
	Dawn Adams, Senior Planner Planning Department	Dawn.Adams@yrdsb.edu.on.ca
Toronto Catholic DSB	Scott Grieve, Officer Energy Conservation (Facilities)	416.222.8282 x2229 Scott.Grieve@tcdsb.org
Dufferin-Peel CDSB	Beth Bjarnason Planning Department	905.890.0708 x24223 Beth.Bjarnason@dpcdsb.org

3.6 COLLEGES

Colleges rank fairly low in terms of energy use and floor space (12th and 9th, respectively) among the sectors that were profiled. However, this sector is very similar to two of the of the priority sub-sectors that were identified, namely universities and elementary and secondary schools. THES also requested that this sector be profiled since it is eager to further penetrate and expand this portion of its market share.

3.6.1 Data Sources

Data on the enrolment and regional distribution of colleges in the GTA were obtained from a special report on GTA colleges and universities by the Toronto Star.[4] Contact information for key players in the sector was obtained through the individual college websites and by contacting officials at these institutions.

3.6.2 Regional Distribution

The GTA is home to six of the 25 colleges in Ontario. These colleges are composed of several campuses, as can be seen in Exhibit 3.15. Although college campuses are located throughout the GTA, the majority of them are situated in the City of Toronto.

Exhibit 3.15: The Regional Distribution of Colleges in the GTA

College	Region(s)	# of Campuses
Centennial	Toronto	4
Durham	Durham (Oshawa, Whitby, Uxbridge, Ajax)	4
George Brown	Toronto	3
Humber	Toronto	2
Seneca	Toronto (4), York (Markham (2), Newmarket, King City)	8
Sheridan	Halton (Oakville), Peel (Brampton)	2

3.6.3 Key Players

Exhibit 3.16 gives a breakdown of student enrolment in colleges in the GTA. The top three colleges, representing over two-thirds of college student enrolment in the GTA, are Seneca College, Humber College, and George Brown College. These colleges, along with Sheridan College, also represent nearly 80% of the full-time college student enrolment in the GTA.

[4] Toronto Star, "Insiders Guide to GTA Colleges and Universities", Sept. 2007, http://www.thestar.com/schoolsguide, accessed on Feb. 25, 2008.

Exhibit 3.16: College Student Enrolment in the GTA

College	Students				Total	
	Full-Time		Part-Time/Distance			
Centennial	11,700	14.3%	28,000	10.0%	39,700	10.9%
Durham	6,000	7.3%	23,000	8.2%	29,000	8.0%
George Brown	14,000	17.1%	50,000	17.8%	64,000	17.6%
Humber	18,000	22.0%	55,000	19.6%	73,000	20.1%
Seneca	17,000	20.8%	90,000	32.0%	107,000	29.5%
Sheridan	15,000	18.4%	35,000	12.5%	50,000	13.8%
TOTALS	**81,700**		**281,000**		**362,700**	

Contact information for officials that deal with facility energy management and planning in the largest colleges in the GTA is presented in Exhibit 3.17. As mentioned previously, the individual colleges were contacted in order to obtain this information.

Exhibit 3.17: Contact Information for Energy Management Officials in GTA Colleges

College	Contact Name, Position	Contact Information
Seneca College	Frank Wang, Sr. Manager, Energy, Projects, and Business Planning	416.491.5050 x6753 frank.wang@senecac.on.ca
	Gordon Mickovski, Sr. Manager, Operations & Maintenance	416.491.5050 x6453 gordon.mickovski@senecac.on.ca
Humber College	Carol Anderson Director, Facilities Management	416.675.6622 x4340 carol.anderson@humber.ca
George Brown College	Reneta Shishkova, Support Officer, Facilities Management	416.415.5000 x4300 rshishko@georgebrown.ca
Sheridan College	Brian Scannell, Director, Facilities Management	905.845.9430 x2240 brian.scannell@sheridanc.on.ca
	Richard Lewis, Manager, Maintenance and Building Operations	905.845.9430 x5441 rick.lewis@sheridanc.on.ca
	Gord Ide, Manager, Maintenance and Building Operations	905.845.9430 x2251 gord.ide@sheridanc.on.ca

4. ENERGY MANAGEMENT OPPORTUNITY ASSESSMENT

This section presents the results of a modeling process that was used to assess the scope of energy management opportunities for the commercial and institutional sector in the GTA. Energy efficiency options evaluated included both electricity and natural gas conserving technologies. Efficiency options were targeted at all the major energy end-uses in buildings.

4.1 METHODOLOGY

A model that was developed in-house, called CSEEM (Commercial Sector Energy End-use Model), was used in the assessment of energy management opportunities. CSEEM is designed to model large numbers of buildings rather than individual ones.

4.1.1 Reference Case Development

The model is used to establish a *reference case* for overall floor space and energy usage in the different sectors, including a breakdown of current (base year) energy consumption and a projection into the future based on projected growth and naturally-occurring changes in energy use. For this study, energy consumption was projected 20 years into the future.

The CSEEM model has been used extensively for electric and gas utility conservation studies in BC, Manitoba, Ontario, and Newfoundland. Marbek was able to draw on the existing models developed for those other studies to develop a model for the GTA quickly and efficiently. The starting point for the electricity model was the model developed for the Lower Mainland of British Columbia in a recently completed Conservation Potential Review (CPR) for BC Hydro. The starting point for the gas model was a CPR completed for Terasen Gas in 2006. The space heating and cooling values were adapted to the Ontario climate based on data developed for studies for Enbridge Gas and for the Ontario Power Authority. Floor space data were drawn from the same sources used in Chapter 3 above.

4.1.2 Economic Potential Scenario

Energy conservation potential is estimated in CSEEM using an *economic scenario* that can be compared against the reference case. This scenario is developed by evaluating a set of energy efficiency measures, comparing their costs and savings against an economic screen, and applying those that pass. The electricity efficiency measures evaluated were drawn from the BC Hydro CPR and the natural gas efficiency measures evaluated were drawn from the 2006 CPR conducted for Terasen Gas. Electricity measures were required to produce savings at a cost of less than 8 cents/kWh to pass the screen. Gas conservation measures were required to produce a benefit/cost ratio of over 1, using a value for gas savings of approximately \$6/GJ (22 cents/m^3). A real discount rate of 8% was used to evaluate the stream of savings occurring over many years.

The measures were applied sequentially, generally with those reducing load applied before those that improve equipment efficiency (an insulation measure would be applied before a boiler retrofit, for example). Within that framework, measures that were more financially attractive were applied first. Interaction between measures that affect the same end use was approximated as follows: if Measure 1 saves 10% of lighting and Measure 2 saves 20% of lighting, application of both measures would result in total lighting savings of 28%, not 30%.[5] There is also interaction between measures that reduce the internal load (such as lighting efficiency measures) and the energy used to heat and cool the building. More efficient lighting will result in increased space heating load and decreased space cooling load. These effects were not accounted for in this study.

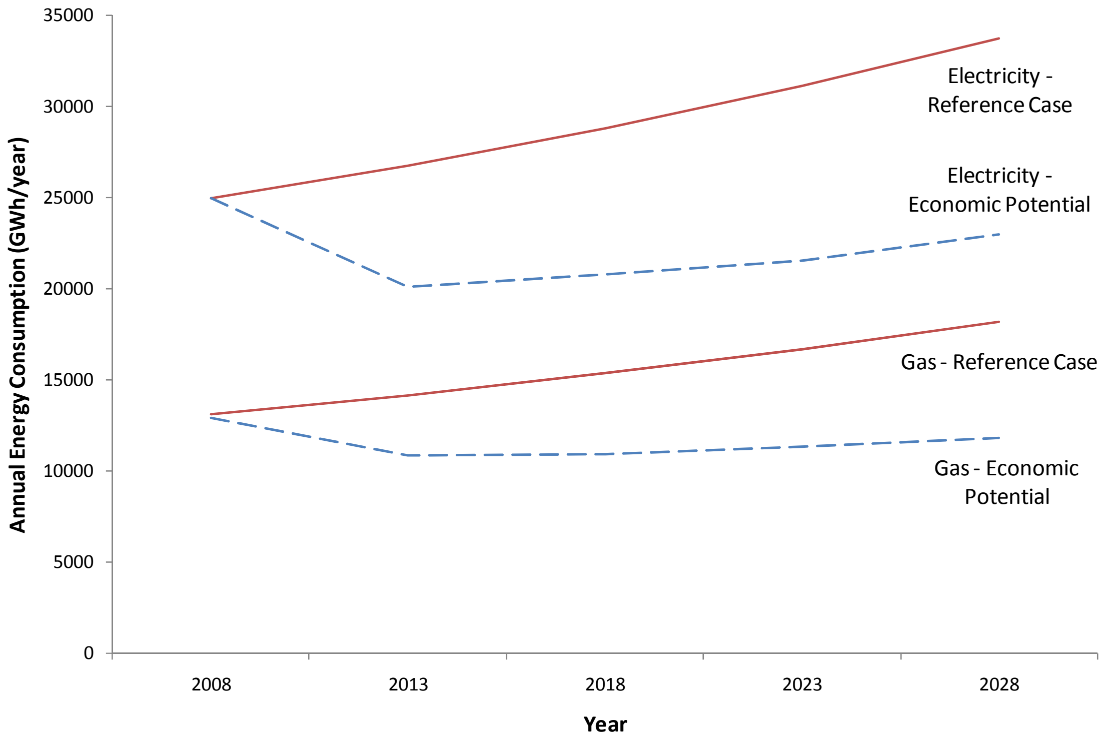
The energy conservation potential was estimated by subtracting economic scenario energy consumption from reference case energy consumption at the end of the forecast period. The amount of economically-viable efficiency potential that is actually achievable is reduced by a variety of factors, including lack of awareness, availability of the technologies in the marketplace, the disconnect between the building owners and those who pay the energy bills (when facilities are leased), and so forth. Estimating the effects of all these factors requires input from experts with local program experience and knowledge of the technologies and the commercial/institutional sub-sectors involved, and was beyond the scope of this study. The economic potential estimates will nonetheless provide a good indication of which sub-sectors and end-uses show the most potential for energy efficiency in the GTA.

4.2 ECONOMIC POTENTIAL RESULTS

Exhibit 4.1 shows the projected consumption of energy in commercial and institutional buildings in the GTA under both the reference case and the economic potential scenarios.

[5] Total Svgs% = 1 - (1 – Measure #1 Svgs%)*(1 – Measure #2 Svgs%) = 1 – (1 – 10%)*(1 – 20%) = 28%

Exhibit 4.1: Projected Energy Consumption for C/I Sector in the GTA (Natural gas converted to equivalent GWh/year)



Exhibits 4.2, 4.3, 4.4, and 4.5 present the percentage breakdown of energy savings potential in 2028 by building type, by end use, by new construction versus existing buildings, and by fuel.

Exhibit 4.2: Energy Savings Potential by Building Type

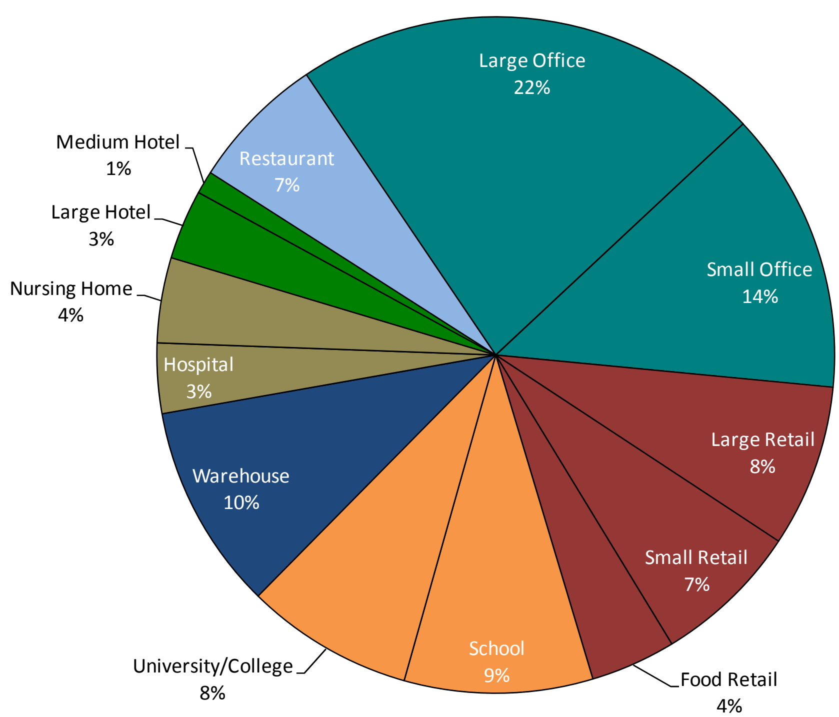


Exhibit 4.3: Energy Savings Potential by Energy End Use

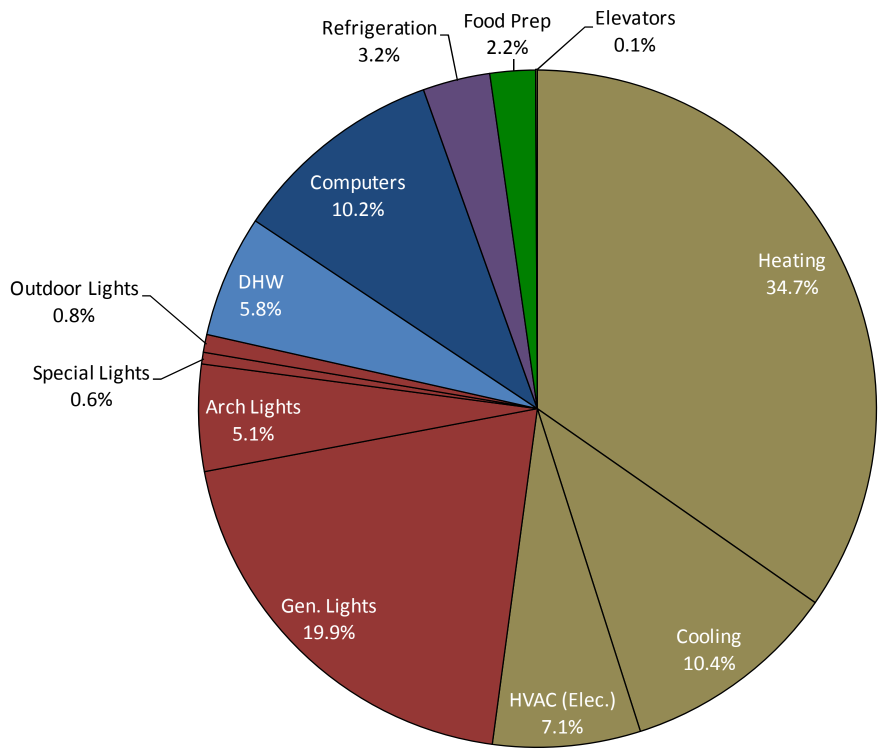


Exhibit 4.4: Energy Savings Potential by New Construction vs. Existing

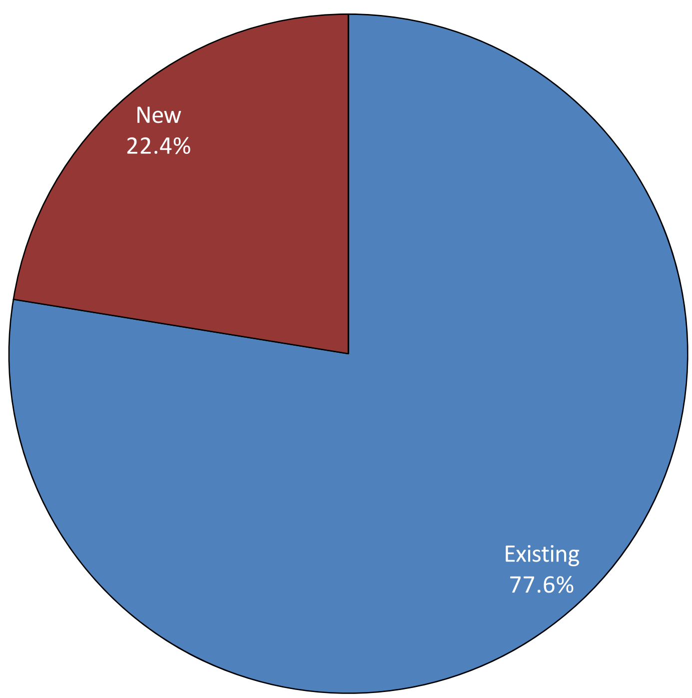


Exhibit 4.5: Energy Savings Potential by Fuel

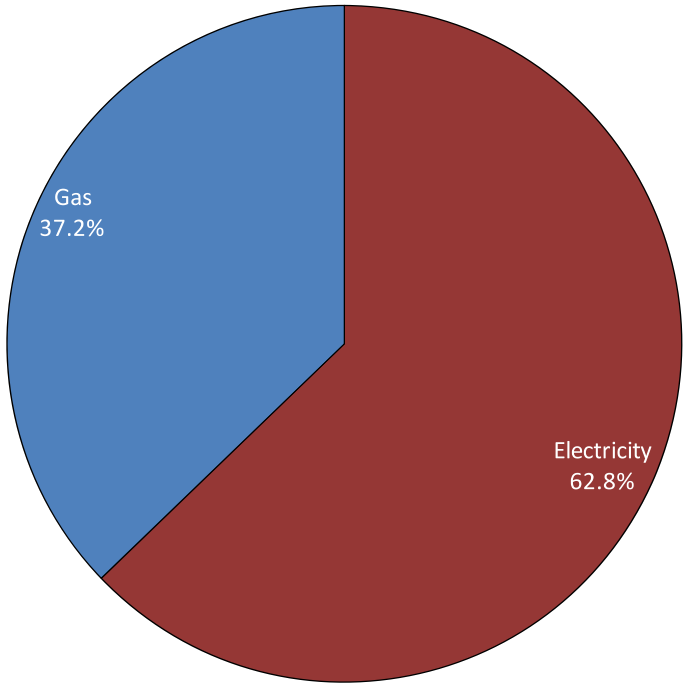
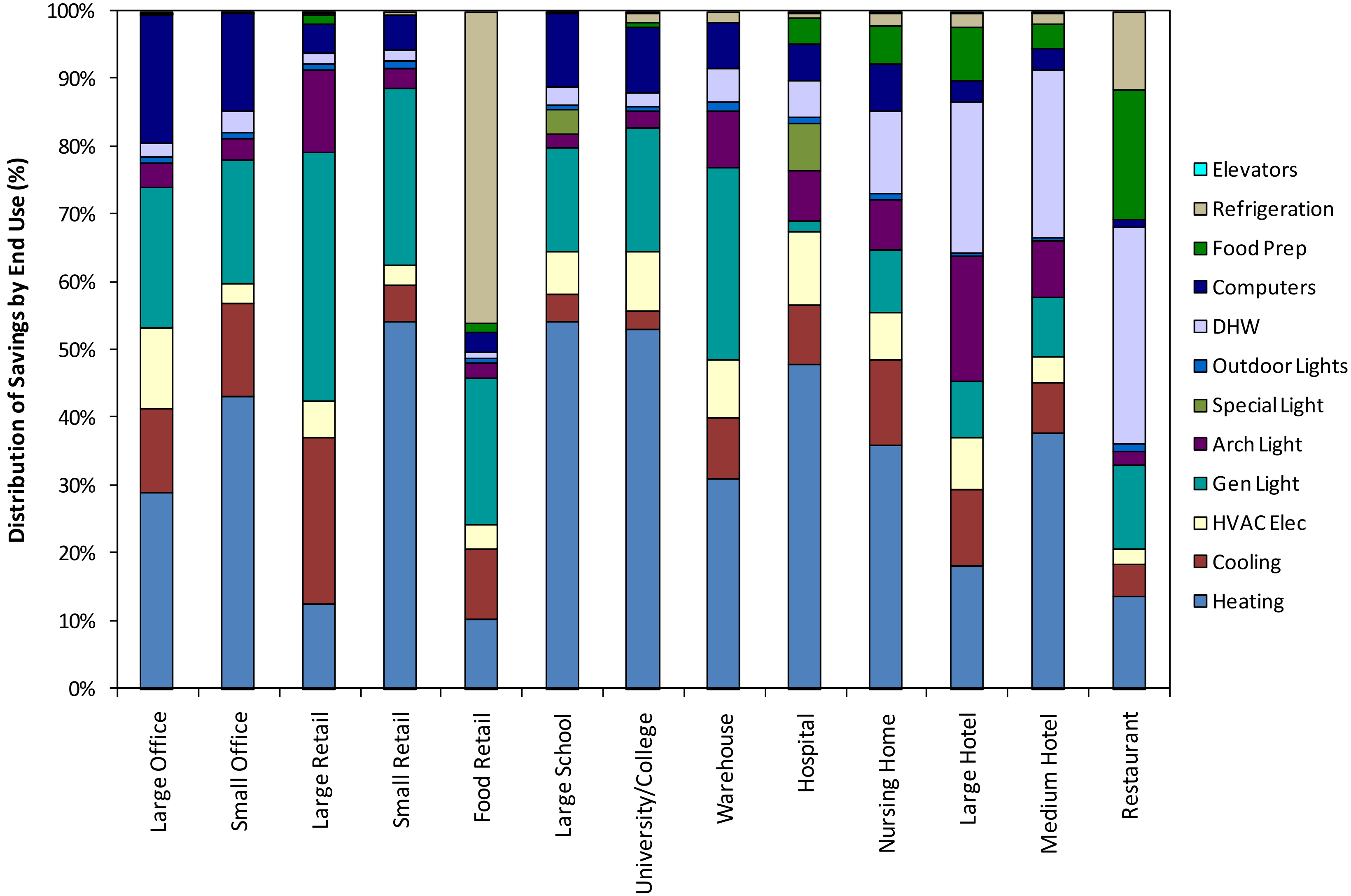


Exhibit 4.6 provides a tabular breakdown of energy savings potential among commercial and institutional buildings in the GTA in 2028 by building type and end use, including both new and existing buildings, and including both electricity savings and natural gas savings (note that natural gas savings are converted to equivalent GWh/year). Exhibit 4.7 provides a relative breakdown of the effect of each of the categories of energy efficiency measures for each of the sub-sectors that were considered. For a given sub-sector, this exhibit suggests the type of energy efficiency measures that should be focused on.

Exhibit 4.6: Energy Savings Potential in 2028 for C/I Buildings in the GTA, by Building Type and End Use (GWh/Year)

Building Type	Heating	Cooling	HVAC (Elec.)	Gen Lights	Arch. Lights	Special Lights	Outdoor Lights	DHW	Comp.	Food Prep	Refrig.	Elevators	TOTAL
Large Office	1,116	476	463	793	141	0	28	79	737	4	2	9	**3,849**
Small Office	996	317	70	420	73	0	19	75	339	0	1	0	**2,310**
Large Retail	166	328	70	489	160	0	13	19	58	17	8	1	**1,329**
Small Retail	653	63	36	314	35	0	15	20	62	0	6	0	**1,203**
Food Retail	72	72	24	151	15	0	5	6	21	9	321	0	**697**
Large School	836	62	96	234	33	54	11	42	168	3	1	0	**1,540**
University/College	730	36	120	250	35	0	7	30	131	11	21	2	**1,373**
Warehouse	522	154	144	477	142	0	21	82	117	0	27	0	**1,686**
Hospital	275	51	62	10	42	41	4	32	30	23	5	1	**575**
Nursing Home	250	88	49	65	52	0	6	85	49	38	15	0	**697**
Large Hotel	103	65	44	48	105	0	3	127	18	46	12	1	**570**
Medium Hotel	70	14	7	17	15	0	1	46	6	7	3	0	**187**
Restaurant	152	52	25	139	23	0	12	356	10	214	128	0	**1,111**
TOTAL	**5,941**	**1,779**	**1,209**	**3,407**	**871**	**95**	**145**	**999**	**1,745**	**372**	**550**	**14**	**17,127**

Exhibit 4.7: Relative Impact of Energy Efficiency Measures in Various Sectors

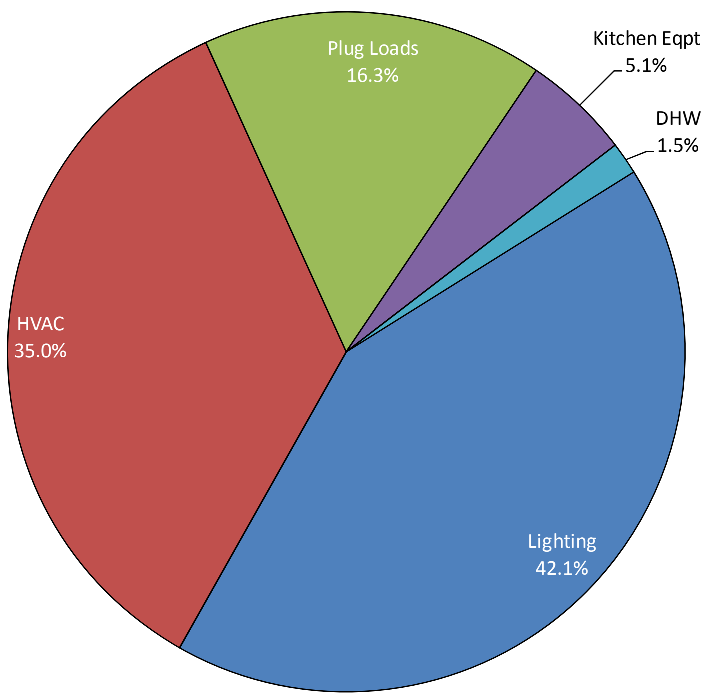


4.3 ELECTRICITY EFFICIENCY OPTIONS

The preceding section identifies the major end uses that offer significant energy saving potential. Although specific technologies were identified as part of the process of estimating potential, they act somewhat as proxies for end use potential as a whole: it is likely that many of the technologies examined will be superseded over the course of 20 years. Nonetheless, this section provides some indication of the technologies that are likely to offer significant potential for each major end use category.

Exhibit 4.8 shows the breakdown of electricity savings by major end use category. The subsections below are in descending order of contribution to the overall potential. New construction has been treated separately, because the applicable measures and program options for it are quite different.

Exhibit 4.8: Breakdown of Electricity Savings by Major End Use Category



4.3.1 Lighting

Lighting measures were considered for general lighting, architectural lighting (e.g. hallways, stairwells), special purpose lighting (e.g. hospital examination room lighting), and outdoor lighting. The measures that were considered include:

- **Next-generation T8 lighting system installation and redesign for overlit areas**, which were applied in baselines with both T12 and standard T8 lighting systems. This measure accounts for the fact that many workspaces are overlit and improves on energy efficiency by reducing the lighting intensity in these areas.

- **CFL reflector lamps**, as replacements to incandescent flood lights. The model also includes a measure for LED lamps, which offer slightly improved energy savings. However, this technology is not applied since its market prospects are uncertain in the near future.
- **T5 high-intensity fluorescent luminaires**, which are meant to replace metal halide fixtures

All of the above measures apply to separate baselines (i.e. different technologies that are currently installed). The potential contribution of each is based on the estimated energy efficiency gain from each technology, in combination with the size of the market that each of the baselines represents. The measures that are expected to have the largest impact are replacements of T12 lighting systems and redesigning for overlit areas.

4.3.2 Plug Loads

The energy-efficient technology measures that were considered for plug load improvements include the following:

- **Energy star copiers**, which are more efficient and go into standby mode when they are not being used
- **Energy efficient servers**, with more efficient processors, cooling systems, and power supplies
- **Energy Star personal computers**, whose monitors and hard drives go on standby when they are not in use

The energy efficiency improvements provided by the copiers are expected to be relatively small, but servers are an increasing load, particularly in office buildings, and the savings opportunity associated with them is substantial. The Energy Star computer measure is expected to have a large impact since computers represent a significant portion of the overall plug loads in many sectors. These machines are estimated to be about 45% more efficient than their non-Energy Star counterparts.

4.3.3 Refrigeration

Refrigeration measures were applied to all sectors except offices, schools and warehouses. The following technology measures were considered for refrigeration:

- **Smart defrost controls**, which reduce the amount of parasitic load required to inhibit ice build-up in refrigerators and freezers
- **Floating head pressure control**, which allows the operating head (or discharge) pressure to “float” with ambient temperature. This strategy can improve refrigerator efficiencies since maintaining a higher pressure requires additional compressor work. Instead, the system works only as hard as it needs to under all weather conditions.
- **Upgrades to display case covers/doors**, in order to decrease the amount of heat leaking into the system. This involves seal replacements and insulation upgrades.
- **High efficiency multiplexed compressors**, in which three or four compressors are used instead of a larger, stand-alone unit. Since individual compressors can be turned

on and off independently in a multiplex compressor design, this arrangement is much more effective at matching the required load.

Dividing the savings potential among these measures is very approximate, because it would vary greatly depending on the order in which they are applied, and how they are combined. All of the measures provide marginal improvements but the smart defrost controls and multiplexed compressors are expected to have the largest impact. These measures are also expected to have the largest effect on food retail and restaurants, where refrigeration loads are the largest.

4.3.4 HVAC Systems

This section describes the energy efficiency measures that were applied to heating and cooling systems, as well as HVAC fans and pumps. These three end-uses were considered separately in the analysis. The following improvements were applied to building HVAC systems:

- **Next generation building automation systems**, which are more effective at regulating temperature and can adapt to varying heating and cooling loads in different areas of a building. The systems can also be programmed to provide different levels of heating and cooling throughout the day and on nights and weekends.
- **Ground-source heat pump systems**, which employ underground piping networks in order to take advantage of the high thermal capacity of soil and rock. These piping networks are used as heat sinks since their temperature change due to climatic conditions is minimal. Ground source heat pumps are at least 60% more energy efficient than many conventional HVAC systems. This measure is applied to all building types except for large offices, large hotels, and hospitals.
- **Variable Speed Drive (VSD) chillers**, which optimise motor speed and change the frequency of the power input to the motor in order to consume the least amount of energy. This allows chillers to be run at very low loads and still obtain the same output. This measure is applied only to large offices, large hotels, and hospitals.
- **Adjustable speed drives**, which allows HVAC fans and pumps to operate at the optimum level, thus minimizing the amount of electricity that must be supplied to these systems.
- **Premium efficiency motors**, which also applies to HVAC fans and pumps and allows for further energy efficiency improvements of these systems.

Once again, dividing the savings potential among these measures is very approximate, because it would vary greatly depending on the order in which they are applied, and how they are combined. The most significant contribution is made by ground source heat pump systems, which offer savings in both heating and cooling applications. Building automation systems offer a fairly small energy efficiency potential, but this is applied to all of the end-uses.

4.3.5 Domestic Hot Water (DHW)

The measures that were applied to domestic hot water end-uses include:

- **Next generation building automation systems**, which improve the efficiency of DHW systems by minimizing the amount of water heating that occurs in periods of lower demand.
- **Low flow shower heads and faucet aerators**, which are effective at reducing the amount of hot water use, and therefore the overall DHW load

Low flow shower heads and faucet aerators offer the largest energy efficiency benefit in the DHW end-use. The potential savings in restaurants is proportionally higher due to the high demand for hot water in this sub-sector.

4.3.6 New Construction

The main measure considered for new construction is the following:

- **Integrated design of new buildings to use 40% less energy than standard construction**, which accounts for the fact that new buildings tend to be significantly more energy efficient. This measure is assumed to be applicable to most new buildings, across the different sub-sectors, throughout the modeling period. The savings would be achieved by incorporating many of the efficiency measures listed for existing buildings, for savings in most end uses, plus additional measures that affect building orientation and envelope.

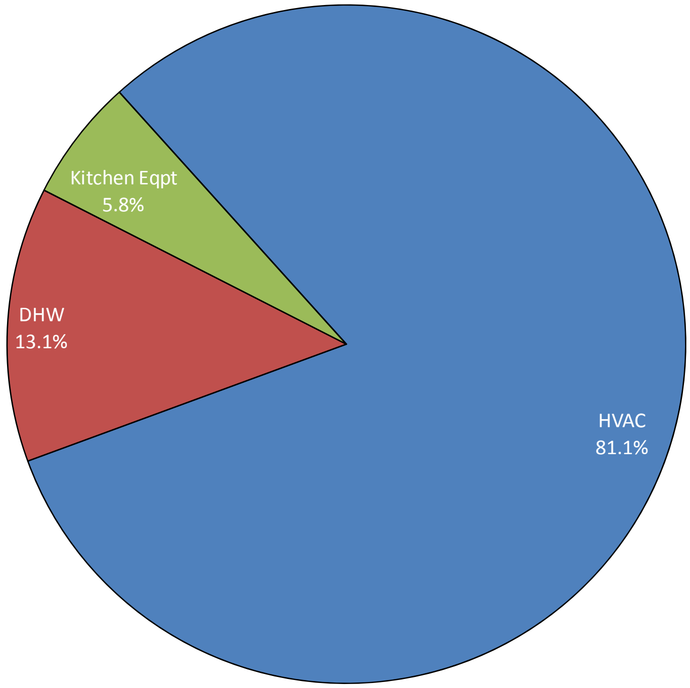
  An integrated design process helps reduce the upfront cost by incorporating efficient choices into the design early enough that expensive changes in direction are not needed. The potential in new construction is smaller than in existing buildings, but a failure to incorporate some efficient choices into new buildings results in the loss of an opportunity that cannot be recaptured for the life of the building – often fifty years or longer.

4.4 NATURAL GAS EFFICIENCY OPTIONS

Section 4.2 identifies the major end uses that offer significant energy saving potential. Although specific technologies were identified as part of the process of estimating potential, they act somewhat as proxies for end use potential as a whole: it is likely that many of the technologies examined will be superseded over the course of 20 years. Nonetheless, this section provides some indication of the technologies that are likely to offer significant potential for each major end use.

Exhibit 4.9 shows the breakdown of natural gas savings by major end use category. The subsections below are in descending order of contribution to the overall potential. New construction has been treated separately, because the applicable measures and program options for it are quite different.

Exhibit 4.9: Breakdown of Natural Gas Savings by Major End Use Category



4.4.1 HVAC Systems

The natural gas used in HVAC systems is of course used for space heating. The measures considered include the following:

- **Near-condensing boilers**, with an assumed efficiency of approximately 85%
- **Condensing boilers**, with an assumed efficiency of approximately 94%
- **Demand-controlled ventilation**, in which ventilation is adjusted according to occupancy. This would also have savings on the electric side, from electric heating, air conditioning, and ventilation fans.
- **High performance glazing systems**, with R-value over 4 (RSI over 0.7)
- **Building recommissioning and advanced building automation systems**, which includes tuning the building systems to eliminate simultaneous heating and cooling, optimizing hot and cold deck temperatures, etc., as well as installing advanced digital controls

Dividing the savings potential among these measures is very approximate, because it would vary greatly depending on the order in which they are applied, and how they are combined. The commissioning/BAS and high performance glazing measures are the most significant. Of the two, the commissioning/BAS measure is somewhat less expensive. Unlike most of the other measures, the commissioning/BAS measure is economically attractive on a full-cost basis – this means a retrofit could be justified even if the existing systems are not at end of life.

Boilers offer significant savings as well – if the upgrade goes all the way to the condensing boiler, a boiler retrofit would offer the greatest savings potential. If only the near-condensing boiler is chosen, the savings would not be as great as those offered by the commissioning/BAS or glazing measures. Boiler retrofit measures are economically attractive only on an incremental basis – meaning that they could be justified only as an upgrade when the boiler needs replacement for other reasons.

4.4.2 Domestic Hot Water (DHW)

The measures considered for DHW included the following:

- **Pre-rinse spray valve**, for restaurants. These valves reduce hot water flow rate in the sprayer from about 15 litres/min to 6 litres/min.
- **Drainwater heat recovery**, for large hotels, hospitals, nursing homes, and restaurants. The system recovers heat from drainwater for pre-heating DHW.
- **Condensing DHW boilers,** for large buildings, with an assumed efficiency of 90%.
- **Condensing DHW tank heaters**, for medium and smaller buildings, with an assumed efficiency of 95%. The recommissioning/BAS measure described under HVAC Systems above would also provide DHW savings.

Again, dividing the savings potential among these measures is very approximate, because it would vary depending on the order in which they are applied, and how they are combined. The condensing boilers and tank heaters appear to offer the largest potential. These measures would be attractive only on an incremental basis – meaning that they could be justified only as an upgrade when the boiler needs replacement for other reasons.

The recommissioning/BAS and pre-rinse spray valve measures also offer significant savings potential, and both are economically attractive on a full cost basis – meaning they could be justified as an upgrade even if the equipment is not at end of life.

4.4.3 Kitchen Equipment

The measures considered for kitchen equipment included the following:

- **Efficient broiler**, in all buildings with kitchen operations. The baseline gas broiler is assumed to be 20% efficient and the high efficiency product is assumed to be 30% efficient.
- **Efficient range**, in all buildings with kitchen operations. The - baseline gas range is assumed to be 27.5% efficient and the high efficiency product is assumed to be 52.5% efficient.

The savings potential is relatively evenly split between these two measures. These measures would be attractive only on an incremental basis – meaning that they could be justified only as an upgrade when the equipment needs replacement for other reasons.

4.4.4 New Construction

The main measure considered for new construction is the following:

- **Integrated design of new buildings to use 40% less energy than standard construction**, in a measure that incorporates many of the other efficiency measures, for savings in most end uses.

  Savings of up to 60% can be attained cost-effectively for most building types. 40% is reached relatively easily, even though standard construction practices have improved in a number of ways. An integrated design process helps reduce the upfront cost by incorporating efficient choices into the design early enough that expensive changes in direction are not needed.

  The potential in new construction is smaller than in existing buildings, but a failure to incorporate some efficient choices into new buildings results in the loss of an opportunity that cannot be recaptured for the life of the building – often fifty years or longer.

4.5 INTERPRETATION OF RESULTS

In a business-as-usual scenario, with only naturally-occurring efficiency measures in the commercial and institutional sectors in the GTA, the consumption of electricity would rise from approximately 25,000 GWh/year to approximately 33,800 GWh/year by 2028 and the consumption of natural gas would rise from 13,100 GWh_e/year to 18,200 GWh_e/year. If, on the other hand, all the cost-effective energy efficiency measures were applied to these buildings, consumption of both electricity and gas could be reduced by 2028, to 23,000 GWh/year and 11,800 GWh_e/year, respectively. Thus the potential energy savings over the twenty-year period are approximately 17,100 GWh/year, just over 60% of which is electricity savings.

The largest potential for energy savings are in the following sub-sectors, in decreasing order:

- Offices (large and small)
- Non-food Retail (large and small)
- Wholesale and Warehousing
- Schools
- Universities and Colleges.

HVAC system efficiency offers the largest potential for energy savings, followed by lighting systems, computers and associated equipment, and DHW.

Over three-quarters of the savings potential is in measures applied to existing building, with the remainder of the potential coming from new construction.

5. CONCLUSIONS AND RECOMMENDATIONS

This study has confirmed that there is significant cost-effective potential for energy efficiency within the commercial and institutional sectors in the Greater Toronto Area. The study results provide:

- Specific estimates of potential energy efficiency opportunities, by sub-sector, energy end use, fuel, and vintage (new construction versus existing buildings)
- Major players within each of the key sub-sectors, for developing a targeted marketing effort.

5.1 MAJOR FINDINGS

The study identified five major sub-sectors as offering the largest energy efficiency potential, based on overall floor space and energy consumption:

- Wholesale and warehousing
- Offices (including public administration)
- Universities and colleges
- Non-food retail
- Schools.

5.1.1 Energy Savings Potential by Sub-Sector

Floor space or energy consumption are only a rough guide to potential, however. A more detailed modeling approach, incorporating assumptions about current energy using technology and the applicability of different measures, refines this considerably. Exhibit 5.1 shows the major sub-sectors, in priority order by descending energy savings potential.

Exhibit 5.1: Energy savings Potential for Major Sub-sectors

Major Sub-Sector	Percentage of Overall Savings Potential
Offices (large and small)	37%
Non-food Retail (large and small)	15%
Wholesale and Warehousing	10%
Schools	9%
Universities and Colleges	8%

Offices offer by far the largest savings potential, with almost as much potential as the next four major sub-sectors combined. Overall, the five categories shown in Exhibit 5.1 account for nearly 80% of the overall savings potential in the commercial and institutional sectors.

5.1.2 Energy Savings Potential by Energy End Use

Heating, ventilation and air conditioning equipment provides over half of the energy savings potential, with heating offering the largest share of this potential.

Lighting offers over one-quarter of the energy savings potential, with most of that potential coming from savings in general lighting.

Computers and associated equipment offer approximately 10% of the energy savings potential, with DHW offering approximately 6%.

5.1.3 Energy Savings Potential by Fuel

Nearly two-thirds of the energy savings potential is electricity savings, and just over one-third is natural gas savings. This study did not explore savings in oil or other fuels.

The lower savings in natural gas relative to electricity is due partly to the fact that electricity accounts for more of the energy consumption currently and partly to the number of gas conservation measures that require major equipment replacement (e.g., boiler retrofits). Replacement of a boiler is viable only on an incremental cost basis, when the boiler is at or near end of life, and boilers tend to have long life. Consequently, this measure would not be implemented throughout the population of buildings even over the 20 year period considered in this study.

5.1.4 Energy Savings Potential by Vintage: New Construction vs. Existing Buildings

Over three-quarters of the energy savings potential is in existing buildings, while just under one-quarter is in new construction.

5.2 OVERALL PROGRAM RECOMMENDATIONS

THES should consider targeting energy efficiency offerings to the commercial and institutional sectors in the GTA as follows:

- Office buildings should be the first priority for program offerings.
- Other major sub-sectors should be targeted for specific programs, in the following approximate descending order of priority: non-food retail, wholesale and warehousing, schools, universities and colleges.
- HVAC energy efficiency programs should be the highest priority, followed by lighting
- Program offerings should include both electricity and natural gas savings.
- Program offerings should include both existing buildings and new construction. Existing buildings offer the largest potential, but failure to capitalize on savings opportunities in new construction results in missed opportunities that will not recur for decades.

5.3 SUB-SECTOR SPECIFIC PROGRAM RECOMMENDATIONS

The following subsections offer some insight into appropriate variation in energy efficiency programs by sub-sector.

5.3.1 Offices

Program offerings to the office sub-sector should be informed by the following insights:

- Section 3.1 outlines the major owners of office space in the GTA, and contact names information is provided in Exhibits 3.3 and 3.4.
- HVAC energy efficiency offers just over half the potential in the office sub-sector. As buildings increase in size, in general heating offers less potential and HVAC electricity (fans, pumps, etc.) offer more.
- Lighting remains a very significant source of savings in offices. Although many buildings have upgraded lighting systems, there are still many that have not. Furthermore, there are now "next generation" lighting systems which, when combined with a redesign to reduce lighting levels in overlit spaces, offer even more potential.
- Computers and associated equipment, including servers, offer significant potential in office buildings.

5.3.2 Non-Food Retail

Program offerings to the non-food retail sub-sector should be informed by the following insights:

- The major owners of retail space in the GTA are identified in Section 3.3 and contact information is provided in Exhibit 3.8.
- In large retail, lighting efficiency offers the largest potential, followed by HVAC energy efficiency. In small retail, it is the other way around.
- The largest potential in small retail comes from heating efficiency.
- The largest potential in large retail comes from general lighting.
- Lighting is a selling tool in the retail sub-sector, and it requires some care to address its efficiency. Projects to reduce overall levels of general lighting must be combined with improvements in spot-lighting, colour rendition, and other aspects of lighting quality. Daylighting should be considered as an efficiency strategy in retail, as it has been shown experimentally to increase sales.

5.3.3 Warehouse/Wholesale

Program offerings to the warehouse/wholesale sub-sector should be informed by the following insights:

- The major owners of warehouse/wholesale space in the GTA are identified in Section 3.2 and contact information is provided in Exhibit 3.6.
- In the wholesale/warehouse sub-sector the largest two sources of energy potential are HVAC energy efficiency and lighting efficiency.
- There is considerable variation in HVAC systems in this sub-sector. Heating offers less potential than in most other sub-sectors, because many warehouses are not maintained at standard room temperature. Some are cool storage, so the potential from both air conditioning and refrigeration are larger than for other sub-sectors.

- High bay lighting is, of course, much more significant in this sub-sector than for most other sub-sectors. There are new fluorescent lighting systems for high bay lighting that offer substantial savings.

5.3.4 Elementary and Secondary Schools

Program offerings to the schools sub-sector should be informed by the following insights:

- The major owners of schools in the GTA are identified in Section 3.5 and contact information is provided in Exhibit 3.14.
- In the schools sub-sector the largest HVAC energy efficiency offers the largest potential savings. Space heating accounts for over half of the overall savings potential. Cooling is a smaller source of savings than for most other sub-sectors, because operating hours during the cooling system tend to be short and because many schools do not have air conditioning.
- Lighting offers less potential than in most sub-sectors, but it is still significant.
- Computers offer more savings potential than in most sub-sectors.

5.3.5 Universities and Colleges

Program offerings to the universities and colleges sub-sectors should be informed by the following insights:

- The distribution of university buildings in the GTA is discussed in Section 3.4 and contact information is provided in Exhibit 3.10.
- The distribution of college buildings in the GTA is discussed in Section 3.6 and contact information is provided in Exhibit 3.17.
- In the universities and colleges sub-sectors the largest HVAC energy efficiency offers the largest potential savings. Space heating accounts for over half of the overall savings potential. The presence of residence buildings on campuses increases the relative importance of HVAC energy in this sub-sector, because these buildings have energy consumption patterns resembling multi-family residential buildings. Lab buildings, which are common on university campuses, are also very energy intensive, with high ventilation rates and consequently high HVAC energy consumption.
- Lighting offers significant potential, though it is a slightly lower percentage of overall savings potential than for most other sub-sectors.
- Computers offer more savings potential than in most sub-sectors.

APPENDIX A

Detailed Methodology Discussion

Methodology – Market Assessment

The overall market profile involves two steps:

- **Step 1:** A macro-level approach was taken to assess the building portfolio size and consumption characteristics of the commercial and institutional sectors in the GTA. The outputs from this step were a list of priority sub-sectors that warranted further analysis and broad sub-sector quantitative data, such as floor space and energy use, which contributed to the energy efficiency opportunity assessment.

- **Step 2:** For each of the priority sub-sectors identified in Step 1, a more detailed analysis was undertaken to provide key sub-sector characteristics, and to confirm/supplement the macro-level data. This included obtaining the contact information of major players within each of these sub-sectors.

Data Sources and Limitations

The macro-level market assessment of the commercial and institutional sectors in the GTA was conducted based on data from a comprehensive market survey that was conducted by Statistic Canada for Natural Resources Canada (NRCan). This report, completed in 2006 and based on data from 2005, is called the Commercial and Institutional Consumption of Energy Survey (CICES). CICES provides data on floor space and energy use patterns for the commercial and institutional sector in Canada as a whole and for individual provinces or group of provinces.

Another source of data, the Commercial and Institutional Building Energy Use Survey (CIBEUS) conducted by NRCan in 2000, is also available. The data presented by CICES were used for several reasons:

- CICES is based on data that are more recent (i.e. 2005 vs. 2000).
- CIBEUS was the first survey of its kind conducted in Canada. As such, it is reasonable to assume that the project team identified and implemented many improvements in subsequent surveys, such as CICES.
- Although the sample size of respondents for both surveys is similar, CIBEUS only sampled buildings in large metropolitan areas, whereas CICES profiled establishments across Canada. Thus, CICES data are deemed to be more representative and robust.
- CICES data for floor space and energy use in individual sectors are twice as large as CIBEUS data in some instances. A previous study that utilized the CIBEUS database and compared it with more sector-specific data found that it was overly conservative in many instances.[6] CICES data are also in fairly good agreement with other data sources such as NRCan's Comprehensive Energy Use Database.
- The sub-sector segmentation in CIBEUS is somewhat arbitrary while the breakdown is based on NAICS (North America Industry Classification System) codes definitions in CICES. This disparity makes it difficult to compare data between the two surveys.

[6] Marbek Resource Consultants Ltd. in association with Summerhill Group, "Market Profile and Conservation Opportunity Assessment for Small Businesses in Ontario", prepared for the Ontario Power Authority, May 30, 2006.

Although CICES data are deemed to be of better quality, the data that are available in the online report is much less extensive than the data available for CIBEUS. Fortunately, more complete CICES data are available to the some of the NRCan staff involved with CICES[7]. These data were used to supplement the data available online.

As mentioned above, CICES segments commercial and institutional facilities by NAICS codes definitions. The analysis is therefore undertaken based on the CICES definitions as shown in Exhibit A.1. More detailed descriptions of the NAICS codes definitions, as of 2007, are available on the Statistics Canada website.[8]

Exhibit A.1: The Sub-Sector Breakdown Used by CICES[9]

SECTOR	NAICS	EXAMPLES
Wholesale Trade and Warehousing and Storage	41, 493	Warehousing and Storage; Wholesalers-Distributors of: Food, Beverage and Tobacco, Building Material and Supplies, Petroleum Products, Motor Vehicle and Parts, etc.
Retail Trade	44, 45	
Food Retail	445	Grocery Stores; Specialty Food Stores; Beer, Wine and Liquor Stores
Non-Food Retail Trade	441 to 444; 446 to 454	Motor Vehicle and Parts Dealers; Furniture and Home Furnishings Stores; Electronics and Appliance Stores; Gasoline Stations
Information and Cultural Industries	51	Publishing Industries; Motion Picture and Sound Recording Industries; Broadcasting; Internet Publishing and Broadcasting
Offices, except Public Administration	52, 53, 54	Finance and Insurance; Real Estate and Rental and Leasing; Professional, Scientific and Technical Services (Legal Services, Accounting, Architectural Services, Engineering Services, etc.)
Public Administration	91	Federal Government; Provincial and Territorial Governments; Local, Municipal and Regional Public Administration
Educational Services	6111 – 6113	
Elementary and Secondary Schools	6111	
Community Colleges and CEGEPs	6112	
Universities	6113	
Health Care and Social Assistance		
Ambulatory (Non-hospital) Health Care Services	621	Offices of Physicians; Offices of Dentists; Medical and Diagnostic Laboratories; Home Health Care Services
Hospitals	622	General Medical and Surgical Hospitals; Psychiatric and Substance Abuse Hospitals
Nursing and Residential Care	623	Nursing Care Facilities; Community Care Facilities for the Elderly
Social Assistance	624	Individual and Family Services; Community Food and Housing
Accommodation Services	721	Traveller Accommodation; RV Parks; Rooming and Boarding Houses
Food Services and Drinking Places	722	Full-Service Restaurants; Limited-Service Eating Places; Drinking Places
Religious Organizations	8131	
Other	71, 81 (except 8131)	Performing Arts, Spectator Sports and Related Industries; Heritage Institutions; Amusement, Gambling and Recreation Industries; Personal and Laundry Services; Civic Organizations

7 More complete data obtained from NRCan OEE, Jan. 16, 2008.

8 Statistics Canada, "North American Industry Classification System (NAICS) 2007 - Canada", http://www.statcan.ca/english/Subjects/Standard/naics/2007/naics07-menu.htm

9 Adapted from Appendix A of the "CICES Summary Report – June 2007", NRCan OEE, http://www.oee.nrcan.gc.ca/Publications/statistics/cices06/pdf/cices06.pdf

In order to use the CICES data to give a rough estimate of sector-specific data for the GTA, it was necessary to estimate some of the data for Ontario (since portions of the data were unavailable) and determine the proportion of establishments that are located in the GTA for each of the sub-sectors. Data were available to facilitate this process with some sub-sectors. For instance, university data were broken down based on the proportion of student enrolment in the GTA relative to all of Ontario. In other cases, reasonable assumptions were made by using Ontario population distribution as a baseline. Although this process yielded a fairly rough estimate of the space and energy use characteristics of the commercial and institutional sector buildings in the GTA, some scaling was applied so that the relative proportions of the data between the sub-sectors were largely maintained. Available sector-specific data were also used to gauge the validity of the estimates.

Although the energy use and floor space represented by the “Other” sub-sector is significant, this sub-sector is not addressed in this study due to the large variation of establishments represented and their wide array of energy usage patterns. These factors would make it quite difficult to profile this sub-sector independently. Furthermore, since the public administration sub-sector is quite similar to offices, these two data sets are grouped together.

Obtaining Contact Information of Major Players

Efforts were made to identify the key players involved in each of the priority sub-sectors. Individuals in charge of facility energy management for each of the key players were then identified so that their contact information could be included in the report. In many cases, this involved several phone calls before being re-directed to the proper person. The study was then explained to them and they were asked if their contact information could be included. In a few cases, contacts could not be reached by phone or email but internet searches indicated that they were the appropriate contact. In these cases, contact information was included in the report without the individuals’ consent. However, this was deemed appropriate since the information was publicly available.

For the office and warehouse sectors, information provided by CB Richard Ellis was used to establish the identity of key players and establish a primary contact. Individuals who deal with energy management were then identified.

MARBEK
Resource Consultants Ltd.

MKJA
MK Jaccard and
Associates Inc

DEMAND SIDE MANAGEMENT POTENTIAL IN CANADA: ENERGY EFFICIENCY STUDY

–Summary Report–

Submitted to:

Canadian Gas Association

Submitted by:

Marbek Resource Consultants Ltd.

and

M.K. Jaccard and Associates, Inc.

May 2006

Marbek Resource Consultants Ltd.
300-222 Somerset Street West
Ottawa, Ontario K2P 2G3
Tel: 613.523.0784 ♦ Fax: 613.523.0717
www.marbek.ca

M.K. Jaccard & Associates, Inc.
414- 675 West Hastings Street
Vancouver, B.C. V6B 1N2
Tel: 604.683-1252 ♦ Fax: 604.683-1253

Table of Contents

List of Exhibits

1. INTRODUCTION

This report summarizes the findings of a high-level study to estimate the achievable demand-side management (DSM) potential in Canada. The study was conducted for the Council of Energy Ministers demand-side management (DSM) Working Group with the goal of bringing DSM to the forefront of the energy and economic policy discourse in the country. The DSM Working Group comprises representatives from the federal government (Natural Resources Canada), provincial governments, the utility industry, major energy users, and non-governmental organizations.

The report culminates a comprehensive analysis of three key sectors of the economy: industrial, residential and commercial/institutional (hereafter, referred to as commercial). The study comprised three important scenarios, reference case (business-as-usual), economic potential and achievable potential; each of those milestones are documented in separate reports which are presented in appendices as follows:

- Reference Case Report-Appendix A
- Economic Potential Report-Appendix B
- Achievable Potential Report-Appendix C.

This report summarizes the findings of these three reports.

The study findings indicate that the total achievable reduction in energy demand in 2025 for the industrial, residential and commercial sectors could be reduced by between 3% and 10%. as a result of a diverse mix of policy instruments.[1] Moreover, this savings range means that achievable energy management can meet 16% to 56% of the projected energy demand growth to 2025. The estimated reduction in energy demand is due to a mix of energy efficiency, cogeneration and fuel substitution measures, driven by a range of policy instruments. This range of achievable potential savings, as determined from this study, represents a credible contribution to meeting Canada's long-term energy supply needs.

The study was conceived as a high level, policy oriented exercise and, as such, the outputs should been seen as the foundation for future dialogue. This dialogue should further examine how to advance DSM to the forefront of energy policy circles and, hopefully, bring direction, certainty and action to the policy concepts presented herein, or to alternative policy mixes.

The study findings should not be taken as the platform for DSM program design. For some jurisdictions the study findings are based on aggregated regional data and do not necessarily reflect the actual situation of the individual jurisdictions within the region. Therefore, while the study provides a sound indication of DSM potential on a national basis, it is not intended to provide all details sufficient for the development of specific programs to meet the needs of individual jurisdictions.

This summary report is organized according to the following subsections:

[1] The term "demand" used in the report refers to the demand for purchased energy to meet energy service needs.

- This introductory section, which includes the study context and scope.
- The method employed.
- The results which present the empirical outputs for the achievable and economic potential scenarios.
- Discussion of the results.

1.2. STUDY SCOPE

The study scope is defined as follows:

- **Sector Coverage:** The study addresses three sectors: residential, commercial/institutional (referred to as commercial) and industrial. Energy supply sectors (electricity, upstream oil and gas and coal) are not included in the study.

- **Geographical Coverage**: The study results are presented for seven provinces and regions, including British Columbia and the territories, Alberta, Saskatchewan, Manitoba, Ontario, Quebec, and the Atlantic region.

- **Energy Types:** All energy types are covered including natural gas, electricity, refined petroleum products and other fuels such as biomass.

- **DSM Coverage:** For this study, DSM includes energy efficiency, fuel substitution, cogeneration and distributed generation. Cogeneration (or combined heat and power) produces both electricity and useful thermal energy simultaneously from the same fuel (or fuels). The analysis considers all technologies that are expected to be commercially viable through to 2025.

  How the DSM Impact is Reported: The DSM scenarios analyzed in the study comprise energy efficiency, fuel substitution, cogeneration and distributed generation measures that affect changes in end-use energy demand among the three studied sectors. This has a resulting effect on the amount of purchased and non-purchased energy supply required by these sectors. The study reports the total effect of the measures on energy demand, meaning that the outputs take into account both reduced secondary energy demand and changes in the mix of primary energy demand. No attempt was made in this study to relate the electricity savings to peak or average demand reduction.

- **Jurisdictions:** DSM and energy efficiency measures are contemplated for utilities and for all levels of government in Canada (including municipal, provincial and federal).

- **Study Period**: This study covers a 25-year period. The base year is 2000, with milestone periods at 5-year increments: 2005, 2010 2015, 2020, and 2025.

- **Metrics Used to Present Results**: All of the national levels results are presented in metric energy units.[2]

[2] The factors used to convert to common units are: NG: 39.8MJ/m3, Fuel Oil (light): 38.68 GJ/m3, propane: 25.53 GJ/m3 (0.02553 GJ / litre), electricity: 0.0036 GJ / kWh

1.3 STUDY CONTEXT

During the past 25 years, governments at all levels, together with both natural gas and electric utilities, have delivered a wide array of market interventions in an effort to reduce overall demand for energy by residential, industrial, or commercial energy users. The energy efficiency of most equipment and buildings in Canada has steadily improved. Moreover, between 1990 and 2004, the energy intensity of industrial production declined. by 30%.[3]

Notwithstanding these performance improvements, energy demand continues to climb for all sectors. Between 1990 and 2003, secondary energy use increased 22 percent, from 6,951 to 8,457 petajoules (PJ).[4] What is happening is that the effects of economic activity, namely, the growth of the housing and commercial building stock, larger homes, the market penetration of more energy using devices, and industrial production growth together offsets the effects of energy efficiency improvements. Hence, the energy demand curve continues to show an upwards trajectory. A difficult question for this study is how much and at what speed we can affect this trend and, consequently, bend the slope of the curve. Key challenges exist and two dimensions to this challenge are worth noting here.

At the risk of over-simplification, a good portion of the DSM "low hanging fruit" has already been attained in all three sectors, i.e., many of the lower cost, short payback measures have been implemented. This includes, for example, the penetration of higher efficiency appliances, motors and lighting. Unless economic circumstances change considerably, the potential that remains will be more difficult to capture for several reasons, including: i) the target sub-markets become more challenging, e.g., small commercial, mid- and high-rise apartments, small and medium sized industry and ii) the solutions can become more complex, e.g., moving to process integration and balance of plant measures in industry; getting industry and commerce to effectively apply corporate energy management systems as the foundation for ongoing, sustainable and strategic management of energy.

Equally important is the degree to which policy can influence the adoption of greater energy efficiency in the economy by addressing fundamental market barriers. Experience with market intervention over the past two decades has shown that, while many energy efficiency opportunities can be shown to be cost-effective, when the monetary value of energy savings is assessed against the initial capital cost outlays, consumers and firms forego apparently cost-effective investments in energy efficiency. Energy users appear to discount future savings of energy-efficiency investments at rates well in excess of market rates for borrowing or saving. This has often been referred to as the energy-efficiency "gap".[5] Exhibit 1.1 lists some of the

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[3] Based on gross output. This is for 'Total Industry' (NAICS 100000). 'Total Manufacturing Industry' (NAICS 100001) shows a similar trend. Canadian Industrial Energy End-use Data and Analysis Centre (CIEEDAC), *Development of Greenhouse Gas Intensity Indicators for Canadian Industry, 1990 to 2004* , Burnaby: Simon Fraser University, 2005.

[4] Office of Energy Efficiency, *Energy Efficiency Trends in Canada, 1990 to 2003*, Ottawa: Natural Resources Canada, 2005.

[5] For example, see A. Jaffe and R. Stavins, "The Energy-Efficiency Gap: What Does it Mean?" *Energy Policy* 22, 10 (1994): 804-810; J. Scheraga, "Energy and the Environment: Something New under the Sun?" *Energy Policy* 22, 10 (1994): 811-818; R. Sutherland, "The Economics of Energy Conservation Policy," *Energy Policy* 24, 4 (1996): 361-370.

cross-cutting barriers, market behaviours and failures identified in the literature to explain why the take up of energy-efficiency is lower than expected.

Exhibit 1.1: Explanations for Lower than Expected Energy Efficiency Investment

Category	Explanation
Price Signals	• Energy pricing at levels that do not integrate externalities associated with the cradle to grave lifecycle (full cost accounting). • Energy pricing signals that do not reflect real-time costs.
Consumer Awareness and Preferences	• Awareness that energy efficiency opportunities & products exist • Awareness of benefits – cost and co-benefits. • Consumer technical ability to assess the options. • Consumer offsetting preferences (e.g., large single detached homes). • Lack of public perception/understanding of infrastructure needs/ resource constraints/ the functionality, cost, drivers and challenges are unknown to the public.
Product and Service Availability	• Local or national product availability. • Existence of a viable infrastructure of trade allies. • Vendor or trade ally awareness of the efficiency options and their understanding of the technical issues.
Technology and Innovation	• An energy efficient technology may not be a perfect substitute for another, accepted technology for an end-use. • An energy efficient technology may not be cost-effective for all consumers, even if it is cost-effective for the average consumer. • Lack of enabling tools and techniques to facilitate market adoption of sustainable energy solutions.
Financing	• Access to appropriate financing. • Uncertain future energy prices, combined with the irreversible nature of energy efficiency investments. • Size of required energy efficiency investment vs. asset base. • Payback ratio – actual vs. required.
Transaction Costs	• Level of effort/hassle required to become informed, select products, choose contractor(s) and install.
Perceived Risk/Reward	• Level of perceived risk that the energy efficient product may not perform as promised. • Level of positive external/personal recognition for “doing the right thing” by installing the efficiency measure(s).
Split Incentive/Motivation	• Level to which the incentives of the agent charged with paying for the energy efficiency measure are aligned with those of the person(s) that would benefit.
Institutional and Regulatory	• Codes or standards that prohibit implementation of innovative energy efficient technologies. • Limited horizontal cooperation/coordination to integrate policies and implementation. • Municipal policies and land planning processes that supported, even encouraged, development of greenfield areas and subsidized the practice through low development fees. • Disconnect between longevity of infrastructure and short-term horizons on crucial decisions, such as budget allocations for maintenance and rehabilitation and rate structures.

2. METHOD EMPLOYED

2.1 MODELLING PLATFORM

The analysis was conducted using the CIMS model, supported by Marbek DSM tools and databases.[6] CIMS is an integrated energy-economy model that simulates technology acquisition in the economy over time. Technologies are represented in unique sub-models that meet energy service demands in the residential, commercial, transportation, electricity supply, and industry sectors. It is therefore possible to specifically represent the evolution of a technology, or group of technologies, in a forecast and to alter model inputs to simulate alternative forecasts and policy scenarios.

The take-up of DSM technologies in CIMS is driven by a model construct that tries to reflect the financial and non-financial considerations affecting energy user decisions and choices. CIMS is a platform for a competition among various DSM technologies. While the engine for this competition is the minimization of annualized life cycle technology costs, energy user decisions not only depend on recognised financial costs (capital, energy and other operating and maintenance costs), but also respond to:

- Identified differences in non-financial preferences (e.g. differences in the quality of lighting from different light bulbs).
- The preferences of firms and households with respect to the risk of newness and risk of irreversible investments. Thus the lifecycle cost is calculated with effective 'private' discount rates that are revealed from market data.[7]
- The non-deterministic nature of market behaviour. Market shares are allocated among technolgoies probabilistically according to a *variance parameter*.[8]

The preference parameters in CIMS are set using a combination of literature review, original survey research, expert judgment, and model validation.

2.2 THE STUDY SCENARIOS

2.2.1 Scenario Definitions

In this project CIMS was applied to develop four scenarios: a reference case, an economic potential, and two achievable potential scenarios. Given that energy systems in Canada differ significantly by region, the national potential for energy demand reduction is derived from the analysis of regional potentials (rather than a single national potential). This is done according to the disaggregation currently available in the CIMS model. Unique sub-models represent British Columbia, Alberta, Saskatchewan, Manitoba, Ontario, Quebec and a combined Atlantic region. The CIMS model is not currently set up to model the Atlantic region on a provincial basis and, therefore, the analysis of the

[6] The CIMS model is developed by the Energy and Materials Research Group and Simon Fraser University.
[7] Revealed discount rates cover both of these factors because the new technologies of interest to energy-economy modellers are those that increase energy efficiency through irreversible, long payback investments.
[8] In contrast, the optimizing models will tend to produce outcomes in which a single technology gains 100% market share of the new stocks.

Atlantic region potential does not reflect the diversity of energy systems, fuel availability, prices and mix, and electricity prices in the Atlantic provinces.[9]

The scenarios are defined as follows:

- **Reference Case**: A projection of energy demand to 2025, in the absence of any new and incremental institutional market interventions after 2005. It is the baseline against which the scenarios of energy savings are calculated. The reference case includes "natural conservation", i.e., changes in end use efficiency due to stock replacement, energy prices and other factors over the study period that are projected to occur in the absence of new and incremental market interventions.

- **Economic Potential**: An estimate of the energy demand that would occur if all equipment and building envelope energy management actions that pass a 'Total Resource Cost' test were implemented in the target markets. These actions are applied at either natural stock turn-over or retrofit rates.

- **Achievable Potential**: An estimate of the energy demand that would occur as a result of market intervention to influence the take up of energy management actions. The potential is estimated in two policy scenarios. The first focuses on the response from subsidies to specifically target the uptake of actions identified in the 'Total Resource Cost' test in the Economic potential. The second scenario includes the energy demand response to broader based policy instruments, land-use measures and 'aggressive' building and equipment standards and renewables subsidies.

2.2.2 Reference Case Elaboration

The reference case forecast is strongly influenced by three factors: energy prices, economic growth, and the saturation and mix of energy using equipment in the existing buildings and industrial stock. The CIMS base year in all regions is calibrated to within +/-5% of the latest 2000 energy supply and demand data from Statistics Canada and, consequently, 2000 is the start year of the study analysis. The most critical challenge was to update the pricing assumptions to ensure a robust and credible modeling foundation.

Prior to this study, the energy prices in CIMS were based on Natural Resources Canada (NRCan)'s *Canada's Emissions Outlook: An Update 2000* which is, of course, outdated. At the time when the Reference Case was to be constructed, NRCan had not yet completed a new national energy use and price forecast. With the support of the DSM Working Group, the consulting team decided to completely update the energy price schedule in CIMS. After consultations with the DSM Working group, we adopted the price forecasts of one of the two scenarios embodied in the National Energy Board (NEB)'s *Canada's Energy Future*, referred to as the "Techno-Vert" scenario.[10]

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[9] The Atlantic region accounts for 7% of the end-use energy (in 2000) for sectors represented in the study.

[10] National Energy Board, *Canada's Energy Future" Scenario's for Supply and Demand to 2025.* (Supply Push and Techno-Vert scenarios). http://www.neb-one.gc.ca/energy/SupplyDemand/2003/index_e.htm

The NEB scenarios represented the only recent forecast available with provincial and sectoral coverage. The Techno-Vert scenario was selected as the more realistic of the two options because: i) it projects higher energy prices and ii) due to the higher energy prices it embodies a higher rate of "natural conservation". Exhibit 2.1 presents the national prices in the Techno-vert forecast.[11] Interestingly, even under the more aggressive price forecast, it shows declining or stable price trends over the study period.

Exhibit 2.1: Techno-vert National Energy Prices

Canada						
	2000	**2005**	**2010**	**2015**	**2020**	**2025**
Residential ($1995/GJ)						
Electricity	$21.24	$21.08	$22.51	$21.95	$21.35	$20.52
Natural Gas	$7.60	$8.90	$9.33	$9.10	$8.87	$8.62
Light Fuel Oil	$12.83	$11.67	$12.77	$12.65	$12.51	$12.38
Commercial ($1995/GJ)						
Electricity	$17.21	$18.83	$19.85	$19.35	$18.76	$17.92
Natural Gas	$6.27	$7.80	$8.23	$8.02	$7.79	$7.52
Light Fuel Oil	$12.99	$11.05	$11.50	$11.61	$11.81	$11.67
Heavy Fuel Oil	$7.18	$5.24	$5.22	$4.99	$4.64	$4.02
Industrial ($1995/GJ)						
Electricity	$12.39	$13.32	$14.02	$13.66	$13.22	$12.63
Natural Gas	$4.19	$5.59	$6.02	$5.76	$5.51	$5.23
Heavy Fuel Oil	$5.42	$5.11	$5.06	$4.83	$4.59	$4.31
Coal	$2.36	$2.30	$2.25	$2.25	$2.25	$2.36

There was also considerable effort invested to review and update the DSM technologies in the CIMS sub-models. The update addressed the following parameters: i) coverage of DSM technology candidates, ii) energy performance and iii) installed costs.

2.2.3 Economic Potential Scenario

The economic potential is defined as a future in which energy efficiency investments are adopted by all producers and consumers (at the rate of technology stock turn-over and/or accelerated take-up through retrofit opportunities), if the life cycle cost (LCC) of the investment is lower than the long-run cost of energy supply. In the economic potential, three major parameters affect the life cycle cost competition and, therefore, drive the economic potential: i) the energy long run marginal cost (LRMC) used for screening the economics of the candidate technologies ii) the discount rate and iii) the variance parameter.

The LRMC valuation combines the costs of generation, production, transmission and distribution and is a two step exercise: i) separate valuation methods are employed to establish the LRMCs for electricity versus natural gas and Refined Petroleum Products and ii) a carbon liability value is added to all of the energy forms.

[11] The regional price forecasts from this scenario were adopted in CIMS.

In CIMS, the electricity LRMC value is derived to estimate the supply price of a new combined cycle gas turbine (CCGT) in each jurisdiction to which is added the costs of transmission and distribution, while taking into account line losses. Among other things, the supply price estimates are regionalized by setting the CCGT variable fuel cost in each 5-year period at the regional market price for industrial natural gas. Again, as this is a high level, policy oriented study, it does not fully capture all of the regional and provincial realities and drivers affecting long run power generation baseload and peaking supply. We recognize that the CCGT option will not necessarily apply to all regions. A carbon price of \$15 / t CO_2e is also incorporated into the energy prices (based on the carbon content of the affected fuels) as a financial cost liability that is considered in a full calculation of the long run marginal cost.[12]

As the economic potential is a societal perspective, the life cycle cost analysis uses a **social discount rate** of 10% real for all regions and technologies. The technology competitions which occur in the reference case and achievable potential projections use a schedule of private discount rates that are typically much higher than the social discount rate. Changing the discount rate from a private to a social perspective has two effects in the competition of technologies in CIMS. First, more energy efficiency measures are likely to pass the life cycle cost test generating a positive net present value. Second, among the larger number of measures that become candidates for competition, an increasing number of higher performing measures are selected as the least cost option.

CIMS contains a variance parameter (‘v’) that represents sensitivity of the technology adoption to relative life cycle costs. A high v value means that the technology with the lowest life cycle cost captures almost all of the market for new equipment stock, a “winner takes all result”. A low v value means that new equipment market shares are distributed more evenly among competing technologies, even if their lifecycle costs are different. The value of the v factor is set low for the economic potential scenario thereby enabling only the least cost measure to be selected. Most DSM studies model the economic potential with the highest performing measures included that pass the economic cost test. The due diligence conducted during the CIMS modeling reveals that in most instances the highest performing measures are selected.

2.2.4 Achievable potential

Two achievable potential scenarios are modelled in this study, referred to as **achievable scenario 1- DSM Status Quo** and **achievable scenario 2-DSM Aggressive**. These scenarios represent considerably different visions of how various policy instruments may

[12] There is evidence that utilities commissions are beginning to force the internalization of greenhouse gas (GHG) liabilities such that these are now part of the real energy cost structure faced by utilities in their decision-making. We have included a price of \$15 / t CO_2e in the modelling that is incorporated into the energy prices based on the carbon content of the affected fuels. This price was chosen as this has already been approved in at least one jurisdiction for utility investment analysis (by the BC Utilities Commission for BC Hydro). It also reflects the commitment from the Canadian government to the Large Final Emitters (LFE) group that their GHG reduction cost compliance will not exceed this value. Note that this liability does not represent an estimate of the full externality cost of GHG or other emissions. It is simply a financial cost liability that is considered in a full calculation of LRMC, recognizing that all cost estimates have present and future uncertainties associated with them.

be brought to bear on the residential, industrial and commercial/institutional markets during the study period.

Scenario 1: DSM Status Quo

DSM Status Quo assumes a continuation of approximately the current levels and types of market interventions by government and utilities. A scan undertaken during the study revealed that current annual energy efficiency expenditures by government and utilities amount to between $400 million and $500 million per annum.[13] Moreover, the majority of the energy efficiency program costs borne by utilities fall into the category of subsidies of one form or another. Not surprisingly then, most utility reported annual energy savings are attributed to the effect of these subsidies, in the vicinity of 75% of total reported savings.[14] Government program costs are more broadly distributed, among subsidies, energy performance standards development and administration, information and R&D. Consequently, reported energy savings from government initiatives are attributed more broadly to the foregoing mix of instruments, particularly due to energy performance standards.

In consultation with the CGA client group, the DSM Status Quo scenario was designed as a combination of subsidies and information/voluntary programs, with the major driver in the scenario assumed to be the subsidy instruments. Financial subsidy is a policy instrument designed to reduce the energy management investment cost to a level commensurate to the business and consumer hurdle rates. Subsidies for energy management continue to be a prevalent means of delivering DSM in Canada and elsewhere. As discussed in the Economic Potential report, there is a considerable gap between the social and private discount rates for energy management. Hence, the argument is that if a particular energy management measure passes a societal cost test, then it is legitimate to use subsidies to induce market take-up of the measure.[15]

The inclusion of energy performance standards was considered for this policy mix, since they are certainly part of the current DSM landscape in Canada. Mandatory energy performance standards are presently focused on improving equipment performance levels, less so on building performance. It was posited that there remains a considerable upside for enhanced performance standards and, consequently, it was decided to include this policy instrument in the second, more aggressive scenario.

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[13] This estimate is based on a scan of the following documents:
i) NRCan "Improving Energy Performance in Canada-Report to Parliament Under the Energy Efficiency Act Fiscal 2004-05, Appendix 1". The estimate for federal expenditures is about $165 million per year.
ii) Canadian Electricity Association and Natural Resources Canada, Description and Results of Energy Management Programs-A survey Of Programs Operated By Electric Utility Companies in Canada, March 2003 and Update in October 2003.
iii) Indeco in association with B. Vernon and Associates, *DSM Best Practices-Canadian Natural Gas utilities Best Practices in Demand-Side Management*, undertaken for the Canadian Gas Association, 2005.

[14] This is based on in-house data/files plus a small selection of telephone conversations with gas and electric utility officials.

[15] Another way of looking at this is that, if the cost of delivering the energy management measure is less than the social cost of the displaced energy form, then it is an economically legitimate investment from the standpoint of society.

The subsidy schedule targeted the energy efficient technologies identified in the economic potential at rates consistent with current observed utility incentive levels (10%-35% of the measure cost).[16] The effect of the information/voluntary programs was modelled exogenously as a multiplier applied to the results based on utility and NRCan estimates of program effectiveness.

Scenario 2: DSM Aggressive

Scenario 2, DSM Aggressive, models the achievable potential to 2025 as a vision of how to more effectively address market barriers and failures and consequently expand and accelerate the energy management effect in the economy over this period. The scenario includes new and expanded policy instruments involving all levels of government, utilities and the private sector that can capture a greater array of options. It also assumes that policies could do more to address fundamental changes that need to be made regarding urban land use intensity and form which, in turn, will affect needed changes to foster sustainable infrastructure. The DSM Aggressive scenario comprises the following policy elements:

- An aggressive application of energy efficiency standards, for both end-use equipment and buildings.

- Subsidies to energy efficiency technologies. These are applied as a complementary instrument to subsidies. The same subsidy levels used for DSM Status Quo were applied but at a different rate of application. The technologies eligible for subsidy application fall into two categories: i) those that will be affected by the standards and ii) those that will not be affected by the standards.
- The energy efficiency standards are introduced at varying schedules during the study period. Consequently, the subsidies are applied to the technologies to be affected by standards in year one of the study period and continue to be applied only until the technology is affected by the performance standard. The subsidies are applied to the technologies, not affected by standards, in year one of the study period and continue during the study period.

- An aggressive subsidy policy directed to induce a greater market penetration of some renewable energy technologies for on-site applications, which would have an incremental fuel substitution effect towards renewable energy, relative to the reference case forecast. The focus is on-site renewables applications to replace secondary energy consumption of gas and refined petroleum products and to reduce electric power purchases. While this is characterized as an aggressive renewables policy, conceptually it corresponds well to efforts internationally. There are many examples worldwide of government, at all levels, instituting aggressive renewable energy policies and programs. For example, the California Public Utilities Commission (PUC) recently voted to adopt the California Solar Initiative (CSI), which will provide up to $2.9 billion in incentives toward solar development over 11

[16] These represent energy efficiency investments whose life cycle cost of the investment is lower than the long-run cost of energy supply. This is roughly equivalent to targetting those investments that 'pass' a Total Resource Cost test.

years. One of the goals this initiative is to install 3,000 MW of solar power capacity by 2017, making it the largest solar program in the U.S.[17]

- Application of marginal cost pricing in electricity. This seeks to simulate the effects of advancing from a monopoly average cost pricing regime for electricity to a regime that embodies marginal cost pricing. In practice, a marginal cost policy instrument could be manifested in a number of ways: regulators requiring this for electricity pricing, or some form of time-of-use pricing measured and reported on a real time basis. This policy only applies to electricity because the other energy prices already represent marginal cost pricing as their prices are determined in competitive markets. This policy is modelled in CIMS by revising the electricity price forecast used in the simulation. The same long run marginal electricity price forecasts are used as calculated for the economic potential.

- A \$15/tonne CO_2e price adder for all fuels based on the carbon content of the affected fuels. This is representative of mechanisms that are starting to be used by energy utilities to price or cost GHG emission reductions for use in planning, acquisition, project development or operational decisions. These mechanisms include: i) government instituted “safety valves” or price assurance relating to CO_2 regulation, ii) resource planning GHG “adders” and iii) energy acquisition GHG bid price adjustments

- Changes to shares of projected housing types (low rise versus mid- to high-rise) to mimic the potential effects of aggressive urban land use policy instruments. The percentage of single detached dwellings was reduced in absolute terms by 25% in 2025. This considers the largely untapped area of land use as a means to reduce the environmental footprint of communities, particularly in the urban centres where 80% or more of the Canadian population resides. In terms of affecting reductions of energy consumption, sustainable land use policy instruments can generate the following possible outcomes: i) reduced average energy use per dwelling or building, ii) reduced transportation energy use. This scenario deals with the challenge of reducing average energy use per dwelling.

There is a wide range of possible policy instruments to affect land use change in municipalities, which taken together, can affect: i) the type and amount of land use, ii) the intensity of use within the land boundary, iii) the spatial distribution and location of use (e.g., degree of sprawl).

To summarize, the aggressive DSM scenario includes:

- Energy efficiency subsidies. These are the same as scenario 1, except they are retargeted where regulation is applied to the same energy end-use.
- Marginal cost pricing for electricity.

[17] California PUC website, CSI includes \$2.5 billion in rebates for existing homes, businesses and public buildings, to be managed by the PUC and funded through revenues collected from gas and electric utility distribution rates. The California Energy Commission (CEC) will manage another \$350 million in rebates targeted for new residential construction, utilizing funds already allocated to the CEC to foster renewable projects between 2007 and 2011.

- A carbon liability. A shadow price of \$15/tonne CO_2e is applied to all energy price forecasts.
- An aggressive schedule of legislatively backed advanced minimum energy performance targets for both equipment and buildings.
- Renewable subsidies. These are targetted at the residential and commercial sectors and in particular solar hot water heaters, solar photovoltaic and geo-exchange, which are subsidized at 30%, 40% and 15% of installed capital cost respectively.
- Changes in the shares of projected housing types (low rise versus mid- to high-rise). The percentage of single detached dwellings was reduced in absolute terms by 25% in 2025.

Exhibit 2.2 summarizes how the mix of policy instruments was applied in both of the achievable potential scenarios; the dark shaded area indicates application of the instrument.

Exhibit 2:2: Summary of Policies Instruments Applied in Each Scenario

Policy Instruments	Scenario 1	Scenario 2
Subsidies-energy efficiency schedule	■	■
Subsidies-renewables schedule		■
Information	■	■
Regulation & Standards		■
Marginal cost pricing		■
Carbon liability		■
Change in dwelling type shares		■

3. RESULTS

3.1 REFERENCE CASE FORECAST

Exhibits 3.1 to 3.3 show the national reference case scenarios for the commercial, residential and industrial sectors respectively. Since the CIMS base year in all regions is calibrated to within +/-5% of the latest 2000 energy supply and demand data from Statistics Canada, the Reference Case forecast runs from 2000 to 2025.

The high level national results by sector are as follows:

- Across all sectors, energy demand is forecast to increase by 23% amounting to an average annual increase of 0.85%. The forecast growth occurs despite a projected decline in energy intensities (energy demand per unit of output) in all sectors. The activity effects of economic growth offset the energy performance improvements. There is no significant change in fuel shares among the major energy forms used in these sectors.

- **Commercial/Institutional.** Exhibit 3.1 shows a total energy demand increase of 353 PJ over the study period, amounting to an annual increase in consumption of 1.14%. The model results also show that the fuel shares remains relatively constant in the commercial sector, with natural gas increasing from 51% to 55% by 2025, and electricity's share falling slightly from 42% in 2000 to 37% in 2025. Energy intensity shows a small improvement over time with an average annual change (or decrease) of 0.56%.

- **Residential.** Exhibit 3.2 shows a total energy demand increase 279 PJ over the study period, amounting to an average rate of less than one percent annually. Once again the split between fuels remains relatively constant. The share of natural gas fluctuates around 48%, and the share of electricity rises slightly from 36% to 39%. Annual growth rates for both fuels are in the order of 1% annually whereas growth in refined petroleum products (RPP) is lower (0.36%) and other fuels (wood) decline about 0.8% annually. Energy intensity show an improvement slightly greater than the commercial sector and in the order of 0.59% annually;

- **Industrial**. Exhibit 3.3 shows that in the industrial sector total energy demand rises from 2,714 PJ in 2000 to 3,296 PJ in 2025, or at a rate of 0.78% annually. In this sector natural gas and electricity both exhibit declines in their fuel share , although the absolute demand for both these fuels continues to rise throughout the forecast period. Refined petroleum products and the other fuels listed see a slight increase as a percent of the total energy demand. The industrial sector forecast represents manufacturing and metals and mineral mining, and does not include energy supply sub-sectors (upstream oil and gas, coal mining and electricity supply sub-sectors). Construction and forestry are also not included.

Exhibit 3.1: Reference Case Energy Demand (PJ), Commercial Sector

	2000	2005	2010	2015	2020	2025	Average Annual Change
Total Energy	1,075	1,130	1,192	1,275	1,352	1,431	1.15%
Electricity	448	462	477	500	519	540	0.75%
Natural Gas *	548	584	626	680	732	785	1.45%
Refined Petroleum Products	79	85	88	95	101	106	1.15%

*Natural gas includes Propane.

Exhibit 3.2: Reference Case Energy Demand (PJ), Residential Sector

	2000	2005	2010	2015	2020	2025	Average Annual Change
Total Energy	1,384	1,419	1,444	1,501	1,576	1,663	0.74%
Electricity	497	516	529	557	600	643	1.04%
Natural Gas	659	676	692	722	753	795	0.75%
Refined Petroleum Products	132	135	134	138	142	145	0.36%
Wood	96	92	89	85	81	79	-0.77%

Exhibit 3.3: Reference Case Energy Demand (PJ), Industrial Sector

	2000	2005	2010	2015	2020	2025	Average Annual Change
Total Energy	2,714	2,785	2,931	3,053	3,154	3,296	0.78%
Electricity	670	676	716	728	738	757	0.49%
Natural Gas*	922	920	925	945	960	999	0.32%
Refined Petroleum Products	161	166	177	191	206	220	1.24%
Coal, Petroleum Coke, Waste Fuels, Off gases	463	514	567	607	653	700	1.67%
Wood Waste/ Spent Pulping Liquor	498	509	546	582	596	619	0.88%

*Natural gas includes propane and other liquefied petroleum products

3.2 ECONOMIC POTENTIAL RESULTS

The consulting team has diverging opinions concerning what is signified by the economic potential. Marbek generally accepts and uses the term ‘economic potential’ to represent an economic upset, a performance ceiling to which energy efficiency market interventions can be targeted. Conversely, MKJA prefers a term like *techno-economic potential,* in recognition that the “economic potential” is usually not all economic for the individual investor or society, and does not in itself represent an economic performance ceiling. MKJA’s position is that the analysis of economic potential rarely accounts for the different costs of competing technologies in terms of their risks or the quality of service.

Notwithstanding these differing views, the results indicate a significant potential for energy demand reduction. Exhibits 3.4 and 3.5 present the economic potential results for all sectors combined. In 2025, the total reduction in energy demand for all three sectors amounts to 918 PJ, a 14% reduction relative to the reference case. This savings impact is equivalent to about 60% of the total aggregate increase in energy consumption in the three sectors between 1990 and 2003. It also amounts to about $10.5 billion in operating savings for industry, businesses and consumers in 2025. relative to the reference case forecast of energy demand.

The economic potential scenario comprises a significant fuel substitution effect due to cogeneration applications in all three sectors, the largest application having been modelled in the commercial sector. As elaborated in the ensuing sections, when the sectoral cogeneration effect is netted out, the economic potential results are generally conservative when compared to recent DSM studies conducted in Canada.

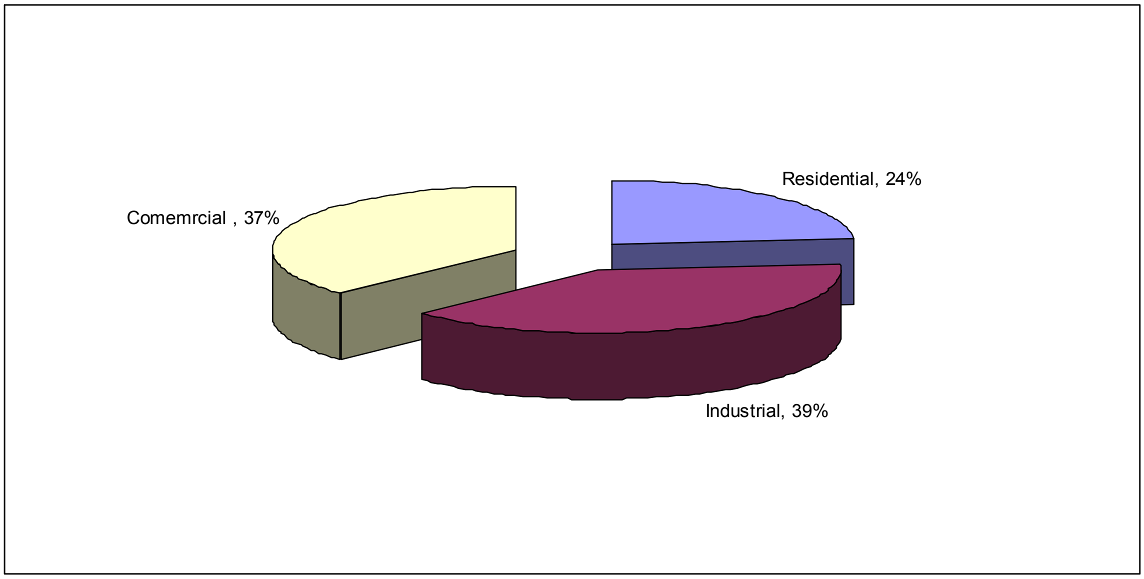
Under the economic potential scenario nearly 40 TWh of electricity will be produced from cogeneration. Nearly 60% of the cogeneration load is attributed to the commercial sector, another 28% in industry.

About 50% of the total energy demand reduction in 2025 is attributed to electricity reduction. Of this amount, about 30% is due to added cogeneration supply. Natural gas savings represent about 28% of the total reduction in 2025 and represent a larger savings when the cogeneration effect is netted out.

Exhibit 3.4: All Sectors National Economic Potential Energy Demand Reduction by Milestone Year and Fuel (PJ)

	2010	2015	2020	2025
Total Energy Demand Savings (PJ)	417.0	613.7	767.6	917.8
% Savings Relative to Reference Case	7%	11%	13%	14%
Electricity (PJ)	184.1	285.1	379.3	466.4
% Savings Relative to Reference Case	11%	16%	20%	24%
Natural Gas (PJ)	157.7	209.0	228.6	250.0
% Savings Relative to Reference Case	7%	9%	9%	10%
Refined Petroleum Products (PJ)	21.6	29.0	39.0	47.6
% Savings Relative to Reference Case	5%	7%	9%	10%
Wood Waste/ Spent Pulping Liquor (PJ)	39.5	57.7	69.0	76.7
% Savings Relative to Reference Case	6%	9%	10%	11%
Coal, Petroleum Coke, Waste Fuels, Off gases (PJ)	13.9	33.0	51.8	77.1
% Savings Relative to Reference Case	2%	5%	8%	11%

Exhibit 3.5: National Economic Potential by Sector Share of Energy Reduction in 2025



3.3 ACHIEVABLE POTENTIAL RESULTS

The achievable potential is a measure of how a target market might respond to one or more market interventions designed to expand and accelerate market take-up of energy management measures. The rationale for market interventions is to address one or more barriers and failures which impede market take-up of these measures to the level of what is economically viable, today and in the future, when market circumstances are expected to change. As noted, two achievable potential scenarios were analyzed: DSM Status Quo and DSM Aggressive.

3.3.2 Overall Impacts

Exhibits 3.6 to 3.9 present the overall impact of the two scenarios. In 2025 the total reduction in energy demand ranges from 182 PJ to 647 PJ, a 2.9% to 10.1% range in energy demand reduction relative to the reference case forecast. The average annual growth rate in energy demand slows to 0.68% in scenario 1 and 0.36% in scenario 2, relative to 0.85% in the reference case. Using the projected energy market prices used in the Reference Case forecast, the achievable potential savings amounts to a range of $3.2 billion to $15.7 billion in energy operating cost savings in 2025 relative to the reference case forecast. The projected energy demand reduction under scenario 2 is equivalent to about 64% of the total aggregate increase in energy consumption in the three sectors between 1990 and 2003.

Exhibit 3.6: Total End-use Energy Demand by Scenario, All Sectors

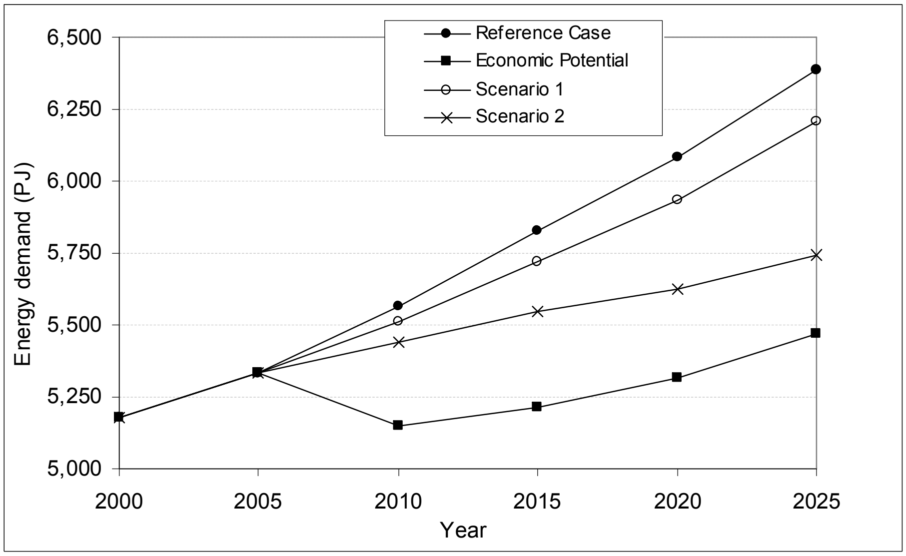


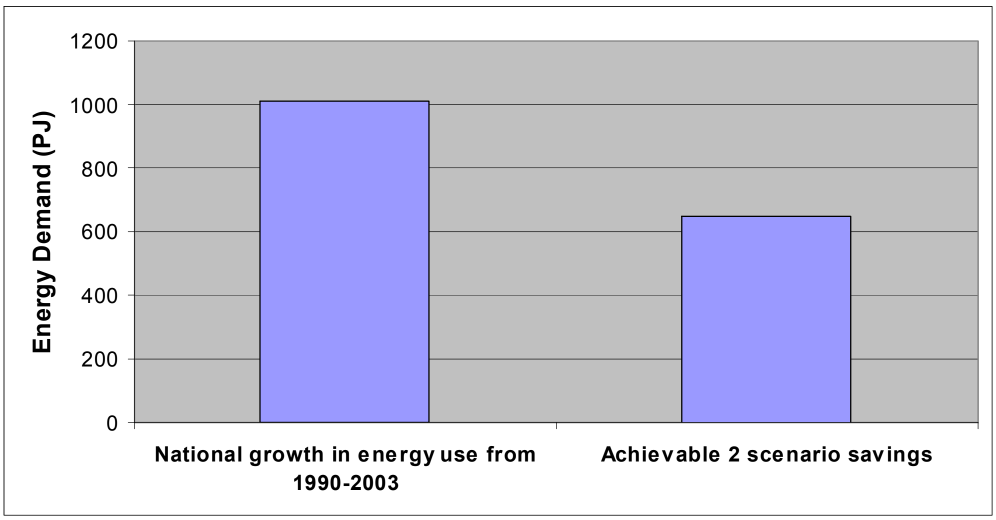
Exhibit 3.7: Energy Demand, by Milestone Year: Achievable Potential Scenarios vs. Reference Case and Economic Potential

Annual Consumption (PJ/yr)				
All Sectors				
Base Year	Reference Case	Economic Potential	Achievable Scenario	
			1	2
2000	5176	5176	5176	5176
2005	5335	5335	5335	5335
2010	5567	5150	5512	5441
2015	5829	5215	5719	5548
2020	6082	5315	5935	5627
2025	6389	5471	6207	5742

Exhibit 3.8: Energy Savings by Milestone Year: Achievable Potential Scenarios vs. Reference Case and Economic Potential

Year	Annual Savings (PJ/yr)			Savings as Percentage of Reference Case Demand		
	Economic Potential	Achievable Potential		Economic Potential	Achievable Potential	
		Scenario 1	Scenario 2		Scenario 1	Scenario 2
2010	417	55	125	7.49%	0.99%	2.25%
2015	614	110	281	10.53%	1.88%	4.82%
2020	768	147	455	12.62%	2.42%	7.49%
2025	918	182	647	14.37%	2.85%	10.13%

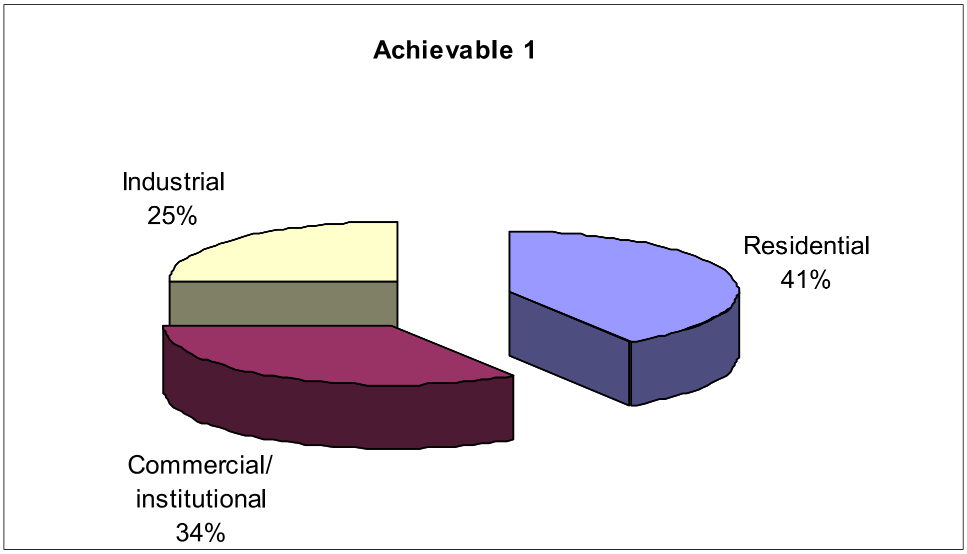
Exhibit 3.9: Comparison of Achievable Potential Scenario 2 Savings and 1990-2003 Energy Demand Growth

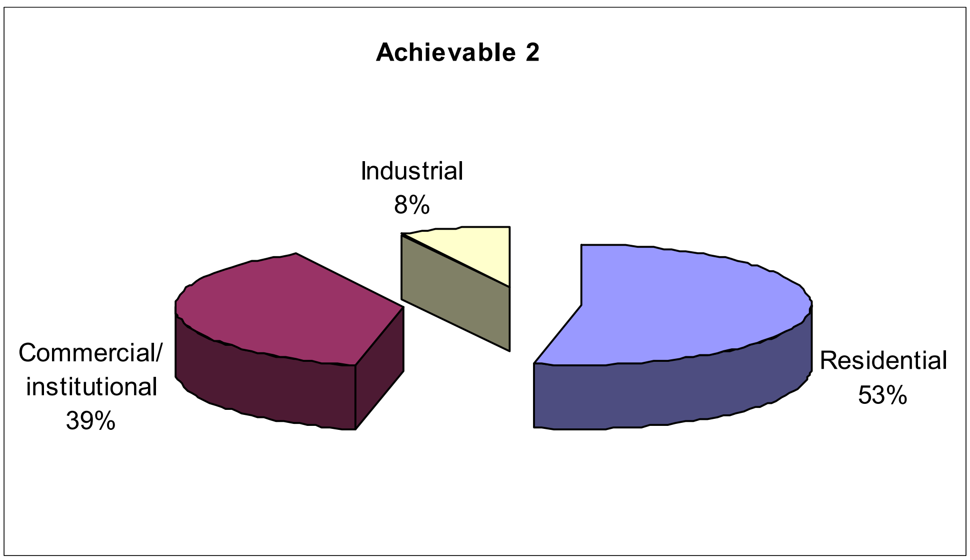


3.3.3 Sector Contributions to Savings Potential

Exhibit 3.10 illustrates how the distribution of the DSM potential in 2025, among the three sectors, changes according to each of the achievable potential scenarios. It's evident that industry's share of the total energy demand reduction declines substantially as we move from the DSM Status Quo to the DSM Aggressive scenarios. Conversely, the share of this saving attributed to the residential and commercial sectors grows considerably; together these sectors represent 75% and 92% respectively, of the scenario 1 and scenario 2 energy demand reduction. This pattern is driven by the fuel substitution effects that occur as we move into an advanced, more complex policy mix. It also reflects differences in how the policies are targetted towards different sectors (for instance, the standards in scenario 2 are primarily directed at the residential and commercial sectors).

Exhibit 3.10: National Achievable Potential by Sector Share of Energy Reduction in 2025: Scenarios 1 and 2





3.3.4 Savings by Fuel: Achievable Potential

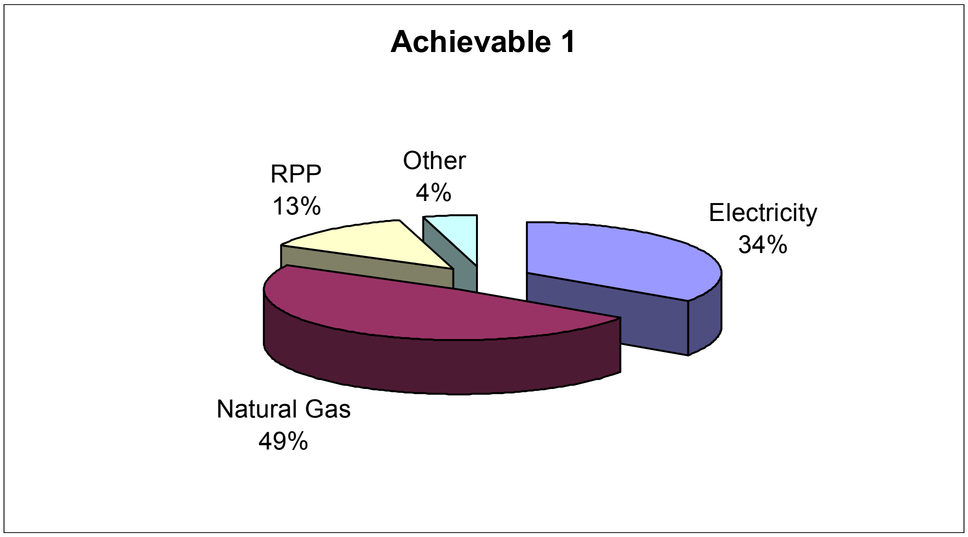
Exhibit 3.11 presents the distribution of the total achievable potential energy demand reduction in 2025 according to the types of fuel. The results show how different policy mixes can affect the energy demand reduction by fuel as the results are markedly different between the two achievable potential scenarios. For scenario 1 the largest energy demand reduction impact in 2025 is achieved in secondary natural gas end-uses, representing 49% of the total savings, followed by electricity energy demand reduction , at 34% of the total. The results are largely reversed under scenario 2 where the largest energy demand reduction impact in 2025 is achieved in electricity reduction, representing 55% of the total energy demand reduction. The main driver contributing to this result is the considerable increase in cogeneration in the DSM Aggressive scenario. About 30% of the electricity reduction impact is due to added cogeneration supply.

Exhibit 3.12 summarizes the amount of additional electricity that is induced by the policies simulated in the two scenarios. As shown, the incremental cogeneration output ranges from 9.2 PJ to 61.7 PJ (2.6 TWh to 17.1 TWh). The upper value is equivalent to nearly 40% of the installed cogeneration capacity in Canada in 2003.[18] It is also about 40% of the economic cogeneration potential.

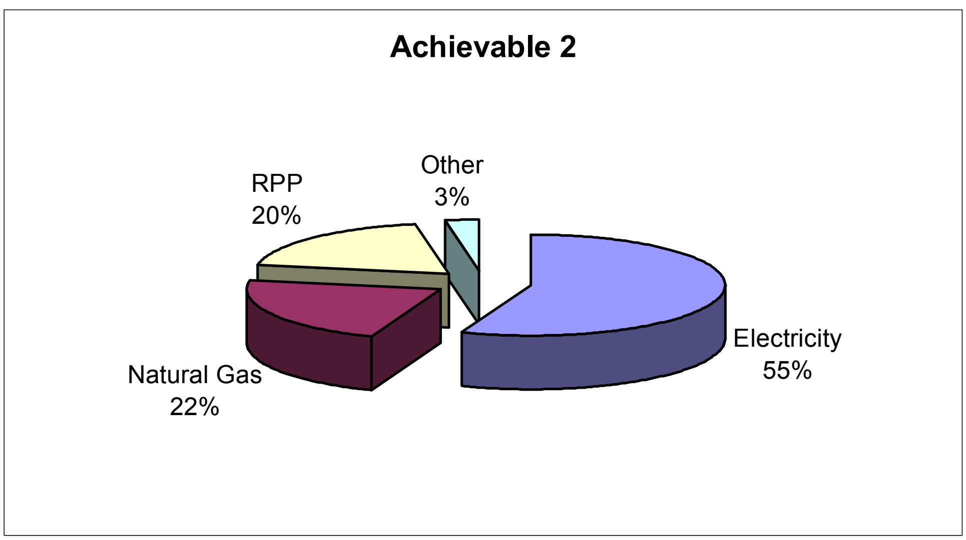
While more than 95% of the current installed cogeneration capacity is in the industrial sector, the commercial sector offers the highest potential for incremental cogeneration, in the range of 31% to 40% of the total for the two scenarios.

[18] Mark Jaccard and Associates, *Strategic Options for Combined Heat and Power in Canada, For Natural Resources Canada*, August 2004, p.40. The installed capacity in 2003 was 6.8 TWe. Assuming an average capacity factor of 70% and an average heat-to-power ratio of 2.5, the amount of electricity currently produced is approximately 40 TWh and the amount of thermal energy produced is approximately 100 TWh per year. This amounts to approximately 6% of total electricity generation in Canada in 2003.

Exhibit 3.11: All Sector Savings According to Fuel



Note:
-'Other' includes: Coal, Petroleum Coke, Waste Fuels, Off gases, Wood Waste and Spent Pulping Liquor
-'RPP' is Refined Petroleum Products



Note:
-'Other' includes: Coal, Petroleum Coke, Waste Fuels, Off gases, Wood Waste and Spent Pulping Liquor
-'RPP' is Refined Petroleum Products

Exhibit 3.12: Added Cogeneration Generation by Sector

	Achievable Potential		Economic Potential
	scenario 1	scenario 2	
Additional Electricity Generated (TWh/year)			
Total	2.56	17.14	54.58
Residential	1.35	6.89	26.14
Commercial	0.42	3.43	6.17
Industrial	0.79	6.83	22.27
Additional Electricity Generated (PJ/year)			
Total	9.23	61.71	196.50
Residential	4.86	24.80	94.12
Commercial	1.52	12.33	22.20
Industrial	2.85	24.59	80.18

4. DISCUSSION

As noted, the results identify an achievable potential of between 2.9% to 10.1% range in DSM potential relative to the reference case forecast. The following discussion examines some of the dynamics affecting the outcomes and attempts to place the results in the context of findings from other studies.

Impact on Industry

In 2003 the industrial sector represented the largest percentage of Canada's secondary energy consumption, 38% of the total (including transportation). Nevertheless, the achievable potential analysis reduction in energy demand for industry is considerably less than that of the residential and commercial sectors. On the surface, it would appear that the energy efficiency performance gains in the residential and commercial sector are not attainable in industry. That would be a misleading conclusion because, as shown in the last part of this section, other studies that focus solely on energy efficiency have shown significant economic and achievable potential in industry. Rather, it is important to understand that the modeling construct and dynamics of this study provide some insight into how a particular mix of policy instruments might affect industry, but in a more dynamic, less linear fashion than shown in some of the other energy efficiency studies.

We have seen from the analysis that, in a dynamic- integrated modeling construct, industry could chose fuel substitution and cogeneration investments as alternative investments to energy efficiency or which could offset some of the energy efficiency gains. The key factors influencing the outcomes of the industry achievable potential results are:

- Scenario 1 was largely driven by subsidies. It appears that, relative to the dynamics of the residential and commercial sectors, the reduced paybacks induced by the subsidies do not have the same effect for industry in addressing the gap between the social and private discount rates. This may be due to the typically higher hurdle rates that industry demands for energy efficiency investments.

- In scenario 2, the application of standards in industry was limited and did not play the same role as building and end-use equipment standards do in the commercial/institutional and residential sectors. In addition, the renewable energy subsidies and the changes in building types (to mimic urban land use policies) had a far less application to industry than the other sectors.

- In scenario 2, the marginal cost pricing instrument has a considerable effect on industry energy use dynamics as electricity prices increase relative to other fuels. This drives additional fuel switching for end-uses where these fuels can be substitutes, particularly combustion. The end-use efficiency of electric heating is always higher than for direct combustion of fuels, resulting in additional secondary energy demand for the affected end-uses. This drop in performance is particularly evident where there is a considerable switch to the utilization of wood waste in industry; wood waste use increases fairly significantly in scenario 2.

Finally, it is also important to note that the study did not examine the energy management potential in the upstream oil and gas sector, which is an energy intensive and growing sector of the economy.

Why the DSM Aggressive Scenario Has a Large Fuel Substitution/Cogeneration Effect

CIMS simulates the competition of DSM technologies of different levels of efficiency and fuel type to meet a given energy service demand. The choice pathway has four options: i) choose a more efficient upgrade within the same fuel type, ii) choose a more efficient upgrade using a different fuel, iii) choose a base technology with a different fuel, iv) make no upgrade or change in fuel choice. The DSM technology competition is largely driven in the policies, but not exclusively so, by two main factors: changes in capital costs or changes to energy prices. Consequently, as the mix of policies assessed in CIMS varies, so does the impact weighted between energy efficiency and fuel substitution.

Therefore, we see that the policy mix in the DSM Aggressive scenario results in significant fuel switching and cogeneration. In particular, marginal cost electricity pricing and the carbon liability in scenario 2 affect different fuels unevenly. In response to the carbon liability, there is fuel switching to less carbon intense fuels (away from coal and oil), while marginal cost pricing encourages fuel switching away from electricity. Together, these two policy instruments contribute to a greater take-up of wood waste (‘hog fuels’) in the pulp and paper and wood and allied products sectors.

Similarly, the policies simulated in the DSM Aggressive scenario bolster the economic conditions for cogeneration, which has significant impact on the results. Marginal cost pricing for electricity, in particular, increases the differential between gas prices and electricity prices – which is critical to cogeneration development.

It’s important not to let the current pricing conditions cast a shadow over the projected outcome in 2025. At the present time, high natural gas prices are making natural gas driven cogeneration less economic because they are reducing the “spark spread”, i.e. the cost differential between natural gas and electricity, so that self-generation becomes less cost effective. However, the simulation of the achievable potential includes policies that favourably influence the economics of cogeneration – marginal cost pricing for electricity in particular increases the differential between gas prices and electricity prices – which is critical to cogeneration development

Why the Sectoral Contribution Changes

We have seen an enormous shift in the allocation of the total savings between the DSM Status Quo and DSM Aggressive scenarios. While the magnitude of the overall savings increased, the share of energy savings that is attributed to industry is significantly smaller. This has occurred because the mix of policies simulated in the DSM Aggressive scenario: i) induce a greater degree of fuel substitution and cogeneration as noted above, and ii) in terms of end-use efficiency, are more conducive to performance improvements in the buildings sectors.

In scenario 2, the application of standards in industry has limited application and cannot play the same role as building and appliance standards do in the commercial/institutional and residential sectors. The effect of the renewable subsidies are similar less pronounced in industry.

What CIMS Did Not Model

The achievable and economic potential scenarios were not run utilizing the CIMS' energy price and macro-economic feedback systems. This level of analysis was beyond the scope of the study. If CIMS had been allowed to iterate between the energy demand and supply sectors, we would have seen the impacts of reduced consumption of electricity on its cost of production, and hence its price. In turn, if the price change had been significant, the energy-demanding residential, commercial and industrial models would have been re-run until a new energy supply and demand equilibrium was achieved. We speculate that if these macro-economic feedbacks had been run, increased production costs in industry might have caused increased final prices and lower production demands, particularly for the scenario 2 policy mix. Ultimately, these dynamics would lead to additional secondary effects in the residential and commercial sectors.

Transportation Benefits: Location Efficiency

In scenario 2, we touched briefly on the possible energy reduction effect of advanced urban land use policies. This was modeled by changing dwelling shares running into the future, to reflect increased urban densities. There is a possible transportation dividend to be reaped from such policies. Numerous studies have been completed in the past 15 years on the energy and lifestyle cost savings of dense urban areas relative to sprawling urban areas – thus termed "location efficiency".

Research has consistently shown savings of 20%-40% in urban transportation energy as urban density doubles. For instance, if policy makers targeted a density of 10 people/hectare in 2030 Canadian urban areas, which would be a 43% increase in urban density compared with current patterns, this could result in a 10%-20% annual reduction in urban transportation energy consumption. To put this into perspective, a 10%-20% annual savings applied in 2003 in Canada's urban areas would save roughly 100PJ-200 PJ annually in *passenger* transportation alone.

System savings

The projected savings in electricity demand have been calculated at the customer level. However, these savings have a significant impact on capacity requirements to meet the demand. A unit of electric demand reduction is worth more (12% to 30% more depending on the generation mix) than a unit of additional supply in terms of generation capacity.[19]

[19] To meet electricity demand, you need to have a generation capacity that exceeds your demand by a minimum of around 12% for hydro generators to around 30% for coal-fired generators to handle routine maintenance and down time of equipment.

Comparison to other studies

There have been many North American studies in the past five years investigating the achievable potential for energy efficiency in various sectors. Comparisons of study outputs from one study to another are always difficult because of often different analytical constructs, modelling approaches, data sets and assumptions. Nevertheless, the comparisons provide another source of estimates to consider, and an indication of how the current study relates to other efficiency potential studies that have been undertaken.

The two achievable potential scenarios generate energy demand reduction reductions ranging from 2.9% to 10.3% in 2025, relative to the reference case forecast. These results are of the same order of magnitude generated by a 2005 U.S. study investigating energy efficiency potential in all sectors which produced a energy demand reduction range of 4% to 9%, also for two scenarios running to 2025.[20] The U.S. study used the National Energy Modelling System (NEMS) and considered a wide range of policy instruments, and like the current study, assessed the potential by directly representing policies in an energy-economy model.

Exhibit 3.13 compares the range of achievable potential energy demand reduction from some recent demand-side management (DSM) studies conducted in Canada, distinguished according to sector and fuel.

The comparison shows that, with the exception of the industrial results, the upper bound (the scenario 2 results) exceeds the upper bound of these recent DSM studies. Indeed, it is clear that the CIMS industrial results act to offset the performance from the other sectors when the overall reduction in demand is considered.

In interpreting this difference, it is important to bear in mind that scenario 2 as defined in this project includes price and regulatory instruments that extend beyond the scope of current utility programs. The analysis also incorporates land-use measures, cogeneration and renewables, and includes the interactive effects of the policies, including their impact on fuel switching.

Industry shows a lower potential for several reasons. First, the regulatory, land use and renewable subsidy policies are largely targetted to the residential and commercial sectors. Second, fuel switching to gas and the additional natural gas required to cogenerate (the cogeneration effect) simply outweighs the gains in energy efficiency gains in industry. Although there is fuel substitution and cogeneration in the other sectors, the other elements in the scenario induce significantly more efficiency over the long run.

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[20] Energy Information Administration, Office of Integrated Analysis and Forecasting, *Assessment of Selected Energy Efficiency Policies*, May 2005 U.S. Department of Energy Washington, DC 20585.

Exhibit 3.13: Achievable Potential Performance Range From Recent DSM Studies

Sector and Fuel	Savings Range			
	Lower %		Upper %	
	Other studies	CIMS analysis	Other studies	CIMS analysis
Residential				
Electricity	3	4.4	7.5-14	27
Natural Gas	2	5.6	3-7	11.8
Commercial				
Electricity	3	4.4	3-5	22.8
Natural Gas	3	3.5	6-10	11.5
Industrial				
Electricity	2	2.9	15-25	14.3
Natural Gas	3	3.3	7-10	-2.7

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 10:

Reference(s): **none provided**

Please provide a list of OPA province-wide program offerings (or expected offerings) that THESL is choosing not to participate in and provide a rationale for that determination in each case.

RESPONSE:

THESL is participating in all OPA province-wide programs.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 11:

Reference(s): **none provided**

Please provide a list of cost-effective measures and programs that are non-duplicative with OPA programs but THESL has chosen not to pursue and provide a rationale for that choice.

RESPONSE:

There are no cost effective and non-duplicative programs identified that THESL is not pursuing. Please refer to response to Board Staff Interrogatory 8.

It is expected that THESL will apply for additional programs beyond those noted, if needed to meet prescribed conservation targets.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 12:

Reference(s): none provided

Does THESL anticipate applying for additional CDM program approvals at a later date for any part of the 2011-2014 period?

RESPONSE:

THESL anticipates applying for two additional programs as noted in the response to GEC Interrogatory 11. THESL may apply for additional programs within the 2011-2014 period if required to meet the mandated targets.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 13:

Reference(s): none provided

Does THESL intend to apply for a shareholder incentive and LRAM recovery?

RESPONSE:

Please see response to VECC Interrogatory 10(a).

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 14:

Reference(s): none provided

Is THESL targeting all cost-effective and attainable CDM in its territory and if so over what time frame? If not why not?

RESPONSE:

THESL is targeting all cost effective CDM opportunities that THESL believes to be achievable in the time period set out in the Ministerial Directive and OEB Code. Unless the programs currently in place perform above expectations, and as discussed in the response to GEC Interrogatory 12, additional programs are being explored and pursued in order to achieve THESL's overall CDM target. These will be developed and proposed in the fullness of time.

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 15:

Reference(s): none provided

Please provide an estimate of rate impact on Ontario ratepayers due to the THESL programs.

RESPONSE:

Please see response to Board Staff Interrogatory 1(b).

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 16:

Reference(s): **none provided**

Please provide an estimate of rate impact on Ontario ratepayers assuming all LDCs offer comparable programs.

RESPONSE:

Please see response to Board Staff Interrogatory 1(b).

RESPONSES TO INTERROGATORIES OF GREEN ENERGY COALITION

INTERROGATORY 17:

Reference(s): **none provided**

Please provide an estimate of rate impact due to the OPA Province-wide programs.

RESPONSE:

Please see response to Board Staff Interrogatory 1(b).

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY A-1:

Reference(s): Community Outreach and Education Initiative

THESL CDM Application: Community Outreach & Education at Page 5 describes Priority Neighbourhoods as “underserviced low income”.

Please provide:

a) the definition of a “Priority Neighbourhood” used by THESL;
b) clarification of what THESL means by “underserviced low income”; and
c) a description (location, socio-economic profile) of the 13 designated Priority Neighbourhoods and how these 13 neighbourhoods were identified.

RESPONSE:

a) Priority Neighbourhoods are as defined by the City of Toronto (“City”). The City has designated 13 Priority Areas through the Neighbourhood Action Plan.

b) “Underserviced low-income” are those living in priority neighbourhoods described above. When planning events in schools, THESL works with the School Boards to ensure schools in priority neighbourhoods are included. For the Toronto Police partnership, the events historically have taken place in priority neighbourhoods, as these neighbourhoods most often experience higher crime and violence than other parts of the City. In 2010, the neighbourhoods targeted were Jane/Finch, Scarborough Village, and Albion/Finch (Jamestown, Mount Olive).

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

c) Documents detailing these areas, in demographic, cartographic and descriptive form, are available at:
http://www.toronto.ca/demographics/priorityareas.htm

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY A-2:

Reference(s): Community Outreach and Education Initiative

Of the 1 million Torontonians expected to be targeted by the Community Outreach and Education Initiative annually, please provide how many per year, both in total, and broken down by each of the 4 channels – in store retail campaign, festive light exchange, Toronto police partnership and school education and outreach – are expected to be:

a) residents in the 13 designated Priority Neighbourhoods;
b) low-income residents; and
c) low-income residents in the 13 Priority Neighbourhoods.

RESPONSE:

The segments targeted through THESL's In Store Retail Campaign depend on retailers selected through THESL's Request for Expressions of Interest (RFEI) process. THESL always strives for broad, city-wide distribution of participating locations.

The segments targeted through THESL's School Education and Outreach depend on the schools selected by the relevant school Boards; however, THESL will request that priority neighbourhoods be included. In 2010, THESL directed the first round of invitations to participate in its Great Exchange program to high priority schools. In the end, 23% of the schools THESL partnered with were in Toronto's priority neighbourhoods. For THESL's Fall 2010 Beat the Peak program, 20% of the schools THESL partnered with were in priority neighborhoods. All of the public high schools THESL partnered with were identified within what Toronto District School Board calls

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

the Learning Opportunity Index ("LOI"). The LOI ranks each school based on measures of external challenges affecting student success.

The segments targeted through Toronto Police Outreach depend on communities identified by police as experiencing high crime/violence. The events historically have taken place in priority neighbourhoods, as these neighbourhoods most often experience higher crime and violence than other parts of the City. In 2010, the targeted neighbourhoods were Jane/Finch, Scarborough Village and Albion/Finch (Jamestown, Mount Olive).

The segments targeted through Festive Light Exchange evolve in partnership with Toronto Association of Business Improvement ("TABIA") areas and depend on TABIA participation and locations within any given community.

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY B-1:

Reference(s): **In Store Engagement and Education Initiative**

Please explain how this once-a-year campaign will be rolled out across Toronto over consecutive weekends.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY B-2:

Reference(s): In Store Engagement and Education Initiative

Of the 50,000 residential customers targeted annually, please provide how many are expected to be:

a) in the 13 designated Priority Neighbourhoods;
b) low-income; and
c) low-income and residing in one of the 13 designated Priority Neighbourhoods.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY C-1:

Reference(s): **Flat Rate Water Heater Conversion & Demand Response (FRWHDR)**

Of the 5,516 single family residences that remain on the flat rate domestic hot water heater service, please provide how many (number and % of total single family residences on flat rate) of these residences are:

a) located in the 13 designated Priority Neighbourhoods;
b) low-income residences; and
c) in one of the 13 designated Priority Neighbourhoods and are low-income residences.

RESPONSE:

a) The FRWHs located in the priority neighbourhoods are shown below:

COT Priority Neighbourhood (PN)	Number of FRWHs in Area
Pilot Project – 2005	
Scarborough Village	0
2006	
Eglinton East/Kennedy Park	2
Weston-Mt. Dennis	169
Lawrence Heights	18
Steeles-L'Amoreaux	0
2007	
Jane-Finch	7
Westminster-Branson	4
Flemingdon Park - Victoria Village	136
Dorset Park	1

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

COT Priority Neighbourhood (PN)	Number of FRWHs in Area
2008	
Jamestown	0
Malvern	2
Kingston-Galloway	0
Crescent Town	315
TOTAL FRWH in PN	**654**
TOTAL FRWH	**5516**
Percentage of FRWH in PN	**11.9%**

Note: year indicates when the neighbourhood was designated as a PN.

b) THESL does not track information on the income status of customers.

c) This information is unknown.

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY C-2:

Reference(s): **Flat Rate Water Heater Conversion & Demand Response (FRWHDR)**

Of the 4,413 single family residences (80% of unmetered single family residences) THESL expects to convert to metered service, please provide how many (number and % of total single family residences on flat rate) of these residences are:

a) located in the 13 designated Priority Neighbourhoods;
b) low-income residences; and
c) in one of the 13 designated Priority Neighbourhoods and are low-income residences.

RESPONSE:

a) Assuming that the projected results are achieved uniformly throughout income classes, the number of conversions in each area would be expected to be:

COT Priority Neighbourhood (PN)	Estimated Number of FRWHs in Area
Pilot Project – 2005	
Scarborough Village	0
2006	
Eglinton East/Kennedy Park	2
Weston-Mt. Dennis	135
Lawrence Heights	14
Steeles-L'Amoreaux	0

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

COT Priority Neighbourhood (PN)	Estimated Number of FRWHs in Area
2007	
Jane-Finch	6
Westminster-Branson	3
Flemingdon Park - Victoria Village	109
Dorset Park	1
2008	
Jamestown	0
Malvern	2
Kingston-Galloway	0
Crescent Town	252
TOTAL FRWH in PN	**523**
TOTAL FRWH	**4413**
% FRWH in PN	**11.9%**

Note: Year indicates when the neighbourhood was designated as a PN.

b) THESL does not track information on the income status of customers.

c) This information is unknown.

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY C-3:

Reference(s): **Flat Rate Water Heater Conversion & Demand Response (FRWHDR)**

For each of the 6 tank conversions shown in the table on Page 6 of THESL CDM Application: FRWHDR, please indicate the total average cost of the conversion and the % of the total cost covered by the proposed incentive.

RESPONSE:

The table below shows the typical cost in relation to incentives. The cost used is for a typical installation, which could be higher depending on site conditions.

Gallons	Element Size Bottom Watts	Element Size Top Watts	kWh Per 30 Days	kWh Annual Consumption	Metered Incentive $	Typical Cost of Conversion* $	Percentage of Cost Covered by Incentive
40	800	800	285	3,468	$138.70	$250.00	55.5%
40	1000	1000	341	4,149	$165.95	$250.00	66.4%
40	1000	3000	363	4,417	$176.66	$250.00	70.7%
40	3000	1000	454	5,524	$220.95	$250.00	88.4%
40	3000	3000	544	6,619	$264.75	$250.00	105.9%
60	1000	3000	407	4,952	$198.07	$250.00	79.2%
Average Total Costs						$250.00	77.7%

*Based on the cost of installing a breaker or fuse block in existing electrical distribution panel

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY C-4:

Reference(s): **Flat Rate Water Heater Conversion & Demand Response (FRWHDR)**

If the FRWHDR program were to cover 100% of the conversion costs to metered service, please provide:

a) the resulting TRC and PAC;
b) a description of input assumptions;
c) incremental costs and benefits; and
d) the calculations.

RESPONSE:

a) Please refer to the table below for the resulting TRC and PAC. This table reflects covering 100% of the typical conversion cost. Some sites will require more extensive electrical upgrades, which are not reflected in the typical conversion cost.

Name of Test	Benefits	Costs	Net Benefits	Ratio
TRC	$ 4,187,405	$ 2,242,177	$ 1,945,228	1.9
PAC	$ 4,229,134	$ 2,670,277	$ 1,558,858	1.6

b) Assumptions:

Conversion Cost = $250

Incentives set to cover 100% of conversion cost

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

c) Refer to the following table:

	Year 1	Year 2	**Total**
Number of Conversions	1,471	2,942	**4,413**
Incremental Cost	$ 87,899	$ 175,798	**$ 263,697**
Incremental MW Savings	-	-	**-**
Incremental MWh Savings	-	-	**-**

d) New Incentive Level = $250 x 0.80 x 5516 = $1,103,300

Old Incentive Level = $839,503

Incremental Change = $263,697

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

INTERROGATORY C-5:

Reference(s): **Flat Rate Water Heater Conversion & Demand Response (FRWHDR)**

For the following scenario:

a) If up to 2 free low-flow showerheads (depending on number of showers in residence), and up to 3 aerators (a kitchen and two bathroom faucet aerators (depending on number of bathrooms) are installed for free at the time that the switch on the hot water heater is being installed for customers who switch to metered service and sign up for peaksaver under the FRWHDR, please provide:
   (i) the resulting TRC and PAC;
   (ii) a description of input assumptions;
   (iii) incremental costs and benefits; and
   (iv) the calculations.

b) If up to 2 free low-flow showerheads (depending on number of showers in residence), and up to 3 aerators (a kitchen and two bathroom faucet aerators (depending on number of bathrooms) are provided to the customer for free but are not installed at the time that the switch on the hot water heater is being installed for customers who switch to metered service and sign up for **peaksaver** under the FRWHDR, please provide:
   (i) the resulting TRC and PAC;
   (ii) a description of input assumptions;
   (iii) incremental costs and benefits; and
   (iv) the calculations.

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

c) If the program covers the full cost of the meter conversion and provides up to 2 free low-flow showerheads (depending on number of showers in residence), and up to 3 aerators (a kitchen and two bathroom faucet aerators depending on number of bathrooms) and installs these devices for free at the time that the switch on the hot water heater is being installed for customers who switch to metered service and sign up for **peaksaver** under the FRWHDR, please provide:

   (i) the resulting TRC and PAC;
   (ii) a description of input assumptions;
   (iii) incremental costs and benefits; and
   (iv) the calculations.

RESPONSE:

The results for the three scenarios and the original application are summarized below. Please note that over the past five years THESL, Enbridge Gas and the City of Toronto have been involved in a number of campaigns to distribute water savings devices. The number of residences that have deployed aerators and low flow showerheads is unknown, but may be significant.

Scenario	TRC	Program Benefit	Program Cost	Net Benefit
Original	1.8	$4,187,405	$2,370,207	$1,817,198
Scenario 1	2.7	$6,205,842	$2,323,396	$3,882,446
Scenario 2	1.9	$4,187,405	$2,242,177	$1,945,228
Scenario 3	2.7	$6,205,842	$2,323,396	$3,882,446

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

Scenario	PAC	Program Benefit	Program Cost	Net Benefit
Original	1.7	$4,229,134	$2,431,191	$1,797,943
Scenario 1	2.5	$6,244,771	$2,547,218	$3,697,553
Scenario 2	1.7	$4,229,134	$2,547,218	$1,681,916
Scenario 3	2.2	$6,244,771	$2,786,304	$3,458,468

a) Scenario 1

i. Please refer to the table below for the TRC and PAC results.

Name of Test	Benefits	Costs	Net Benefits	Ratio
TRC	$ 6,205,842	$ 2,323,396	$ 3,882,446	2.7
PAC	$ 6,244,771	$ 2,547,218	$ 3,697,553	2.5

ii. OPA's Prescriptive Measures and Assumptions List (Release 1 – 2010) was used for input assumptions for both low-flow showerheads and aerators. In addition, THESL has also used the following assumptions for the above cost effectiveness tests:

- free ridership: 30%
- --aerator cost: $5/unit
- --showerhead cost: $7/unit
- --Average (3) aerator savings: 176.3 kWh / residence
- --Average (2) showerhead savings: 377 kWh / residence

*Savings

Aerator Savings = 176.3 kWh per house

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

Showerhead Savings = 377 kWh per house
Total Savings = 553.3 kWh per house

iii. Refer to the following table for incremental cost and benefits

	Year 1	Year 2	**Total**
Number of Conversions	1,471	2,942	**4,413**
Incremental Cost	$ 42,657	$ 85,314	**$ 127,971**
Incremental MW Savings	0.1	0.2	**0.3**
Incremental MWh Savings	1,321	2,642	**3,963**

iv. Calculations – see (ii)

b) Scenario 2

i. Please refer to the table below for the TRC and PAC results.

Name of Test	Benefits	Costs	Net Benefits	Ratio
TRC	$ 4,187,405	$ 2,242,177	$ 1,945,228	1.9
PAC	$ 4,229,134	$ 2,547,218	$ 1,681,916	1.7

ii. Other than the input assumptions provided in the application, it is assumed that there will be no savings related to the free showerheads and aerators provided, as they are not installed.

Additional assumptions are provided as follows:

- aerator cost: $5/unit
- showerhead cost: $7/unit

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

- Average (3) aerator savings: 176.3 kWh / residence
- Average (2) showerhead savings: 377 kWh / residence

iii. Refer to the following table for incremental cost and benefits

	Year 1	Year 2	**Total**
Number of Conversions	1,471	2,942	**4,413**
Incremental Cost	$ 42,657	$ 85,314	**$ 127,971**
Incremental MW Savings	-	-	**-**
Incremental MWh Savings	-	-	**-**

iv. Calculations – see (ii)

c) Scenario 3

i. Please refer to the table below for the TRC and PAC results.

Name of Test	Benefits	Costs	Net Benefits	Ratio
TRC	$ 6,205,842	$ 2,323,396	$ 3,882,446	2.7
PAC	$ 6,244,771	$ 2,786,304	$ 3,458,468	2.2

ii. OPA's Prescriptive Measures and Assumptions List was used for input assumptions for both low-flow showerheads and aerators. In addition, THESL has also used the following assumptions for the above cost effectiveness tests:

- free ridership: 30%
- financial incentive for full conversion: $250/unit
- aerator cost: $5/unit
- showerhead cost: $7/unit

RESPONSES TO INTERROGATORIES OF LOW-INCOME ENERGY NETWORK INTERROGATORIES

- Average (3) aerator savings: 176.3 kWh / residence
- Average (2) showerhead savings: 377 kWh / residence

iii. Refer to the following table for incremental cost and benefits

	Year 1	Year 2	**Total**
Number of Conversions	1,471	2,942	**4,413**
Incremental Cost	$ 130,556	$ 261,112	**$ 391,669**
Incremental MW Savings	0.1	0.2	**0.3**
Incremental MWh Savings	1,321	2,642	**3,963**

iv. Calculations – see (ii)

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 1:

Reference(s): none provided

For each of Toronto Hydro's OPA-Contracted and Board-Approved CDM programs, please state each program's cumulative impact on demand (MW) and energy consumption (MWh) in 2014.

RESPONSE:

Please refer to the response to Board Staff Interrogatory 1.

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 2:

Reference(s): none provided

For each of Toronto Hydro's OPA-Contracted CDM programs please provide their:

a) Annual budgets;

b) Annual number of participants;

c) TRC Test benefit-cost ratio; and

d) Program Administrator Cost Test benefit-cost ratio.

RESPONSE:

a) The table below provides THESL's program administration working budget for OPA-Contracted CDM programs:

Program	2011	2012	2013	2014	Total
Consumer	$ 4,511,689	$ 3,159,164	$ 3,159,164	$ 3,159,164	**$ 13,989,180**
Commercial	$ 5,348,611	$ 8,950,186	$ 8,950,186	$ 8,950,186	**$ 32,199,168**
Industrial	$ 1,582,650	$ 807,908	$ 807,908	$ 807,908	**$ 4,006,373**
Total	**$ 11,442,950**	**$ 12,917,257**	**$ 12,917,257**	**$ 12,917,257**	**$ 50,194,721**

b) Please refer to response to Board Staff Interrogatory 1.

c) Please refer to response to Board Staff Interrogatory 1.

d) Please refer to response to Board Staff Interrogatory 1.

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 3:

Reference(s): none provided

Please state Toronto Hydro's forecasted actual and potential number of residential *peaksaver* customers as of December 31, 2014.

RESPONSE:

THESL's forecasted total number of *peaksaver* customer in 2014 is expected to be 70,000.

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 4:

Reference(s): none provided

Please provide Toronto Hydro's forecasted number of new residential *peaksaver* customers that will be added each year from 2011 to 2014.

RESPONSE:

The forecasted numbers of new residential *peaksaver* customers are provided below:

- 2011 – 400 customers
- 2012 – 2,400 customers
- 2013 – 2,400 customers
- 2014 – 2,400 customers

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 5:

Reference(s): none provided

Does Toronto Hydro have any studies on the costs and benefits of adopting more aggressive new participant targets for its residential *peaksaver* progam between 2011 and 2014? If so, please provide copies of these studies.

RESPONSE:

THESL does not have any studies on the cost and benefits of adopting more aggressive participant targets.

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 6:

Reference(s): none provided

Would the adoption of more aggressive new participant targets for its residential *peaksaver* program have an adverse impact on Toronto Hydro's bottom line? If yes, please explain why.

RESPONSE:

The adoption of more aggressive participant targets for residential *peaksaver* would not impact THESL's profitability.

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 7:

Reference(s): **none provided**

With respect to your proposed Commerical Energy Management Load Control program, please describe the benefits and costs associated with doubling the total participation target for the 2011 to 2014 time period.

RESPONSE:

The table below summarizes the estimated budget with doubling the total participation target.

Cost Category	2011	2012	2013	2014	Total	% Increase
Marginal Costs						
Fixed Costs						
Legal Cost	$52,500	$15,750	$15,750	$15,750	**$99,750**	0%
Marketing	$252,656	$189,492	$189,492	$63,164	**$694,805**	75%
Sales	$53,680	$27,377	$27,924	$26,840	**$135,821**	100%
Program EMV	$0	$75,000	$75,000	$150,000	**$300,000**	25%
Administrative Costs	$5,553	$11,328	$13,481	$7,857	**$38,219**	100%
Operation Cost	$81,367	$70,053	$71,892	$39,760	**$263,072**	100%
Total Fixed Costs	**$445,756**	**$389,000**	**$393,539**	**$303,371**	**$1,531,667**	**60%**
Variable Costs						
Administrative Costs	$22,212	$45,313	$67,403	$39,286	**$174,213**	100%
Operation Cost	$451,469	$406,213	$413,568	$285,039	**$1,556,289**	100%
Vendor Cost	$2,520,087	$5,178,446	$6,295,019	$4,097,569	**$18,091,120**	100%
Total Variable Costs	**$2,993,768**	**$5,629,972**	**$6,775,990**	**$4,421,894**	**$19,821,623**	**100%**
Total Marginal Cost	**$3,439,524**	**$6,018,972**	**$7,169,529**	**$4,725,265**	**$21,353,289**	**97%**
Total Allocable Cost	$49,394	$85,495	$101,603	$67,761	**$304,252**	0%
Total Program Costs	**$3,488,918**	**$6,104,467**	**$7,271,131**	**$4,793,025**	**$21,657,541**	**94%**
Total Incentives	$74,606	$206,360	$345,524	$404,262	$1,030,752	100%
Total Budget	**$3,563,524**	**$6,310,827**	**$7,616,655**	**$5,197,287**	**$22,688,293**	**94%**

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

The test effective results with doubling the target are shown in the following table:

Name of Test	Benefits	Costs	Net Benefits	Ratio
TRC	$ 30,052,304	$ 17,091,703	$ 12,960,601	1.8
PAC	$ 26,305,259	$ 5,807,017	$ 20,498,243	4.5

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 8:

Reference(s): none provided

With respect to your proposed Commercial, Institutional and Small Industrial Monitoring & Targeting program, please describe the benefits and costs associated with doubling the total participation target for the 2011 to 2014 time period.

RESPONSE:

The table below summarizes the estimated budget with doubling the total participation target.

Description	2011	2012	2013	2014	Total	% Increase
Marginal Costs						
Fixed Costs						
Legal Cost	$42,000	$15,750	$15,750	$15,750	**$89,250**	0%
Marketing	$174,563	$128,625	$91,875	$9,188	**$404,250**	75%
Sales	$281,819	$287,456	$219,904	$70,455	**$859,633**	100%
Program EMV	$85,313	$85,313	$85,313	$85,313	**$341,250**	25%
Administrative Costs	$8,782	$21,662	$17,613	$11,992	**$60,049**	100%
Operation Cost	$30,387	$59,372	$69,431	$67,229	**$226,419**	100%
Total Fixed Costs	**$622,864**	**$598,177**	**$499,884**	**$259,926**	**$1,980,851**	**70%**
Variable Costs						
Administrative Costs	$35,129	$86,649	$70,450	$47,966	**$240,194**	100%
Operation Cost	$121,549	$237,488	$277,723	$268,917	**$905,677**	100%
Total Variable Costs	**$156,678**	**$324,137**	**$348,173**	**$316,884**	**$1,145,871**	**100%**
Total Marginal Cost	**$779,541**	**$922,314**	**$848,058**	**$576,809**	**$3,126,722**	**80%**
Total Allocable Cost	$12,567	$14,107	$12,994	$9,031	**$48,699**	0%
Total Program Costs	**$792,108**	**$936,421**	**$861,052**	**$585,840**	**$3,175,421**	**78%**
Total Incentives	$1,010,704	$2,737,699	$2,276,211	$1,402,336	$7,426,951	100%
Total Budget	**$1,802,813**	**$3,674,120**	**$3,137,263**	**$1,988,176**	**$10,602,371**	**93%**

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

The test effective results with doubling the target are shown in the following table.

Name of Test	Benefits	Costs	Net Benefits	Ratio
TRC	$ 14,398,230	$ 8,376,029	$ 6,022,200	1.7
PAC	$ 14,398,230	$ 9,353,837	$ 5,044,393	1.5

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 9:

Reference(s): **none provided**

With respect to your proposed Multi-Unit Residential Demand Response program, please describe the benefits and costs associated with doubling the total participation target for the 2011 to 2014 time period.

RESPONSE:

The table below summarizes the estimated budget with doubling the total participation target.

Description	2011	2012	2013	2014	Total	% Increase
Marginal Costs						
Fixed Costs						
Legal Cost	$52,500	$15,750	$15,750	$15,750	**$99,750**	0%
Marketing	$258,169	$258,169	$193,627	$129,084	**$839,048**	75%
Sales	$134,200	$268,399	$268,399	$134,200	**$805,198**	100%
Program EMV	$0	$75,000	$75,000	$75,000	**$225,000**	25%
Administrative Costs	$583	$14,567	$20,394	$22,725	**$58,270**	100%
Operation Cost	$98,777	$118,364	$118,955	$76,919	**$413,015**	100%
Total Fixed Costs	**$544,228**	**$750,249**	**$692,126**	**$453,678**	**$2,440,281**	**75%**
Variable Costs						
Administrative Costs	$2,331	$58,270	$81,577	$90,901	**$233,079**	100%
Operation Cost	$395,107	$473,454	$475,822	$307,677	**$1,652,060**	100%
Vendor Cost	$215,238	$5,380,939	$7,600,582	$8,555,706	**$21,752,465**	100%
Total Variable Costs	**$612,675**	**$5,912,663**	**$8,157,981**	**$8,954,284**	**$23,637,604**	**100%**
Total Marginal Cost	**$1,156,903**	**$6,662,912**	**$8,850,107**	**$9,407,963**	**$26,077,884**	**97%**
Total Allocable Cost	$17,448	$94,648	$125,139	$132,820	**$370,055**	0%
Total Program Costs	**$1,174,351**	**$6,757,560**	**$8,975,246**	**$9,540,783**	**$26,447,939**	**95%**
Total Incentives	$126,462	$2,860,361	$4,358,411	$5,311,537	$12,656,772	100%
Total Budget	**$1,300,813**	**$9,617,921**	**$13,333,657**	**$14,852,319**	**$39,104,711**	**96%**

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

The test effective results with doubling the target are shown in the following table:

Name of Test	Benefits	Costs	Net Benefits	Ratio
TRC	$ 42,587,853	$ 20,360,477	$ 22,227,376	2.1
PAC	$ 34,881,409	$ 32,712,264	$ 2,169,144	1.1

RESPONSES TO INTERROGATORIES OF POLLUTION PROBE

INTERROGATORY 10:

Reference(s): none provided

Please state the MW and GWh contributions of each of Toronto Hydro's OPA Contracted and proposed Board-Approved CDM programs with respect to meeting Toronto Hydro's:

a) 2014 Net Annual Peak Demand Savings Target; and

b) 2011-2014 Net Cumulative Energy Savings Target.

RESPONSE:

Please refer to the table below:

	THESL 2014	OPA Contract Programs		Board-Approved Programs	
	Target	Target	%	Target	%
MW	286	221	77%	24	9%
GWh	1,304	1,141	87%	127	10%

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 1:

Reference(s): none provided

With respect to current and proposed CDM activities,

a) Please provide the latest approved budget for the Applicant's CDM business unit covering all or any part of the period 2011 through 2014 inclusive, and providing a breakdown by function and between the categories i) Board-approved programs, ii) OPA programs, and iii) other costs.

b) Please provide a breakdown of current and proposed FTEs in Applicant's CDM business unit, broken down by function and between the same three categories if possible.

RESPONSE:

Please refer to responses to Board Staff Interrogatories 1 and 7.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 2:

Reference(s): none provided

With respect to the incremental staffing additions for 2011-2014 for all CDM programs, please provide a detailed breakdown by: year, role (as categorized by the Applicant in their proposed Board-Approved Program budgets), type (contract, union, non-union, management etc.) and by OPA program and proposed Board-Approved Program.

RESPONSE:

Please refer to responses to the following two interrogatories for staffing additions for 2011-2014 CDM programs, provided by year and functional role:

1) Board Staff Interrogatory 7
2) AMPCO Interrogatory 11

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 3:

Reference(s): **none provided**

Please provide a total budget broken down by category for all proposed Board-Approved Programs.

RESPONSE:

Please refer to the table below:

Cost Category	2011	2012	2013	2014	**Total**
Marginal Costs	**$ 5,464,481**	**$ 9,769,714**	**$ 10,301,051**	**$ 8,853,475**	**$ 34,388,721**
Fixed Costs	$ 2,212,737	$ 2,154,128	$ 1,987,225	$ 1,682,811	**$ 8,036,902**
Legal Cost	*$ 232,700*	*$ 85,900*	*$ 78,025*	*$ 70,525*	***$ 467,150***
Marketing	*$ 995,279*	*$ 877,206*	*$ 797,875*	*$ 641,556*	***$ 3,311,917***
Sales	*$ 241,559*	*$ 298,460*	*$ 265,095*	*$ 122,457*	***$ 927,571***
Program EMV	*$ 153,250*	*$ 253,250*	*$ 238,250*	*$ 308,250*	***$ 953,000***
Administrative Costs	*$ 35,264*	*$ 66,972*	*$ 39,148*	*$ 34,691*	***$ 176,075***
Operation Cost	*$ 147,269*	*$ 179,923*	*$ 176,417*	*$ 112,916*	***$ 616,525***
External Costs	*$ 384,916*	*$ 384,916*	*$ 384,916*	*$ 384,916*	***$ 1,539,664***
Contractor Training	*$ 22,500*	*$ 7,500*	*$ 7,500*	*$ 7,500*	***$ 45,000***
Variable Costs	$ 3,251,744	$ 7,615,586	$ 8,313,826	$ 7,170,664	**$ 26,351,819**
Administrative Costs	*$ 92,743*	*$ 227,890*	*$ 126,736*	*$ 96,227*	***$ 543,596***
Operation Cost	*$ 1,320,640*	*$ 1,166,607*	*$ 1,239,289*	*$ 747,799*	***$ 4,474,334***
Vendor Cost	*$ 1,838,361*	*$ 6,221,090*	*$ 6,947,801*	*$ 6,326,638*	***$ 21,333,889***
Allocable Costs	**$ 126,828**	**$ 247,794**	**$ 262,672**	**$ 222,000**	**$ 859,294**
Financial Incentives	**$ 1,625,107**	**$ 5,076,199**	**$ 5,581,140**	**$ 4,574,027**	**$ 16,856,473**
Grand Total	**$ 7,216,416**	**$ 15,093,707**	**$ 16,144,863**	**$ 13,649,502**	**$ 52,104,488**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 4:

Reference(s): none provided

Please confirm all costs in this Application are incremental to the existing approved budget.

RESPONSE:

THESL confirms that all costs submitted in its Application for Board-Approved Programs are incremental to the existing approved budget for OPA Programs.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 5:

Reference(s): none provided

Please provide a full, live, and populated TRC and PAC model for each of the programs in which there is a TRC and/or PAC result or target forecast.

RESPONSE:

THESL submits full, live, and populated TRC and PAC models for each of the five programs (as attached files). Please refer to the response to Board Staff Interrogatory 1 for a summary of the TRC and PAC results.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 6:

Reference(s): none provided

Please provide a combined budget showing all planned spending for web pages, web presence, and related activities, in any of the proposed Board-approved programs and in any OPA programs the Applicant plans to implement in 2011-2014.

RESPONSE:

THESL budgeted $173,000 for web-related work over the period of 2011-2014.

Web-related expense for Board-approved programs

Commercial Energy Management & Load Control	$ 22,000
Commercial, Institutional & Small Industrial Monitoring & Targeting	$ 17,000
Flat Rate Water Heater Conversion & Demand Response	$ 5,000
Hydronic System Balancing	$ 10,000
Multi-Unit Residential Demand Response	$ 27,000
Community Outreach + In-store Engagement & Education	$ 30,000
Total	**$ 111,000**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

Web-related expense for OPA programs

Commercial & Institutional Programs	$ 57,000
Residential Programs	$ 5,000
Total	**$ 62,000**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 7:

Reference(s): **Business Outreach and Education, p.4**

For each of the past 3 years, please provide the number of speaking engagements employees of the Applicant have given on the topic of conservation and demand management to the building services audience.

RESPONSE:

Over the past three years, CDM speaking engagements by THESL staff have not been tracked or recorded. Consequently, this information is not available to report.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 8:

Reference(s): Business Outreach and Education, p.4

Please provide a list of 'business association forums' in which the Applicant intends to become involved.

RESPONSE:

Please refer to the response to Board Staff Interrogatory 15(b).

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 9:

Reference(s): Business Outreach and Education, p.8

Please provide the budget and actual spending for each of 2009 and 2010 for business association memberships, event education sponsorships and show booth outreach.

RESPONSE:

In 2009, THESL spent a total of $49,419 ($29,816 on sponsorships, and $19,603 in outreach & promotion). In 2010, THESL spent a total of $233,727 (BOMA Membership $720, Sponsorship = $98,596, and Outreach & Promotion = $134,411). This excludes a $250,000 sponsorship for the Greening Greater Toronto Commercial Building Energy Initiative.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 10:

Reference(s): **Business Outreach and Education, p.10 and a number of other places in the Application**

With respect to 'Key Messaging', please provide an explanation of,

a) How "THESL wants to work with its customers" is relevant and specific to conservation and demand management?

b) How "THESL is a trusted and honest broker" is relevant and specific to conservation and demand management?

RESPONSE:

a) THESL endeavours to establish consultative and/or collaborative relationships with its customers in order to provide value, superior customer service and to positively support them in making CDM investment decisions.

b) Because THESL is not in a contracted relationship to design or build energy projects, THESL is perceived as a neutral party acting in a manner independent of the building owner's project delivery team. Furthermore, because incentive programs promote energy savings, building owners recognize that the interests of THESL and the building owner are in alignment. Subsequently, THESL can be relied upon to provide unbiased opinions and recommendations.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 11:

Reference(s): Business Outreach and Education, p.11

With respect to the budget, please provide a detailed breakdown of the variable costs and allocable cost associated with this program.

RESPONSE:

The variable costs for this program in 2011, 2012, and 2013 are broken down as outlined below:

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

Affiliation Priority	Engagement Model	Annual Engagements	Estimated # of Participants per Event	Total Estimated # of Participants	Estimated # of Engagements per Event	Total Estimated # of Engagements	Unit Cost	Industry Forums and Membership	Training Event	Event & Material Sub-Total	Labour Sub-Total	TOTAL
High	Association Membership	4			6	288	$4,000	$16,000		$16,000	$27,322	$43,322
High	Key Event Education Sponsorship	3	200	600			$15,000		$45,000	$45,000	$5,123	$50,123
High	Show Booth Outreach	3			200	600	$15,000		$45,000	$45,000	$14,755	$59,755
Medium	Association Membership	8			4	384	$3,000		$24,000	$24,000	$40,982	$64,982
Medium	Key Event Education Sponsorship	8	30	240			$4,000	$32,000		$32,000	$6,830	$38,830
Low	Association Membership	8			2	192	$1,000	$8,000		$8,000	$13,661	$21,661
Low	Key Event Education Sponsorship	8	20	160			$3,000		$24,000	$24,000	$4,554	$28,554
General	On-site Seminars	120	8	960			$170		$20,400	$20,400	$68,304	$88,704
General	Miscellaneous Materials	1					$25,000		$25,000	$25,000	$3,415	$28,415
Annual Total				**1,960**		**1,464**		**$56,000**	**$183,400**	**$239,400**	**$184,945**	$424,345

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

The cost in 2014 is estimated at 50% of the previous years' total.

The allocable cost is calculated as 2.8% of the total variable cost to account for supervision costs.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 12:

Reference(s): Business Outreach and Education, p.11

Please provide a more detailed description of the types of legal costs proposed to be incurred under this program.

RESPONSE:

Please see response to Board Staff Interrogatory 18(a).

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 13:

Reference(s): Commercial Energy Management and Load Control

Please confirm that schools will be able to take part in the Commercial Energy Management and Local Control program.

RESPONSE:

Schools that meet the eligibility criteria for the program will be eligible to participate.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 14:

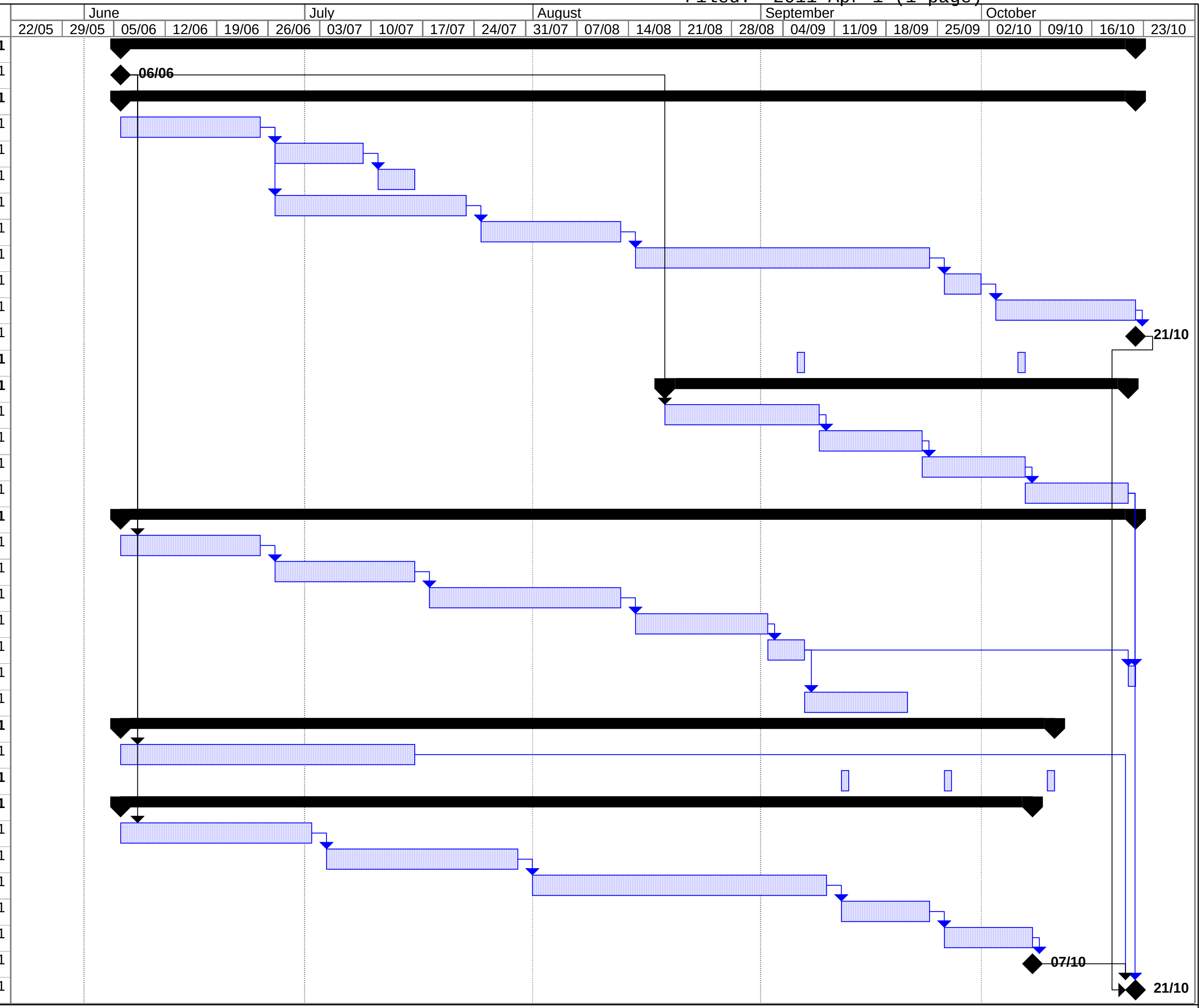
Reference(s): Commercial Energy Management and Load Control

Please provide a detailed timeline from Board Approval of the program to full program implementation and deployment. Please detail all significant steps and tasks needed to be undertaken.

RESPONSE:

Please refer to detailed project schedule attached as Appendix A.

ID	Task Name	Duration	Start	Finish
1	**CEMLC Program Deployment**	**100 days**	**Mon 06/06/11**	**Fri 21/10/11**
2	OEB Program Approval	0 days	Mon 06/06/11	Mon 06/06/11
3	**System Deployment**	**100 days**	**Mon 06/06/11**	**Fri 21/10/11**
4	Develop RFQ	15 days	Mon 06/06/11	Fri 24/06/11
5	Request for Qualification	10 days	Mon 27/06/11	Fri 08/07/11
6	Evaluate RFQ	5 days	Mon 11/07/11	Fri 15/07/11
7	Prepare RFP	20 days	Mon 27/06/11	Fri 22/07/11
8	Legal Review	15 days	Mon 25/07/11	Fri 12/08/11
9	Procurement Process	30 days	Mon 15/08/11	Fri 23/09/11
10	Review Response	5 days	Mon 26/09/11	Fri 30/09/11
11	Contract Negotiation	15 days	Mon 03/10/11	Fri 21/10/11
12	Contract Signed	0 days	Fri 21/10/11	Fri 21/10/11
13	**Vendor Training**	**23 days**	**Tue 06/09/11**	**Thu 06/10/11**
16	**Back Office**	**45 days**	**Fri 19/08/11**	**Thu 20/10/11**
17	Participant Agreements	15 days	Fri 19/08/11	Thu 08/09/11
18	Legal Review	10 days	Fri 09/09/11	Thu 22/09/11
19	Forms Development	10 days	Fri 23/09/11	Thu 06/10/11
20	Web Interface	10 days	Fri 07/10/11	Thu 20/10/11
21	**Marketing**	**100 days**	**Mon 06/06/11**	**Fri 21/10/11**
22	Finalize Marketing Plan	15 days	Mon 06/06/11	Fri 24/06/11
23	Procurement Process	15 days	Mon 27/06/11	Fri 15/07/11
24	Legal Review	20 days	Mon 18/07/11	Fri 12/08/11
25	Develop Creative	14 days	Mon 15/08/11	Thu 01/09/11
26	Print Materials	3 days	Fri 02/09/11	Tue 06/09/11
27	Launch Website	1 day	Fri 21/10/11	Fri 21/10/11
28	Media Plan	10 days	Wed 07/09/11	Tue 20/09/11
29	**Human Resources**	**91 days**	**Mon 06/06/11**	**Mon 10/10/11**
30	Hire Project Manager	30 days	Mon 06/06/11	Fri 15/07/11
31	**Staff Training**	**21 days**	**Mon 12/09/11**	**Mon 10/10/11**
35	**Program M and V**	**90 days**	**Mon 06/06/11**	**Fri 07/10/11**
36	Prepare RFP	20 days	Mon 06/06/11	Fri 01/07/11
37	Legal Review	20 days	Mon 04/07/11	Fri 29/07/11
38	Procurement Process	30 days	Mon 01/08/11	Fri 09/09/11
39	Review Response	10 days	Mon 12/09/11	Fri 23/09/11
40	Contract Negotiation	10 days	Mon 26/09/11	Fri 07/10/11
41	Contract Signed	0 days	Fri 07/10/11	Fri 07/10/11
42	Program Deployment	0 days	Fri 21/10/11	Fri 21/10/11



Project: CEMLC Deployment Schedule
Date: Tue 29/03/11

Task	Progress	Summary	External Tasks	Deadline
Split	Milestone	Project Summary	External Milestone	

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 15:

Reference(s): Commercial Energy Management and Load Control, p.5

Please reconcile the statement that the program will "[c]ontribute 6.3 GWh in cumulative net electricity savings" with the table on the previous page stating the total MWh savings of 13,864.

RESPONSE:

The 6.3 GWh total is a typographical error – 13.8 GWh is the correct figure.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 16:

Reference(s): Commercial Energy Management and Load Control, p.5

The Applicant states that it might issue an RFP on behalf of itself and other utilities deploying the same program. If other utilities are deploying the same program has the Applicant discussed the possibility with the OPA of the OPA conducting the RFP process and/or sponsoring the program?

RESPONSE:

No, discussion with the OPA to procure services and material through an RFP on behalf of the interested groups of utilities has not taken place.

If a group of utilities do ultimately receive OEB approval for the program, cost efficiencies would be deployed for all aspects of design, development, and delivery of the program including an aggregate RFP.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 17:

Reference(s): **Commercial Energy Management and Load Control, p.5**

Please provide a breakdown of the 'Institutional' sector displayed in the Sector Analysis table.

RESPONSE:

The following table gives a breakdown of the facilities that comprise the Institutional Sector (between 50 and 200 kW service) as noted in Section 2.1 of the CEMLC Program application.

Universities/Colleges	58
Religious	348
Hospital/Healthcare	128
Private/School Boards	562
Community Centres	16
Cultural Centres	12
TOTAL	**1,124**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 18:

Reference(s): Commercial Energy Management and Load Control, p.11

Please explain why the number of participants per year decreases in 2014.

RESPONSE:

The customer's incentive stream is larger the earlier they choose to participate in the program due to the annual incentive payments for both persistence and activation. THESL expects that this will lead to a fall in participation particularly in year 4 as the program is nearing completion.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 19:

Reference(s): Commercial Energy Management and Load Control, p.11

Please provide the specific source and date of the US Department of Energy setback calculator used in the determination of the electricity demand and consumption savings.

RESPONSE:

The spreadsheet is available on the Energy Star website at: http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorProgrammableThermostat.xls

The spreadsheet is not dated, but includes a note indicating it was updated February 2010.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 20:

Reference(s): Commercial Energy Management and Load Control, p.19

With respect to the budget,

a) Please provided a detailed breakdown of the fixed marketing, administrative and operations costs?

b) Please provide a detailed breakdown of the variable vendor and operations costs?

c) Please confirm that the equipment and component costs are not being classified as capital costs?

d) Please provide a detailed breakdown of the allocable cost.

RESPONSE:

a)

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

1) Fixed Marketing Costs

Item	2011	2012	2013	2014	Total
Web and digital (Video)	$12,000	$7,000	$5,000	$2,000	$26,000
FAQ	$2,000	$2,281	$2,281	$0	$6,562
Sell sheet	$5,375	$2,000	$2,000	$0	$9,375
Case Study (print and web)	$5,000	$6,000	$6,000	$0	$17,000
Direct mail package (based on 20K	$41,000	$45,000	$45,000	$23,094	$154,094
Sponsorships	$5,000	$5,000	$5,000	$3,000	$18,000
Public, Government, Media	$2,000	$2,000	$2,000	$0	$6,000
Advertisements print & online	$22,000	$20,000	$22,000	$3,000	$67,000
Third Party Vendor training	$3,000	$3,000	$3,000	$0	$9,000
Outreach and education sessions	$22,000	$10,000	$10,000	$2,000	$44,000
Legal	$20,000	$1,000	$1,000	$1,000	$23,000
Marketing	$5,000	$5,000	$5,000	$2,000	$17,000
Total	**$144,375**	**$108,281**	**$108,281**	**$36,094**	**$397,031**

2) Fixed Administration Costs

Type	2011	2012	2013	2014	Total
Applications	$1,685	$3,437	$4,090	$2,384	**$11,595**
Incentive Processing	$7,885	$16,085	$19,141	$11,157	**$54,268**
Settlement	$2,628	$5,362	$6,380	$3,719	**$18,089**
Administration	$1,685	$3,437	$4,090	$2,384	**$11,595**
Total Admin Costs	**$13,883**	**$28,320**	**$33,701**	**$19,643**	**$95,547**
20% Allocated to Fixed Cost	**$2,777**	**$5,664**	**$6,740**	**$3,929**	**$19,109**
Total Fixed Admin Costs	**$2,777**	**$5,664**	**$6,740**	**$3,929**	**$19,109**

3) Fixed Operation Costs

Type	2011	2012	2013	2014	Total
Energy Analyst	$31,336	$20,807	$22,317	$18,554	**$93,013**
Program Manager/Settlement	$140,910	$143,728	$146,602	$70,455	**$501,695**
Energy Manager	$0	$0	$0	$0	**$0**
Manager	$31,173	$10,599	$10,811	$10,391	**$62,973**
Operation Costs	**$203,418**	**$175,133**	**$179,730**	**$99,399**	**$657,681**
20% Allocated to Fixed Cost	**$40,684**	**$35,027**	**$35,946**	**$19,880**	**$131,536**
Total Fixed Operation Costs	**$40,684**	**$35,027**	**$35,946**	**$19,880**	**$131,536**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

4) Variable Operation Costs

Type	2011	2012	2013	2014	Total
Energy Analyst	$31,336	$20,807	$22,317	$18,554	**$93,013**
Program Manager/Settlement	$140,910	$143,728	$146,602	$70,455	**$501,695**
Annual Operation Cost	$78,750	$78,750	$78,750	$78,750	**$315,000**
Manager	$31,173	$10,599	$10,811	$10,391	**$62,973**
Operation Costs	**$282,168**	**$253,883**	**$258,480**	**$178,149**	**$972,681**
80% Allocated to Variable Cost	**$225,735**	**$203,107**	**$206,784**	**$142,519**	**$778,145**
Total Variable Operation Costs	**$225,735**	**$203,107**	**$206,784**	**$142,519**	**$778,145**

5) Variable Vendor Costs

Type	2011	2012	2013	2014	Total
Controller Cost	$1,190,907	$2,381,814	$2,778,783	$1,587,876	**$7,939,380**
Cell Modem Costs	$31,426	$94,277	$167,603	$209,504	**$502,809**
Access Fees	$37,711	$113,132	$201,124	$251,405	**$603,371**
Total Variable Operation Costs	**$1,260,043**	**$2,589,223**	**$3,147,510**	**$2,048,784**	**$9,045,560**

b) See a) above

c) Confirmed.

d) The allocable cost is defined in the OEB code as ". . .indirect costs (i.e., costs that would be incurred regardless of whether or not the non rate-regulated activities were undertaken)". THESL allocated shared service costs for corporate services which include finance, procurement, legal, regulatory and executive support. The $859,294 amount of allocable cost in the Board-Approved application (excluding the "In Store Engagement and Education Initiative" and "Community Outreach and Education") is approximately 2.8% of the total program costs less participant incentives. The allocable cost for "Community Outreach and Education" was omitted in error and would have been $103,591 if included.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 21:

Reference(s): Commercial Energy Management and Load Control, p.20

Please provide the basis for the input assumption of 10% free ridership?

RESPONSE:

A nominal 10% free-ridership factor has been applied to the CEMLC program to be consistent with the OPA assumptions for similar programs. THESL expects that this is a conservative value as there are no means by which a participant could participate in a load control program without being enrolled in the program.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 22:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting**

Please confirm that schools will eligible for the Commercial, Institutional and Small Industrial Monitoring & Targeting program.

RESPONSE:

Yes, schools will be eligible provided that their average monthly demand is greater than 200kW. The target market for the M&T program includes medium and large-sized facilities in the Office, Retail, Institutional and Industrial sectors with average monthly peak demand exceeding 200 kW per month, but not exceeding 15 GWh in annual electricity consumption.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 23:

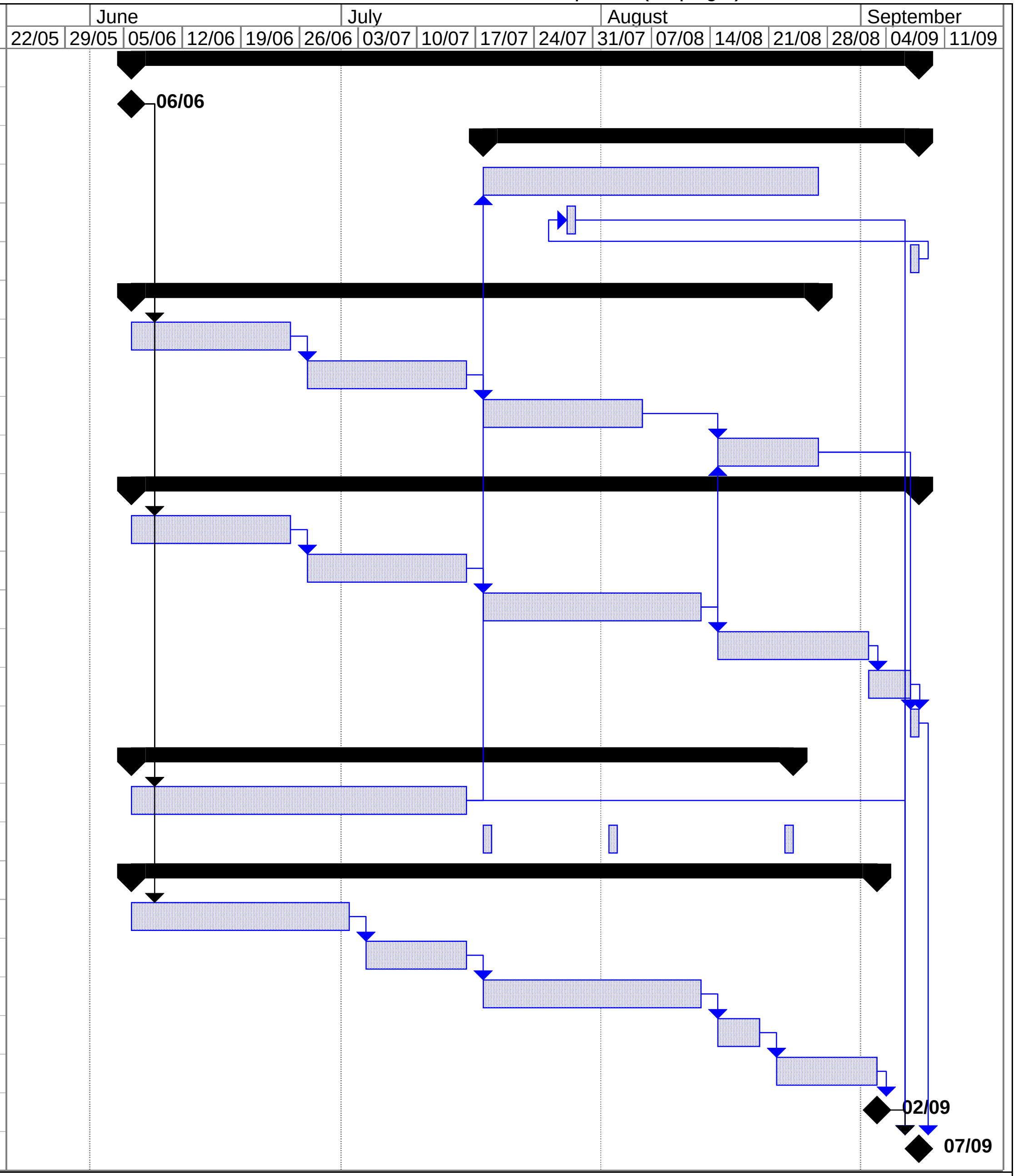
Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting**

Please provide a detailed timeline from Board Approval of the program to full program implementation and deployment. Please detail all significant steps and tasks needed to be undertaken.

RESPONSE:

Approximate duration from Board Approval to program implementation is expected to be between four to six months. A detailed project schedule is attached as Appendix A.

ID		Task Name	Duration	Start	Finish	Predecessors
1		**M and T Program Deployment**	**68 days**	**Mon 06/06/11**	**Wed 07/09/11**	
2		OEB Board Approval	0 days	Mon 06/06/11	Mon 06/06/11	
3		**Program Development**	**38 days**	**Mon 18/07/11**	**Wed 07/09/11**	
4		Develop M and T System Requirements	30 days	Mon 18/07/11	Fri 26/08/11	20
5		Initial Contractor Training Session	1 day	Thu 28/07/11	Thu 28/07/11	6FS-30 days
6		Prelaunch Contractor Trainign Session	1 day	Wed 07/09/11	Wed 07/09/11	
7		**Back Office**	**60 days**	**Mon 06/06/11**	**Fri 26/08/11**	
8		Participant Agreements	15 days	Mon 06/06/11	Fri 24/06/11	2
9		Legal Review	15 days	Mon 27/06/11	Fri 15/07/11	8
10		Forms Development	15 days	Mon 18/07/11	Fri 05/08/11	9
11		Web Interface	10 days	Mon 15/08/11	Fri 26/08/11	10,15
12		**Marketing**	**68 days**	**Mon 06/06/11**	**Wed 07/09/11**	
13		Finalize Marketing Plan	15 days	Mon 06/06/11	Fri 24/06/11	2
14		Procurement Process	15 days	Mon 27/06/11	Fri 15/07/11	13
15		Legal Review	20 days	Mon 18/07/11	Fri 12/08/11	14
16		Develop Creative	14 days	Mon 15/08/11	Thu 01/09/11	15
17		Print Materials	3 days	Fri 02/09/11	Tue 06/09/11	16
18		Launch Website	1 day	Wed 07/09/11	Wed 07/09/11	17,11
19		**Human Resources**	**57 days**	**Mon 06/06/11**	**Tue 23/08/11**	
20		Hire Program Manager	30 days	Mon 06/06/11	Fri 15/07/11	2
21		**Staff Training**	**27 days**	**Mon 18/07/11**	**Tue 23/08/11**	**20**
25		**Program M and V**	**65 days**	**Mon 06/06/11**	**Fri 02/09/11**	
26		Prepare RFP	20 days	Mon 06/06/11	Fri 01/07/11	2
27		Legal Review	10 days	Mon 04/07/11	Fri 15/07/11	26
28		Procurement Process	20 days	Mon 18/07/11	Fri 12/08/11	27
29		Review Response	5 days	Mon 15/08/11	Fri 19/08/11	28
30		Contract Negotiation	10 days	Mon 22/08/11	Fri 02/09/11	29
31		Contract Signed	0 days	Fri 02/09/11	Fri 02/09/11	30
32		Program Deployment	0 days	Wed 07/09/11	Wed 07/09/11	31,20,11,24,18,5



Project: M and T Deployment Schedul
Date: Tue 29/03/11

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 24:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting, p.4**

Please explain how “participants will be required to demonstrate that the results of the operational process changes implemented are maintain on a go forward basis”.

RESPONSE:

The program offers an incentive to encourage participants to sustain projected savings beyond the implementation period. In this manner, the expectation is that enhanced operational processes will be adopted by building operators and managers as the standard service level for the building.

In order to encourage a sustained level of effort during the term of the program, building operators and management customers will also be eligible for an energy savings incentive at a rate of $0.025 for each kWh saved as defined by the baseline. This performance incentive will be paid at the end of each year for savings achieved during the four-year program. To be eligible for this incentive, the annual kWh savings indicated must be equal to or greater than 8% with respect to the (normalized) baseline year kWh consumption. On the yearly anniversary of project completion, a qualified third-party energy professional will submit an annual project savings Measurement & Verification report.

Of equal importance in the long term, participants will be asked to provide assurance that resulting operational changes will be sustained for a minimum of five years in order to

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

assure persistence of savings. This assurance can be in the form of a binding agreement or commitment with the applicant or another party such as the building owner, facility or property manager who has operational responsibility for that facility.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 25:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting, p.14**

Please provide details of how the Applicant derived the estimated reduction of 0.86 MW and savings of 40.7 GWh.

RESPONSE:

The savings attributable to M&T systems are based on studies noting 5-15% savings based on industrial installations in the UK[1], and by the Department of Energy in the USA[2]. CIPEC recommends using 8%[3] energy savings as the basis of evaluating these systems. To be consistent with the CIPEC report THESL has used a factor of 8% to calculate potential electricity savings.

This yields the following savings calculations:

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[1] Zak, Juan, & Ramirez, Edwin. (1999). Introduction to monitoring and targeting. Proceedings of the Ministry of Economy and Planning (Cuba).

[2] Guidance for Electric Metering in Federal Buildings. (2006). US Department of Energy: Energy Efficiency and Renewable Energy.

[3] Office of Energy Efficiency of Natural Resources Canada. (2004). Energy management information systems. CIPEC.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

Savings and Market Penetration Assumptions

Description	Commercial	Industrial	Total
Total Sites	1912	564	2476
Load (MW)	1074	396	1470
Consumption (MWh)	6,193,800	2,044,700	8,238,500
Demand per Site (kW/site)	562	701	593
Consumption per Site (kWh/site)	3,239,435	3,625,355	3,327,342
System Penetration	5.0%	2.0%	
Demand Savings	2.0%	2.0%	
Consumption Savings	8.0%	8.0%	

Gross Annual Consumption and Demand Savings

Sector	Demand/Consumption	2011	2012	2013	2014	Total
Commercial	Demand (MW)	0.00	0.27	0.54	0.27	**1.07**
	Consumption (MWh)	0	6194	12388	6194	**24775**
Industrial	Demand (MW)	0.00	0.10	0.06	0.00	**0.16**
	Consumption (MWh)	0	2082	1190	0	**3272**
Total	**Demand (MW)**	**0.00**	**0.37**	**0.59**	**0.27**	**1.23**
	Consumption (MWh)	**0**	**8276**	**13577**	**6194**	**28047**
Cumulative	**Commercial (MWh)**	**0**	**6194**	**18581**	**24775**	**49550**
	Industrial (MWh)	**0**	**2082**	**3272**	**3272**	**8625**
	Consumption (MWh)	**0**	**8276**	**21853**	**28047**	**58175**

Net Annual Consumption and Demand Savings

Sector	Demand/Consumption	2011	2012	2013	2014	Total
Commercial	Demand (MW)	0.00	0.19	0.38	0.19	**0.75**
	Consumption (MWh)	0	4336	8671	4336	**17343**
Industrial	Demand (MW)	0.00	0.07	0.04	0.00	**0.11**
	Consumption (MWh)	0	1457	833	0	**2290**
Total	**Demand (MW)**	**0.00**	**0.26**	**0.42**	**0.19**	**0.86**
	Consumption (MWh)	**0**	**5793**	**9504**	**4336**	**19633**
Cumulative	**Commercial (MWh)**	**0**	**4336**	**13007**	**17343**	**34685**
	Industrial (MWh)	**0**	**1457**	**2290**	**2290**	**6037**
	Consumption (MWh)	**0**	**5793**	**15297**	**19633**	**40723**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

On this basis, the program cumulative net peak demand reduction has been estimated to be 0.86 MW and a cumulative electrical savings of 40.7 GWh at program conclusion.

Note that the estimated net savings include a free-ridership factor of 30%[4], although Evaluation, Measurement and Verification will determine actual results.

[4] This is the default free-rider factor for custom projects as noted in OEB Decision and Order, EB-2007-0096 (Page 9).

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 26:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting, p.17**

Please explain how the Applicant will "[l]everage relationships with professional and industry based organizations to promote program to their membership". Please provide the estimated budget for this and where it is found in the overall program budget.

RESPONSE:

If approved by the Board, THESL plans to include this program in its general description of CDM programs to the professional and industry based organizations/associations through its regular sales and marketing communications efforts. This is described under section 1.3 "Program Details". The cost of this leveraging has not been included and is entirely consistent with THESL's cross-promotional strategy. (See response to Board Staff Interrogatory 11)

The Sales and Marketing budget line items included under this budget identify incremental sales and marketing costs to promote the program.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 27:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting, p.18**

Please explain why the Applicant is limiting the program to buildings that have an average peak demand exceeding 200kW.

RESPONSE:

THESL established 200kW as the peak demand threshold of economic viability on the basis of its technical experience and familiarity with the Toronto marketplace. Below this threshold, the likelihood of projects being attractive to customers economically with sufficient material savings and worthy of their effort is low.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 28:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting, p.19**

With respect to the Incentive Application, please explain the baseline normalization process.

RESPONSE:

Participants must agree to baseline normalization to occur as a necessary part of the agreed savings reconciliation process.

Baseline normalization is a mathematical process to account for building and operational variations such as modified production levels, weather differences, building use, occupancy, etc. These considerations are commonly beyond the control of the participant and would otherwise unfairly skew comparisons in energy consumption even without the M&T measures. Baseline normalization allows for equitable energy savings assessments.

Baseline normalization is accomplished using a baseline adjustment mechanism submitted by the participant in conformance with International Performance Measurement & Verification Protocol practices, which is an industry standard. The M&T plan and the detailed M&T reports will be generated by the M&T system. THESL agreement will be required for all proposed baseline adjustments.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

This will provide the required information for the M&V of each project showing weather and/or production-normalized energy savings and peak demand reductions as required. Please refer to Appendix B of the Application for a description of M&T methodology.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 29:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting, p.24**

With respect to the budget,

a) Please provide detailed breakdown of the allocable and incentive costs.

b) Please provide a detailed breakdown of the fixed sales cost and variable operations costs.

RESPONSE:

a) Allocable costs represents management supervision and is calculated as a roll up of Total Fixed Costs plus Total Variable Costs multiplied by 2.8%.

Description	2011	2012	2013	2014	Total
Total Fixed Costs	$370,494	$341,745	$289,973	$164,088	$1,166,300
Total Variable Costs	$78,339	$162,068	$174,087	$158,442	$572,936
Total Allocable Cost	**$12,567**	**$14,107**	**$12,994**	**$9,031**	**$48,699**

Incentive Costs represent a roll up of Total Ongoing Performance Incentives plus Total Initial System Incentives. Total Ongoing Performance incentives and Total Initial System Incentives are based on an average project size ($) which includes software and hardware multiplied by the number of projects anticipated per year over the program duration.

b) A detailed breakdown of fixed sales and variable operations costs by year are as follows:

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

Staff Type	Task	2011					
		Number	Hours per Activity	Total Hours (incl. LUR)	Percent	Labour Cost - Unburdened	Labour Cost - Burdened
Clerical	Applications	24	7	224	11%	$6,302	$9,264
	Incentive Processing - Initial	24	4	128	6%	$5,618	$8,258
	Incentive Processing - Annual	0	2	0	0%	$0	$0
	Settlement	24	1	32	2%	$1,404	$2,065
	Administration	24	1	32	2%	$900	$1,323
	Total			**416**	**20%**	**$14,224**	**$20,910**
Energy Analyst	Review Initial Reports	24	7	224	11%	$9,831	$14,452
	Verify Installation	24	7	224	11%	$9,831	$14,452
	Review Savings Reports	0	14	0	0%	$0	$0
	Total			**448**	**22%**	**$19,663**	**$28,905**
Program Manager/ Settlement	Percent Allocation Only				25%	$22,823	$33,550
Energy Manager	Not applicable						
Manager	Percent Allocation Only				5%	$6,732	$9,896
Marketing Analyst	In marketting budget						
Key Account	Percent Allocation Only				100%	$91,292	$134,200
Total Labour Cost						**$154,735**	**$227,460**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

Staff Type	Task	2012					
		Number	Hours per Activity	Total Hours (incl. LUR)	Percent	Labour Cost - Unburdened	Labour Cost - Burdened
Clerical	Applications	55	7	513	25%	$14,730	$21,653
	Incentive Processing - Initial	55	4	293	14%	$13,132	$19,304
	Incentive Processing - Annual	24	2	64	3%	$1,836	$2,700
	Settlement	55	1	73	4%	$3,283	$4,826
	Administration	55	1	73	4%	$2,104	$3,093
	Total		0	**1017**	**49%**	**$35,086**	**$51,577**
Energy Analyst	Review Initial Reports	55	7	513	25%	$22,981	$33,782
	Verify Installation	55	7	513	25%	$22,981	$33,782
	Review Savings Reports	24	14	448	22%	$20,056	$29,483
	Total			**1475**	**71%**	**$66,018**	**$97,047**
Program Manager/ Settlement	Percent Allocation Only				25%	$23,280	$34,221
Energy Manager	Not applicable						
Manager	Percent Allocation Only				5%	$6,867	$10,094
Marketing Analyst	In marketting budget						
Key Account	Percent Allocation Only				100%	$93,118	$136,884
Total Labour Cost						**$224,369**	**$329,822**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

Staff Type	Task	2013					
		Number	Hours per Activity	Total Hours (incl. LUR)	Percent	Labour Cost - Unburdened	Labour Cost - Burdened
Clerical	Applications	28	7	261	13%	$7,649	$11,244
	Incentive Processing - Initial	28	4	149	7%	$6,819	$10,024
	Incentive Processing - Annual	79	2	211	10%	$6,166	$9,064
	Settlement	79	1	105	5%	$4,810	$7,071
	Administration	79	1	105	5%	$3,083	$4,532
	Total		0	**832**	**40%**	**$28,527**	**$41,935**
Energy Analyst	Review Initial Reports	28	7	261	13%	$11,933	$17,542
	Verify Installation	28	7	261	13%	$11,933	$17,542
	Review Savings Reports	79	14	1475	71%	$67,339	$98,988
	Total			**1997**	**96%**	**$91,206**	**$134,072**
Program Manager/ Settlement	Percent Allocation Only				15%	$14,247	$20,943
Energy Manager	Not applicable						
Manager	Percent Allocation Only				5%	$7,004	$10,296
Marketing Analyst	In marketting budget						
Key Account	Percent Allocation Only				75%	$71,235	$104,716
Total Labour Cost						**$212,219**	**$311,962**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

Staff Type	Task	2014					
		Number	Hours per Activity	Total Hours (incl. LUR)	Percent	Labour Cost - Unburdened	Labour Cost - Burdened
Clerical	Applications	0	7	0	0%	$0	$0
	Incentive Processing - Initial	0	4	0	0%	$0	$0
	Incentive Processing - Annual	107	2	285	14%	$8,518	$12,522
	Settlement	107	1	143	7%	$6,645	$9,768
	Administration	107	1	143	7%	$4,259	$6,261
	Total		0	**571**	**27%**	**$19,423**	**$28,551**
Energy Analyst	Review Initial Reports	0	7	0	0%	$0	$0
	Verify Installation	0	7	0	0%	$0	$0
	Review Savings Reports	107	14	1997	96%	$93,030	$136,754
	Total			**1997**	**96%**	**$93,030**	**$136,754**
Program Manager/ Settlement	Percent Allocation Only				10%	$9,129	$13,420
Energy Manager	Not applicable						
Manager	Percent Allocation Only				5%	$6,732	$9,896
Marketing Analyst	In marketing budget						
Key Account	Percent Allocation Only				25%	$22,823	$33,550
Total Labour Cost						**$151,137**	**$222,171**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 30:

Reference(s): **Commercial, Institutional and Small Industrial Monitoring & Targeting, p.25**

Please provide a basis for the input assumption of an operation life of 8 years.

RESPONSE:

Commercial, Institutional and Industrial operational expectancies vary widely from technology to technology, from application to application and from manufacturer to manufacturer. The typical range across the numerous software based variables is predictably five to ten years. Given the wide range of variables (applications, technology, manufacturer, operations) THESL settled on eight years as the median for operational expectancy.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 31:

Reference(s): Community Outreach and Education Initiative, p.4

Please provide budget and actual figures for the predecessor program for each year from 2007-2010.

RESPONSE:

Budget and actual figures for the Mass Market program under the Toronto Directive from 2007-2010 are shown in the following table:

	2007		2008		2009		2010	
Program	Budget	Actual	Budget	Actual	Budget	Actual	Budget	Actual
Mass Market	$ 267,296	$ 192,194	$ 2,199,110	$ 2,360,799	$ 2,085,587	$ 1,869,825	$ 3,052,452	$ 2,612,996

Toronto Directive was launched in the fourth quarter of 2007, as reflected in 2007 budget and actual figures.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 32:

Reference(s): Community Outreach and Education Initiative, p.4

Please explain in greater detail the Toronto Police Outreach segment of this Initiative.

RESPONSE:

During the summer of 2010, Toronto Police Services ("TPS") assigned a lead Officer to the Albion-Finch Neighbourhood Toronto Anti Violence Intervention Strategy ("TAVIS") Initiative. This is one of three neighbourhoods where TAVIS assigned additional police officers during the summer to make the neighbourhoods safer, but most importantly, to strengthen community relationships and create solutions to prevent the violence from returning. The assigned Officer noticed that many of the porch lights and rear yard lights were burnt out. As a result, TPS contacted THESL to partner in a lighting initiative.

By installing energy efficient compact fluorescent light bulbs, residents could increase their lighting at night while still reducing the electrical load on the grid with the energy efficient bulbs. The bulb would serve as a symbol to help these communities understand the benefits of energy efficiency and the advantages that could be had with Time-Of-Use rates (using electricity during the lowest price period). More importantly to TAVIS, the initiative would illuminate the area, therefore reducing the opportunity for criminal activity.

During the 2010 Light the Night program, THESL discovered that thousands of porch

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

lights had 100-watt incandescent bulbs installed in fixtures with 60-watt capacity. The bulbs were changed to 13-watt (or similar).

Other event partners that engaged with THESL during this 2010 outreach included Toronto Community Housing local tenant representatives and Action for Neighbourhood Change.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 33:

Reference(s): Community Outreach and Education Initiative, p.4

With respect to the budget,

a) Please explain why there is no variable cost associated with this program.

b) Please provide details about the legal costs incurred by this program.

RESPONSE:

a) This is an education based program, so is it not tied to variable costs.

b) Legal costs include reviewing and approve all RFPs, contracts and data protection agreements. All marketing material is reviewed by Legal.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 34:

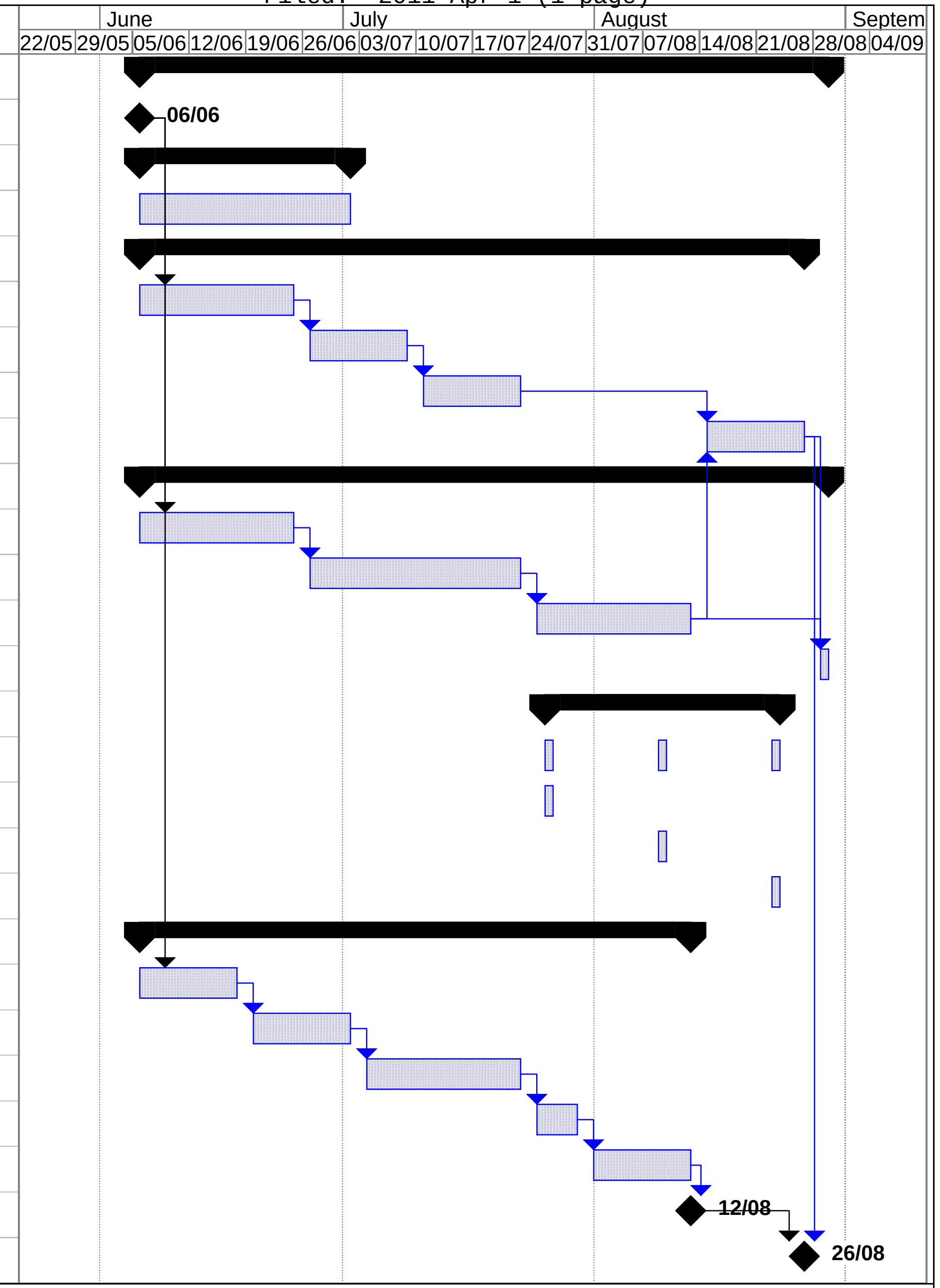
Reference(s): Flat Rate Water Heater Conversion & Demand Response

Please provide a detailed timeline from Board Approval of the program to full program implementation and deployment. Please detail all significant steps and tasks needed to be undertaken.

RESPONSE:

Please refer to the detailed project schedule attached as Appendix A.

ID		Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		**FRWH Program Deployment**	**61 days**	**Mon 06/06/11**	**Mon 29/08/11**		
2		OEB Board Approval	0 days	Mon 06/06/11	Mon 06/06/11		
3		**Program Development**	**20 days**	**Mon 06/06/11**	**Fri 01/07/11**		
4		Develop Conversion Specification	20 days	Mon 06/06/11	Fri 01/07/11		
5		**Back Office**	**60 days**	**Mon 06/06/11**	**Fri 26/08/11**		
6		Participant Agreements	15 days	Mon 06/06/11	Fri 24/06/11	2	
7		Legal Review	10 days	Mon 27/06/11	Fri 08/07/11	6	
8		Forms Development	10 days	Mon 11/07/11	Fri 22/07/11	7	
9		Web Interface	10 days	Mon 15/08/11	Fri 26/08/11	8,13	
10		**Marketing**	**61 days**	**Mon 06/06/11**	**Mon 29/08/11**		
11		Procurement Process for Vendors	15 days	Mon 06/06/11	Fri 24/06/11	2	
12		Legal Approval	20 days	Mon 27/06/11	Fri 22/07/11	11	
13		Develop Creative	15 days	Mon 25/07/11	Fri 12/08/11	12	
14		Launch Website	1 day	Mon 29/08/11	Mon 29/08/11	13,9	
15		**Human Resources**	**21 days**	**Tue 26/07/11**	**Tue 23/08/11**		
16		**Staff Training**	**21 days**	**Tue 26/07/11**	**Tue 23/08/11**		
17		Staff Training 1	1 day	Tue 26/07/11	Tue 26/07/11		
18		Staff Training 2	1 day	Tue 09/08/11	Tue 09/08/11		
19		Staff Training 3	1 day	Tue 23/08/11	Tue 23/08/11		
20		**Program M and V**	**50 days**	**Mon 06/06/11**	**Fri 12/08/11**		
21		Prepare RFP	10 days	Mon 06/06/11	Fri 17/06/11	2	
22		Legal Review	10 days	Mon 20/06/11	Fri 01/07/11	21	
23		Procurement Process	15 days	Mon 04/07/11	Fri 22/07/11	22	
24		Review Response	5 days	Mon 25/07/11	Fri 29/07/11	23	
25		Contract Negotiation	10 days	Mon 01/08/11	Fri 12/08/11	24	
26		Contract Signed	0 days	Fri 12/08/11	Fri 12/08/11	25	
27		Program Deployment	0 days	Fri 26/08/11	Fri 26/08/11	26,9	



Project: FRWH Deployment Schedule
Date: Tue 29/03/11

Task | Progress | Summary | External Tasks | Deadline
Split | Milestone | Project Summary | External Milestone

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 35:

Reference(s): Flat Rate Water Heater Conversion & Demand Response, p.11

Please explain why normal marketing tactics are no longer effective. Please provide evidence to support this conclusion.

RESPONSE:

THESL has implemented a communication plan that has been active since 2008 to encourage customers to switch to metered service. Communications to customers were sent out in eight groups (consisting of pamphlets, letters and automated phone calls, first notice letter and pamphlet, reminder, phone call, second reminder letter, etc.) over the three years. Even though there has been continuous communication with the customer base, the number of conversions has declined significantly.

The following illustrates the decline in the number of flat rate water heaters to meter service:

Year	Number of Tanks Converted	Percent Change, 2008 base
2008	11,318	NA
2009	9,679	(14)%
2010	2,435	(78)%

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 36:

Reference(s): Flat Rate Water Heater Conversion & Demand Response, p.14

Please explain why the project M&V will be limited to only 30 customers per year.

RESPONSE:

See response to Board Staff Interrogatory 56(a).

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 37:

Reference(s): Flat Rate Water Heater Conversion & Demand Response, p.15

With respect to the budget:

a) Please provide a detailed breakdown of the variable vendor and administrative costs.

b) Please provide a detailed breakdown of the allocable and incentive costs.

RESPONSE:

The following table provides detailed breakdowns for variable administration, incentive, and vendor costs:

1) Incentive Costs and Vendor Costs

Type	2011	2012	2013	2014	Total
Conversions	**1471**	**2942**	**0**	**0**	**4413**
Average Incentive (951 kWh x $0.20 per kWh)	**$279,834**	**$559,668**	**$0**	**$0**	**$839,503**
Vendors Cost ($320 per load control switch)	**$470,699**	**$941,397**	**$0**	**$0**	**$1,412,096**

2) Variable Administration Costs

Type	2011	2012	2013	2014	Total
Applications	**$14,194**	**$28,955**	**$0**	**$0**	**$43,149**
Incentive Processing	**$22,144**	**$45,174**	**$0**	**$0**	**$67,318**
Settlement	**$22,144**	**$45,174**	**$0**	**$0**	**$67,318**
Administration/Call Centre	**$14,194**	**$28,955**	**$0**	**$0**	**$43,149**
Clerical Staff	**$72,676**	**$148,258**	**$0**	**$0**	**$220,934**
80% Allocated to Variable Costs	**$58,141**	**$118,607**	**$0**	**$0**	**$176,747**
Total Variable Admin Costs	**$58,141**	**$118,607**	**$0**	**$0**	**$176,747**

For allocable costs please refer to the response to SEC Interrogatory 20. Incentives are based on 961 kWh savings per tank (refer to page 9 of the Application), multiplied by $0.20 per kWh, multiplied by the number of tanks converted.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 38:

Reference(s): **Greening Greater Toronto Commercial Building Energy Initiative. p.4**

Please provide the financial amounts that have been allocated towards the CBEI from the Applicant in 2010. Please provide the original business case for the creation of the CBEI and any supporting documentation.

RESPONSE:

THESL contributed $250,000 in 2010 to support the work of the CBEI. Please see Appendix A to this Schedule.

GREENING GREATER TORONTO

February 5, 2010

Chris Tyrell
Vice President and Chief Conservation Officer
Toronto Hydro
14 Carlton St Toronto, ON M5B 1K5

Dear Chris,

Re: Funding for Greening Greater Toronto's Commercial Building Energy Initiative

I am writing to follow up on our brief chat after the January 21 Commercial Building Energy Initiative (CBEI) Leadership Council meeting. I will be away for the next two weeks and, while you and I are scheduled to meet the week of February 22, there is some urgency to this and I wanted to submit a proposal for you to consider before we meet. Paul Shervill and I have also discussed this and I understand that he intends to follow up with you shortly.

You were briefed on our progress to date at the CBEI meeting, but I will briefly summarize it below before laying out our 2010 plan and request for Toronto Hydro's support of that plan.

Progress to Date: Leadership Council and Landlord/Tenant Summit

Greening Greater Toronto's CBEI Leadership Council is comprised of over 45 senior representatives of major landlords, tenants, ESCOs, and technical service experts committed to driving greater energy efficiency in commercial buildings (list attached as Appendix A). Because of its unique multi-stakeholder makeup, and the vast amount of commercial space its members own or occupy (the owners represent alone over 40 percent of the GTA's 179 million square feet of office space), the Leadership Council is uniquely suited to overcome obstacles and create, adopt and promote strategies for increased energy efficiency within members' own organizations and within the broader real estate community. Council members are actively engaged and have already devoted serious leadership, volunteer time and other resources to set this project up to produce solid results.

The Leadership Council is also leveraging the Greening Greater Toronto Task Force (53 members), Green Procurement Leadership Council (39 members) and Partners (172 organizational members and counting) (full list at http://www.greeninggreatertoronto.ca/partners/). By increasing the demand for retrofits and other energy efficiency measures, the Commercial Building Energy Initiative is supporting Ontario-based companies in the retrofit industry, creating additional jobs in the retrofitting and related sectors, and improving the energy performance of the Province's commercial building stock.

On September 29, 2009, we and BOMA Toronto presented a half-day Summit for the Leadership Council and over 50 additional key stakeholders to identify and discuss the major issues inhibiting greater energy efficiency and to engage these and other participants in addressing them. Major

GTA tenants representing over 38 million square feet of GTA office space and building owners representing over 40 percent of space took part in the Summit dialogue about the barriers to broader energy efficiency and solutions for change, a discussion which yielded some interesting “aha's”.

2010 Action Plan

At the January 21 Leadership Council meeting, members committed to a plan to make commercial buildings more energy efficient and reduce overall carbon output. Specific actions we will undertake in 2010 include:

- **Building a catalogue of case studies and energy benchmarks to promote best practices of GTA tenants and building owners, promoting it with existing information sources**
  - To build this quickly, each Council member has committed to contribute a case study by the end of February

- **Launching a “Greening our Workplace” series, where tenants will host structured meetings with other tenants in their buildings (and their landlords) to showcase, inspire and inform further tenant-led energy efficiency initiatives**
  - We are scheduling three initial events, the first with Stikeman Elliott LLP in Commerce Court, to get this underway

- **Developing, facilitating and documenting owner-tenant collaborations at high potential buildings to improve and expand that partnership model**
  - Council members with large buildings have each committed to selecting a high potential building by the end of February
  - BMO and Brookfield Properties kicked things off by announcing their formal commitment to work together to make First Canadian Place more energy efficient (press release attached as Appendix B)

- **Generating a building energy baseline for Council members’ energy usage, with the goal of launching a broader corporate challenge at the next Toronto Summit in February 10-11, 2010**
  - Council member building owners have committed to work with us to determine the conditions under which they would be willing to pool their building data, including energy reductions, and to agree on applicable metrics and establishing building targets
  - The Council will measure progress, report key 2010 energy savings initiatives and results, and publicly celebrate “wins”

These actions and our corresponding work plan respond to the substantial feedback and direction we have received from the OPA, BOMA Toronto, and the many Leadership Council members we have consulted. Given this, and the commitment of our Leadership Council, we are confident that the CBEI action plan will effectively drive the uptake of CDM Programs and the implementation of energy reduction measures in the GTA and the rest of Ontario.

Funding Request

Greening Greater Toronto completed the initial phase of the CBEI with minimal funding, including a contribution from BOMA Toronto, and significant *pro bono* contributions from Council members, including The Boston Consulting Group. We are now well-poised to achieve the key objectives outlined above but, while we will continue to source and leverage considerable volunteer and *pro bono* resources, we require funding in order to proceed.

As I mentioned when we spoke, we have been in discussions with BOMA Toronto about further funding but, given that its CDM mandate is now winding down, BOMA is not prepared to provide seed funding for the 2010-11 CBEI activities planned. We certainly understand that performance targets are a central aspect of CDM programs and are prepared to accept a small portion of funding contingent on achieving certain metrics but are not in a position to undertake a program of this intensity without funding in hand.

With the strong support for our planned activities, we are keen to get underway and have stripped down our budget in the hopes that we can quickly get the funding we need to move forward. As you will see from our budget summary in Appendix C, our main costs are staff time - we will make significant use of donated resources, including our donated office space and *pro bono* consulting work from The Boston Consulting Group.

Toronto Hydro has long been a terrific partner of the TCSA and we hope very much to deepen this partnership through the CBEI. As mentioned, I will be away until February 22 and look forward to speaking with you after that. In the meantime, our Chair John Tory will be available to you if needed at 416-309-4480 ext.508 or jhtory@rogers.blackberry.net.

Best regards,

Julia Deans

Julia Deans, CEO

Copy: Paul Shervill, Vice-President, Conservation, Ontario Power Authority
John Tory, Chair, Toronto City Summit Alliance

GREENING GREATER TORONTO

Appendix A - COMMERCIAL BUILDING ENERGY LEADERSHIP COUNCIL

Co - CHAIRS

Royal Bank of Canada
Linda Mantia
Senior Vice President, Procurement and Corporate Real Estate

BMO Financial Group
Michael Thornburrow
Senior Vice President, Corporate Real Estate and Strategic Sourcing

TENANTS

Bell
Maarika Paul
Senior Vice President, Corporate Services

BMO Financial Group
Jim Johnston, Director, Environmental Sustainability

CIBC
Barb Pohner, Senior Director, Corporate Real Estate

City of Toronto
Jim Kamstra, Acting Director, Business & Strategic Innovation

Environics Communications
Bruce MacLellan, President

Government of Canada
Paul Wong, A/Regional Director General, Ontario Region

Ontario Realty Corporation
David Glass, President & CEO

Rogers
Guy Knowles, Vice President Real Estate

Scotiabank
Andrew Lennox, Senior Vice President Real Estate
Zev Rosenblum, Director Real Estate

Stikeman Elliott
Jean McLeod

TD Bank Financial Group
Roger Johnson, Senior Vice President Corporate Real Estate & Procurement

Telus
Trish Clarry, Executive Director, Real Estate Enterprise Services

WalMart
Carmine Francella, Director of Real Estate and Development

BUILDING MANAGERS & OWNERS

Brookfield Properties
Stefan Dembinski, Senior Vice President, Asset Management Eastern Canada

Cadillac Fairview
Scott Pennock, Senior Vice President, Toronto Office Portfolio;
Karen Jalon, National Sustainability Director

CREIT
Andy Robins

First Capital Realty
Peter Papagiannis, Vice President Property Management

GE Capital Real Estate
Tony Maduri, Regional Director GTA

GWL Realty Advisors
Mike Snell, Senior Vice President, Asset Management

Manulife Financial
Stephani Kingsmill
Senior Vice President and General Manager, Real Estate;
Todd MacLaughlin, Engineering and Technical Services Director, Real Estate

Menkes Developments
Andrew Hoffman, Chief Operating Officer

Morguard Investments
Derek Billsman, Director Strategic Initiatives

Northam Properties
Craig Walters, Senior Vice President

Oxford Properties Group Inc.
Darryl Neate, Manager, Sustainable Programs

SERVICE PROVIDERS (TECHNICAL & PROFESSIONAL)

Ameresco
Sam Goldberg

Bennett Jones
Leonard Griffiths, Partner

Cushman & Wakefield LePage
Pierre Bergevin, President &CEO;
Nancy Cohen, Vice President, Strategic Occupancy Planning

David Peltz

Enerlife
Ian Jarvis

Enermodal
Ian Sinclair

Halsall
Doug Webber

Toronto Hydro Energy Services
Chris Tyrell, President

PARTNER ORGANIZATIONS

BOMA Toronto
Chris Conway, Executive Vice President and Chief Staff Officer

Canada Green Building Council
Lyle Shipley, Executive Director, Toronto Chapter

The Continuum Network
Elisa Turner

Ontario Power Authority
Paul Shervill, Vice President, Conservation and Sector Development
Steve Mooney, Segment Manager, Commercial Buildings & Sector Development

Province of Ontario - Climate Change Secretariat
Rachel Kampus, Director of Policy

Real Estate Search Corp
Iain Dobson

REALpac
S. Michael Brooks
Chief Executive Officer

Toronto and Region Conservation Authority
Brian Denney, CAO

WWF-Canada *(ex-officio)*
Gerald Butts, President & CEO

Zerofootprint
Ron Dembo, Founder & CEO

Appendix B

FOR IMMEDIATE RELEASE

Greening Greater Toronto Announces Commitment by Owners and Tenants to Green the GTA's Largest Office Buildings

TORONTO, Jan. 28, 2010 – Greening Greater Toronto today announced that owners and tenants of the largest commercial buildings in the Greater Toronto Area (GTA) have made the formal commitment to work together to make office towers more energy efficient and reduce overall carbon output.

The commitment came at a meeting of Greening Greater Toronto's Commercial Building Energy Initiative (CBEI) Leadership Council, comprising major building owners, tenants and real estate professionals from across the GTA.

The meeting was co-hosted by Commercial Building Energy Initiative Co-Chairs Michael Thornburrow, Senior Vice President, Corporate Real Estate and Strategic Sourcing, BMO Financial Group, and Linda Mantia, Senior Vice President, Procurement and Corporate Real Estate, RBC Financial Group.

"We are delighted that the leaders of the real estate sector have come together to take cooperative actions to accelerate the energy efficiency of commercial buildings in the GTA," said Mantia. "By convening this group of building owners and tenants, we have an exciting opportunity to work cooperatively to make our workplaces more sustainable and reduce their environmental impact."

The CBEI Leadership Council members announced that its members had committed to promote greater energy efficiency by agreeing to the following four components:

- Building a catalogue of case studies and energy benchmarks to promote best practices of GTA tenants and building owners;
- Launching a "Greening our Workplace" series, where tenants will host other tenants of the same building to showcase recent tenant-led retrofit initiatives;
- Expanding and improving the effectiveness of the owner-tenant partnership model by indentifying and facilitating landlord-tenant working groups at "high-priority" buildings; and
- Committing to measure Council members' energy usage, with the goal of launching a corporate challenge.

“Commercial buildings are one of the key drivers of the GTA’s carbon emissions and one of the largest consumers of energy in Ontario,” said Thornburrow. “It’s vital for both owners and tenants to work together to make our office buildings more environmentally sustainable and significantly reduce greenhouse gas emissions.”

As part of this initiative, Greening Greater Toronto announced that the Bank of Montreal and Brookfield Properties have committed to work together to reduce energy usage, and will be piloting this approach at First Canadian Place in downtown Toronto.

“This commitment marks an important step in overcoming the barriers to making the GTA’s office towers more energy efficient,” said Julia Deans, CEO of the Toronto City Summit Alliance. “The Toronto City Summit Alliance’s Greening Greater Toronto initiative has identified commercial building retrofits as a key opportunity to tackle climate change and accelerate the development of a green economy and related jobs. By breaking the owner-tenant gridlock through collaboration and teamwork, we can combine commercial building retrofits with behavioural changes to produce a positive result for all.”

The Commercial Building Energy Initiative, one of four identified by Greening Greater Toronto to address the region's environmental challenges, is aimed at breaking down the barriers to achieve greater resource efficiency in the GTA's existing commercial building stock.

- 30 –

About Greening Greater Toronto:

Greening Greater Toronto (www.greeninggreatertoronto.ca) is an initiative of the Toronto City Summit Alliance, a coalition of civic leaders who develop and launch solutions to pressing social and economic challenges in the Toronto region. More than 150 partners from corporations, industry, government, and the non-profit sector have joined the Greening Greater Toronto initiative, which aims to make the Greater Toronto Area the greenest city region in North America. They and others are engaged in four initial programs to address the region’s environmental challenges, including: driving a large-scale retrofit of Toronto region commercial buildings; creating a local emissions reduction fund; developing a green procurement initiative; and building a network of public education/demonstration centres.

Media Contact:

Rebecca Geller
Communications and Events Officer, Toronto City Summit Alliance
rebecca.geller@torontocitysummit.ca, (416) 309-4480 x.509

Appendix C

Greening Greater Toronto
Commercial Building Energy Initiative Expense Budget
March 2010 – February 2011

EXPENSE	
Equipment Lease	$ 1,923
Gen Administration	$ 1,998
IT	$ 4,396
Staff Expense [1]	$ 226,403
Rent and Utilities [2]	$ -
Program Expense	$ 12,700
Professional Fees	
Accounting	$ 1,998
Travel & Entertainment	$ 1,200
Total Expense	***$ 250,618***

[1] Includes GST and HST.
[2] Donated resources include:

		Estimated Value
1.	The Boston Consulting Group – Consulting and staff support	$300,000
2.	Environics - Communications and media relations support	$ 20,000
3.	Ontario Power Authority – Technical resources	$ 50,000
4.	Corporate sponsor – Office space and facilities	$ 33,000
5.	Gowlings LLP – Legal services	$ 10,000
		$413,000

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 39:

Reference(s): **Greening Greater Toronto Commercial Building Energy Initiative. p.13**

Please provide a breakdown of the variable operation cost budgeted.

RESPONSE:

Please see response to Board Staff Interrogatory 62.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 40:

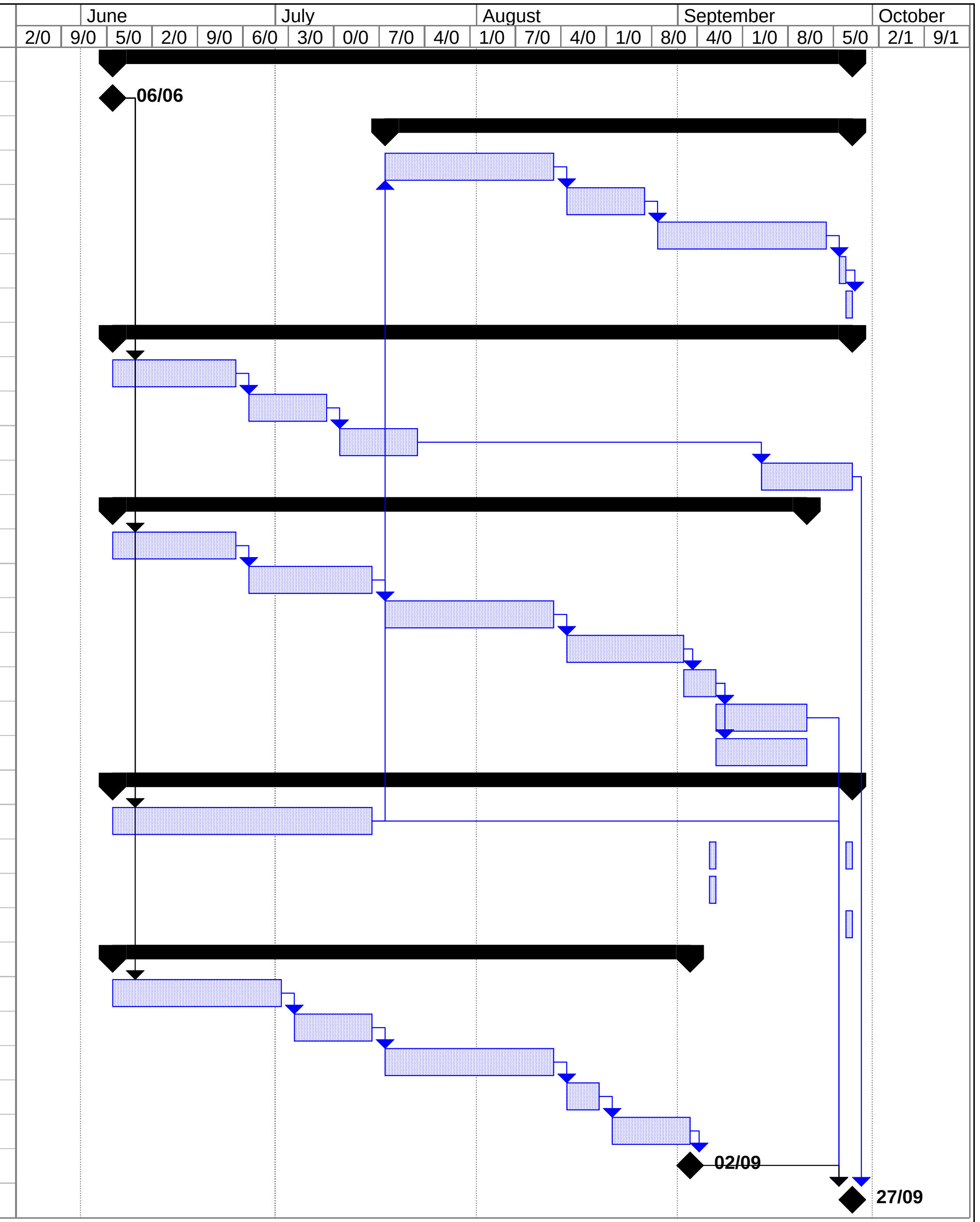
Reference(s): **Hydronic System Balancing Program**

Please provide a detailed timeline from Board Approval of the program to full program implementation and deployment. Please detail all significant steps and tasks needed to be undertaken.

RESPONSE:

Please refer to the detailed project schedules attached as Appendix A.

ID		Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		**HSBP Program Deployment**	**82 days**	**Mon 06/06/11**	**Tue 27/09/11**		
2		OEB Board Approval	0 days	Mon 06/06/11	Mon 06/06/11		
3		**System Deployment**	**52 days**	**Mon 18/07/11**	**Tue 27/09/11**		
4		Develop Contractor Qualifications	20 days	Mon 18/07/11	Fri 12/08/11	23	
5		Legal Review	10 days	Mon 15/08/11	Fri 26/08/11	4	
6		Establish Contractor List	20 days	Mon 29/08/11	Fri 23/09/11	5	
7		Initial Contractor Training Session	1 day	Mon 26/09/11	Mon 26/09/11	6	
8		Prelaunch Contractor Trainign Session	1 day	Tue 27/09/11	Tue 27/09/11	7	
9		**Back Office**	**82 days**	**Mon 06/06/11**	**Tue 27/09/11**		
10		Participant Agreements	15 days	Mon 06/06/11	Fri 24/06/11	2	
11		Legal Review	10 days	Mon 27/06/11	Fri 08/07/11	10	
12		Forms Development	10 days	Mon 11/07/11	Fri 22/07/11	11	
13		Web Interface	10 days	Wed 14/09/11	Tue 27/09/11	12	
14		**Marketing**	**77 days**	**Mon 06/06/11**	**Tue 20/09/11**		
15		Finalize Marketing Plan	15 days	Mon 06/06/11	Fri 24/06/11	2	
16		Procurment Process	15 days	Mon 27/06/11	Fri 15/07/11	15	
17		Legal Review	20 days	Mon 18/07/11	Fri 12/08/11	16	
18		Develop Creative	14 days	Mon 15/08/11	Thu 01/09/11	17	
19		Print Materials	3 days	Fri 02/09/11	Tue 06/09/11	18	
20		Launch Website	10 days	Wed 07/09/11	Tue 20/09/11	19	
21		Media Plan	10 days	Wed 07/09/11	Tue 20/09/11	19	
22		**Human Resources**	**82 days**	**Mon 06/06/11**	**Tue 27/09/11**		
23		Hire Program Manager	30 days	Mon 06/06/11	Fri 15/07/11	2	
24		**Staff Training**	**16 days**	**Tue 06/09/11**	**Tue 27/09/11**	**23**	
25		Staff Training 1	1 day	Tue 06/09/11	Tue 06/09/11		
26		Staff Training 2	1 day	Tue 27/09/11	Tue 27/09/11		
27		**Program M and V**	**65 days**	**Mon 06/06/11**	**Fri 02/09/11**		
28		Prepare RFP	20 days	Mon 06/06/11	Fri 01/07/11	2	
29		Legal Review	10 days	Mon 04/07/11	Fri 15/07/11	28	
30		Procurement Process	20 days	Mon 18/07/11	Fri 12/08/11	29	
31		Review Response	5 days	Mon 15/08/11	Fri 19/08/11	30	
32		Contract Negotiation	10 days	Mon 22/08/11	Fri 02/09/11	31	
33		Contract Signed	0 days	Fri 02/09/11	Fri 02/09/11	32	
34		Program Deployment	0 days	Tue 27/09/11	Tue 27/09/11	33,23,20,13	



Project: HSBP Deployment Schedule2
Date: Tue 29/03/11

Task		Progress		Summary		External Tasks		Deadline	
Split		Milestone		Project Summary		External Milestone			

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 41:

Reference(s): Hydronic System Balancing Program, p.6

Please explain why the balancing assessment incentive is limited based on amount per facility and not per pump.

RESPONSE:

The incentive is limited on a per facility basis as there are relatively significant setup costs involved for the balancing contractor, which are more consistent with a per facility incentive than a per pump incentive. A facility-based approach also makes the processing of the applications and approvals more cost effective.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 42:

Reference(s): **Hydronic System Balancing Program, p.6**

Please provide examples of the proposed measures customers must implement to be eligible for the incentive.

RESPONSE:

The customer must commit to completing HSBP measures identified in the assessment that have a simple payback, including incentives, of less than one year within 12 months of assessment completion.

HSBP measures can include:

- Applying variable frequency drives.
- Trimming impellers on over-sized chilled/hot water main circulation pumps.
- Retrofitting the domestic cold water booster pumps with multi-stage pumps.
- Applying variable frequency drives and controls to domestic cold water booster pumps.
- Identifying mechanical deficiencies associated with the distribution systems.
- Converting systems to variable flow.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 43:

Reference(s): Hydronic System Balancing Program, p.22

With respect to the budget,

a) Please provide a breakdown of the fixed operation cost.

b) Please provide a breakdown of the variable administrative and operation costs.

c) Please explain why the total fixed costs line item is not the aggregation of the fixed costs.

RESPONSE:

a) See table for breakdown of variable administrative, operation costs, and fixed operation costs.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

1) Variable Administration Costs

Type	2011	2012	2013	2014	Total
Audit Application	$718	$1,914	$1,436	$718	**$4,786**
Audit Incentive Processing	$1,120	$2,987	$2,240	$1,120	**$7,467**
Measure Application	$1,436	$3,829	$2,872	$1,436	**$9,572**
Measure Processing	$373	$2,240	$3,734	$1,120	**$7,467**
Settlement	$1,307	$4,107	$4,107	$1,680	**$11,201**
Administration	$1,005	$2,632	$2,632	$1,077	**$7,347**
Clerical/Analyst	**$5,959**	**$17,710**	**$17,020**	**$7,151**	**$47,840**
80% Allocated to Variable Cost	**$4,767**	**$14,168**	**$13,616**	**$5,721**	**$38,272**
Total Variable Admin Costs	**$4,767**	**$14,168**	**$13,616**	**$5,721**	**$38,272**

2) Variable Operation Costs

Type	2011	2012	2013	2014	Total
Energy Analyst	$23,539	$79,990	$100,235	$38,055	**$241,818**
Program Manager/Settlement	$7,045	$7,186	$7,330	$7,045	**$28,607**
Energy Manager	$140,910	$107,796	$105,682	$42,273	**$396,661**
Manager	$10,391	$10,599	$10,811	$10,391	**$42,191**
Key Account	$7,045	$7,186	$7,330	$7,045	**$28,607**
Operation Costs	**$188,931**	**$212,757**	**$231,388**	**$104,809**	**$737,885**
80% Allocated to Variable Cost	**$151,144**	**$170,206**	**$185,110**	**$83,847**	**$590,308**
Total Variable Operation Costs	**$151,144**	**$170,206**	**$185,110**	**$83,847**	**$590,308**

3) Fixed Operation Costs

Type	2011	2012	2013	2014	Total
Energy Analyst	$23,539	$79,990	$100,235	$38,055	**$241,818**
Program Manager/Settlement	$7,045	$7,186	$7,330	$7,045	**$28,607**
Energy Manager	$140,910	$107,796	$105,682	$42,273	**$396,661**
Manager	$10,391	$10,599	$10,811	$10,391	**$42,191**
Key Account	$7,045	$7,186	$7,330	$7,045	**$28,607**
Operation Costs	**$188,931**	**$212,757**	**$231,388**	**$104,809**	**$737,885**
20% Allocated to Fixed Cost	**$37,786**	**$42,551**	**$46,278**	**$20,962**	**$147,577**
Total Fixed Operation Costs	**$37,786**	**$42,551**	**$46,278**	**$20,962**	**$147,577**

b) See a) above.

c) The Program Budget chart found on page 22 of the Hydronic System Balancing Program incorrectly displays the total fixed costs. The description column is offset

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

by one row. The total amount of fixed cost is found in the row title Variable Costs. The corrected Program Budget table is as follows:

Description	2011	2012	2013	2014	Total
Marginal Costs					
Fixed Costs					
Legal Cost	$26,250	$5,775	$5,775	$5,775	**$43,575**
Marketing	$47,250	$21,450	$21,450	$21,450	**$111,600**
Sales	$6,710	$6,844	$6,981	$6,710	**$27,245**
Program EM&V	$25,000	$25,000	$25,000	$25,000	**$100,000**
Administrative Costs	$1,192	$3,542	$3,404	$3,404	**$11,542**
Operation Cost	$37,786	$42,551	$46,278	$20,962	**$147,577**
Contractor Training	$22,500	$7,500	$7,500	$7,500	**$45,000**
Total Fixed Costs	**$166,688**	**$112,663**	**$116,388**	**$90,801**	**$486,539**
Variable Costs					
Administrative Costs	$4,767	$14,168	$17,020	$7,151	**$43,106**
Operation Cost	$151,144	$170,206	$231,388	$104,809	**$657,547**
Project M&V	$0	$0	$0	$0	**$0**
Audit Cost	$0	$0	$0	$0	**$0**
	$0	$0	$0	$0	**$0**
Total Variable Costs	**$155,912**	**$184,374**	**$248,408**	**$111,960**	**$700,653**
Total Marginal Cost	**$322,600**	**$297,036**	**$364,796**	**$202,761**	**$1,187,193**
Total Allocable Cost	$9,033	$8,317	$10,214	$5,677	**$33,241**
Total Program Costs	**$331,632**	**$305,353**	**$375,010**	**$208,438**	**$1,220,434**
Total Incentives	$249,387	$1,124,320	$1,601,067	$524,960	$3,499,734
Total Budget	**$581,019**	**$1,429,673**	**$1,976,077**	**$733,398**	**$4,720,167**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 44:

Reference(s): In Store Engagement and Education Initiative, p.6

With respect to the six years of past retail partnerships and retail based events:

a) Please provide evidence to sustain the conclusion that there have been unprecedented participation rates over the past six years.

b) Please provide the communication plans, that would be similar in type to that referenced on page 8 for paid media, that were in place for the previous program or programs.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 45:

Reference(s): In Store Engagement and Education Initiative, p.8

Please provide details on how the Applicant calculates that its proposed program will reach 80% of its target audience a minimum of 6 times.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 46:

Reference(s): In Store Engagement and Education Initiative, p.8

Has a communication plan for paid media been developed for the implementation of this program yet? If so please provide a copy of the plan.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 47:

Reference(s): In Store Engagement and Education Initiative, p.11

With respect to the budget:

a) Please provide a detailed breakdown of the marketing and external costs.

b) Please provide details about the legal costs incurred by this program.

c) Please provide a detailed breakdown and explanation of the incentives portion of the budget.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 48:

Reference(s): In Store Engagement and Education Initiative

Please explain why this program requires third-party EM&V.

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 49:

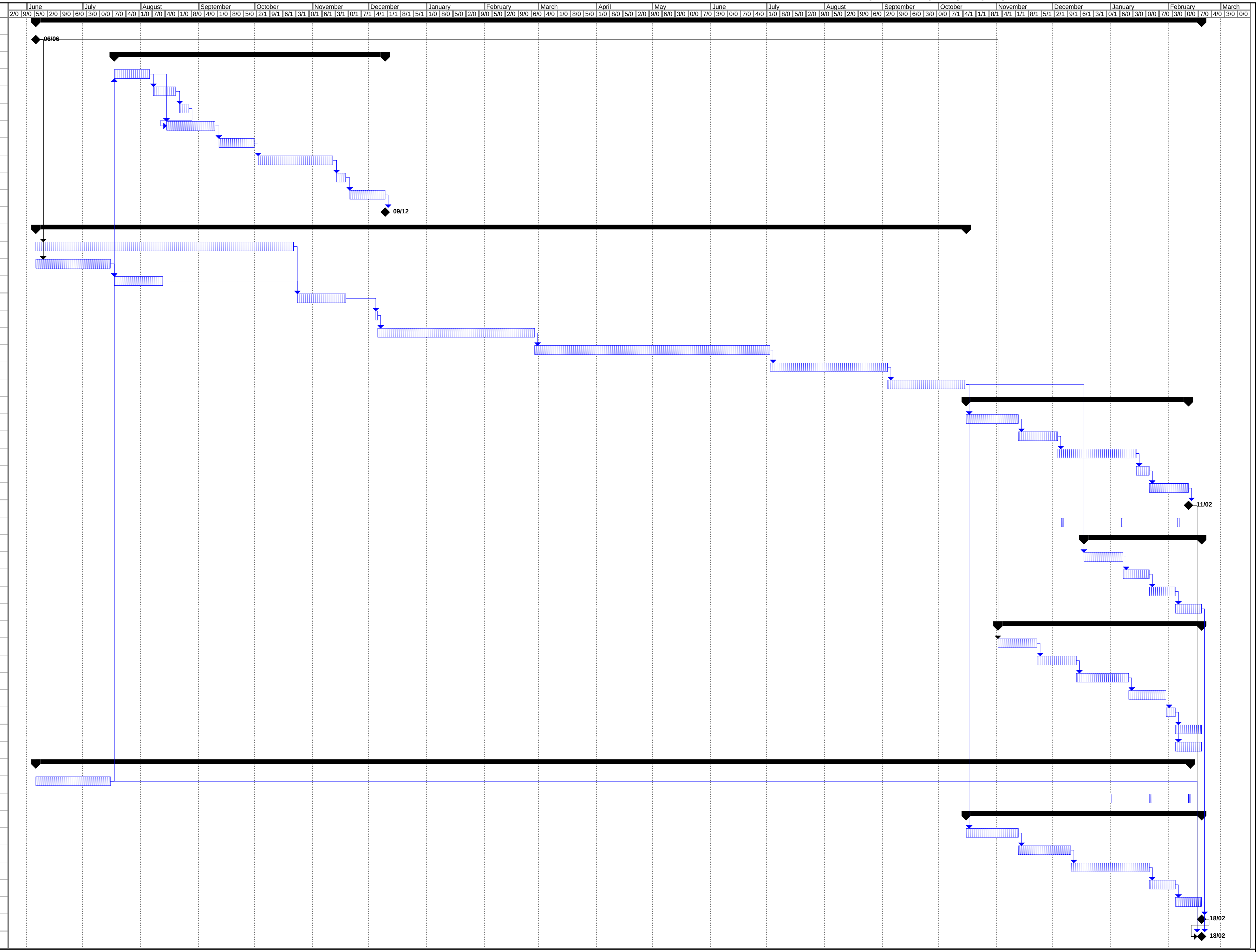
Reference(s): Multi-Unit Residential Demand Response

Please provide a detailed timeline from Board Approval of the program to full program implementation and deployment. Please detail all significant steps and tasks needed to be undertaken.

RESPONSE:

Please refer to the detailed project schedule attached as Appendix A.

ID		Task Name	Duration	Start	Finish	Predecessors	Resource Names
1		**MURB DR Program Deployment**	**446 days**	**Mon 06/06/11**	**Mon 18/02/13**		
2		OEB Board Approval	0 days	Mon 06/06/11	Mon 06/06/11		
3		**Calibration Stage**	**105 days**	**Mon 18/07/11**	**Fri 09/12/11**		
4		Develop RFQ	15 days	Mon 18/07/11	Fri 05/08/11	48	
5		Request for Qualification	10 days	Mon 08/08/11	Fri 19/08/11	4	
6		Evaluate RFQ	5 days	Mon 22/08/11	Fri 26/08/11	5	
7		Prepare RFP	20 days	Mon 15/08/11	Fri 09/09/11	4,6FS-10 days	
8		Legal Review	15 days	Mon 12/09/11	Fri 30/09/11	7	
9		Procurement Process	30 days	Mon 03/10/11	Fri 11/11/11	8	
10		Review Response	5 days	Mon 14/11/11	Fri 18/11/11	9	
11		Contract Negotiation	15 days	Mon 21/11/11	Fri 09/12/11	10	
12		Contract Signed	0 days	Fri 09/12/11	Fri 09/12/11	11	
13		**Site Identification**	**356 days**	**Mon 06/06/11**	**Mon 15/10/12**		
14		Initial Site Identification	100 days	Mon 06/06/11	Fri 21/10/11	2	
15		Participant Agreements	30 days	Mon 06/06/11	Fri 15/07/11	2	
16		Legal Review	20 days	Mon 18/07/11	Fri 12/08/11	15	
17		Corporation Level Contract	20 days	Mon 24/10/11	Fri 18/11/11	16,14	
18		Facility Information Sessions	1 day	Mon 05/12/11	Mon 05/12/11	17FS+10 days	
19		Unit Signups	60 days	Tue 06/12/11	Mon 27/02/12	18	
20		Installation of Control Equipment	90 days	Tue 28/02/12	Mon 02/07/12	19	
21		Testing	45 days	Tue 03/07/12	Mon 03/09/12	20	
22		Evaluation of Results	30 days	Tue 04/09/12	Mon 15/10/12	21	
23		**System Deployment**	**85 days**	**Tue 16/10/12**	**Mon 11/02/13**		
24		Prepare RFP	20 days	Tue 16/10/12	Mon 12/11/12	22	
25		Legal Review	15 days	Tue 13/11/12	Mon 03/12/12	24	
26		Procurement Process	30 days	Tue 04/12/12	Mon 14/01/13	25	
27		Review Response	5 days	Tue 15/01/13	Mon 21/01/13	26	
28		Contract Negotiation	15 days	Tue 22/01/13	Mon 11/02/13	27	
29		Contract Signed	0 days	Mon 11/02/13	Mon 11/02/13	28	
30		**Vendor Training**	**45 days**	**Thu 06/12/12**	**Wed 06/02/13**		
34		**Back Office**	**45 days**	**Tue 18/12/12**	**Mon 18/02/13**		
35		Participant Agreements	15 days	Tue 18/12/12	Mon 07/01/13	22	
36		Legal Review	10 days	Tue 08/01/13	Mon 21/01/13	35	
37		Forms Development	10 days	Tue 22/01/13	Mon 04/02/13	36	
38		Web Interface	10 days	Tue 05/02/13	Mon 18/02/13	37	
39		**Marketing**	**77 days**	**Fri 02/11/12**	**Mon 18/02/13**		
40		Finalize Marketing Plan	15 days	Fri 02/11/12	Thu 22/11/12	2	
41		Procurement Process	15 days	Fri 23/11/12	Thu 13/12/12	40	
42		Legal Review	20 days	Fri 14/12/12	Thu 10/01/13	41	
43		Develop Creative	14 days	Fri 11/01/13	Wed 30/01/13	42	
44		Print Materials	3 days	Thu 31/01/13	Mon 04/02/13	43	
45		Launch Website	10 days	Tue 05/02/13	Mon 18/02/13	44	
46		Media Plan	10 days	Tue 05/02/13	Mon 18/02/13	44	
47		**Human Resources**	**442 days**	**Mon 06/06/11**	**Tue 12/02/13**		
48		Hire Project Manager	30 days	Mon 06/06/11	Fri 15/07/11		
49		**Staff Training**	**31 days**	**Tue 01/01/13**	**Tue 12/02/13**		
53		**Program M and V**	**90 days**	**Tue 16/10/12**	**Mon 18/02/13**		
54		Prepare RFP	20 days	Tue 16/10/12	Mon 12/11/12	22	
55		Legal Review	20 days	Tue 13/11/12	Mon 10/12/12	54	
56		Procurement Process	30 days	Tue 11/12/12	Mon 21/01/13	55	
57		Review Response	10 days	Tue 22/01/13	Mon 04/02/13	56	
58		Contract Negotiation	10 days	Tue 05/02/13	Mon 18/02/13	57	
59		Contract Signed	0 days	Mon 18/02/13	Mon 18/02/13	58	
60		Program Deployment	0 days	Mon 18/02/13	Mon 18/02/13	59,48,38,29	



Project: MURB Deployment Schedule
Date: Tue 29/03/11

Task | Split | Progress | Milestone | Summary | Project Summary | External Tasks | External Milestone | Deadline

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 50:

Reference(s): Multi-Unit Residential Demand Response, p.6

Please explain and provide details about the statement, "[t]he owner/occupant will also be able to manually modify or override these initial settings on a limited basis".

RESPONSE:

The proposed technology to be installed includes a Programmable Communicating Thermostat that is pre-programmed with a specific profile, as identified from the signup package, for occupied and unoccupied space temperature setpoints. Limited adjustability will be provided to the setpoints (+/-1ºC) and schedules; however, the activations will trigger a return to the preset setup temperatures. See response to Board Staff Interrogatory 81(b).

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 51:

Reference(s): Multi-Unit Residential Demand Response, p.9

Please provide a detailed explanation on how the Applicant reached the projected 40% participation rate for the program.

RESPONSE:

The 40% factor relates to the minimum number of suite owners required for deployment of the program in that building.

The 40% participation rate used is based on the 30% penetration rates achieved with *peaksaver*. It is felt that the provision of incentive rates, paid to both suite owners and condominium boards, plus higher incentive rates than those paid to customers participating in the *peaksaver* program will result in a greater participation rate.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 52:

Reference(s): Multi-Unit Residential Demand Response, p.10

Please explain why the Applicant is expecting a 0% building and suite penetration rate for rental buildings and units.

RESPONSE:

There are minimal opportunities in this sector as the vast majority of rental apartments do not have central air conditioning.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 53:

Reference(s): Multi-Unit Residential Demand Response, p.17

With respect to the budget:

a) Please provide a detailed breakdown of the variable operation and vendor costs.

b) Please provide a breakdown of the fixed administrative costs.

c) Please provide a detailed breakdown of the incentive costs.

RESPONSE:

a), b), and c) Please see below.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

1) Incentive Costs

Description	2011	2012	2013	2014	Total
New Suites	135	3363	4709	5247	13453
Existing Suites Total	135	0	3363	8072	11570
New Buildings	2	55	76	85	218
Existing Buildings Total	2	0	55	131	188
Suite Incentives	$53,141	$1,244,443	$1,826,304	$2,143,133	$5,267,022
Building Incentives	$10,090	$185,737	$352,901	$512,635	$1,061,364
Total Incentives	**$63,231**	**$1,430,181**	**$2,179,206**	**$2,655,768**	**$6,328,386**

2) Variable Vendor Costs

Description	2011	2012	2013	2014	Total
New Suites	135	3363	4709	5247	13453
New Buildings	2	55	76	85	218
Building Vendor Cost	$107,619	$2,690,470	$3,800,291	$4,277,853	$10,876,233
Total Vendor Costs	**$107,619**	**$2,690,470**	**$3,800,291**	**$4,277,853**	**$10,876,233**

3) Variable Operation Cost

Type	2011	2012	2013	2014	Total
Energy Analyst	$85,250	$144,608	$146,088	$76,225	**$452,172**
Program Manager	$140,910	$140,910	$140,910	$105,682	**$528,411**
Manager	$20,782	$10,391	$10,391	$10,391	**$51,955**
Operation Costs	**$246,942**	**$295,909**	**$297,389**	**$192,298**	**$1,032,537**
80% Allocated to Variable Cost	**$197,553**	**$236,727**	**$237,911**	**$153,839**	**$826,030**
Total Variable Operation Costs	**$197,553**	**$236,727**	**$237,911**	**$153,839**	**$826,030**

4) Fixed Administration Cost

Type	2011	2012	2013	2014	Total
Applications	$285	$7,113	$9,958	$11,096	**$28,451**
Incentive Processing	$444	$11,097	$15,535	$17,311	**$44,387**
Settlement	$444	$11,097	$15,535	$17,311	**$44,387**
Administration	$285	$7,113	$9,958	$11,096	**$28,451**
Other Costs	**$1,457**	**$36,419**	**$50,986**	**$56,813**	**$145,674**
20% Allocated to Fixed Cost	**$291**	**$7,284**	**$10,197**	**$11,363**	**$29,135**
Total Fixed Admin Costs	**$291**	**$7,284**	**$10,197**	**$11,363**	**$29,135**

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 54:

Reference(s): **Multi-Unit Residential Demand Response, p.17**

Please provide the basis for the input assumption of 10% free ridership.

RESPONSE:

A nominal 10% free-ridership factor has been applied to the MURB Demand Response program to make it consistent with the values used by the OPA in evaluating *peaksaver*. It is expected that this number will be conservative as the participants do not have access to any other comparable program.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 55:

Reference(s): Program Development, Planning Costs and Application Costs

Please provide the legal basis on which THESL believes it can apply for recovery of its 2010 and 2011 Program Development, Planning Costs and Application Costs in addition to its Proposed Board-Approved expenses, in this Application.

RESPONSE:

The program development, planning, and application costs were directly incurred as a result of the requirement for THESL to file its Applications in order to meet its Board mandated CDM targets. THESL submits that there is no mechanism, nor would it be appropriate for one to exist, by which the costs to develop programs which are to be funded through the Global Adjustment Mechanism would be funded by THESL ratepayers through distribution rates. Consequently, it is THESL's position that planning and development costs associated with the Applications are appropriately recovered by the same mechanism as the CDM program costs themselves.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 56:

Reference(s): **Program Development, Planning Costs and Application Costs, p.2**

Please provide greater detail and explanation about each element of the budget contained in Table 1.

RESPONSE:

Program Planning involves all aspect of the program design, including the measures, budget, cost efficiency, program rollout, target participants, projected results, and the development of the marketing plan.

Market Analysis involves verifying the customer database against the Municipal Property Assessment Corporation data and determining each facility type.

Technology Review involves vetting the suitability of new technology for inclusion in the programs. This includes reviewing case studies, going through product reports from research labs, and communicating with manufacturers to gather research information.

RESPONSES TO INTERROGATORIES OF SCHOOL ENERGY COALITION

INTERROGATORY 57:

Reference(s): **Program Development, Planning Costs and Application Costs, p.3**

With respect to $40,250 in 2011 labour costs:

a) Please provide a basis for the $100/hr cost per FTE technical support cost.

b) Please provide a detailed explanation of the nature of the work these individuals are performing

c) Is this work being done by THESL employees and/or outside contractors?

RESPONSE:

a) The $100/hr per FTE cost is the average, fully-burdened rate of THESL employees who work on the Board-approved program research, design, development and program applications.

b) These individuals provide market, financial, technical and other relevant information to support the applications.

c) This work is done by THESL employees.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORY 1:

Reference(s): Appendix A

Although not covered in the evidence, VECC assumes THESL will take full advantage of the OPA-Contracted CDM Programs:

a) Provide The Ministers Directive Targets for THESL

b) Provide the documentation regarding the OPA program Targets and Budget allocations to THESL

c) Provide the Attachments to the OPA-THESL Master Agreement that detail the OPA Programs to be delivered by THESL

d) Provide a table that shows by year, by sector and in total the OPA Program Targets and Budgets allocated to THESL and the contribution and percentage that these will contribute to the THESL overall CDM Targets

e) Provide specifically information on the OPA Low Income program targets and budgets allocated to THESL

f) Provide by year the anticipated peak savings, and energy savings achievements for *both* OPA Contracted and THESL Board-Approved CDM Programs for the 2011 to 2014 period.

RESPONSE:

a) The Minister's Directive concerning CDM Targets is attached as Appendix A to this Schedule. THESL specific targets were established by the OEB as part of the EB-2010-0216 proceeding.

b) Please refer to the response to Board Staff Interrogatory 1.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

c) The attachment to the THESL OPA Master Agreement is subject to confidentiality and as such cannot be disclosed without consent of the OPA.

d) Please refer to the table below.

Customer Class		2011	2012	2013	2014	Total	% of Target
Residential	MW	9	11	11	8	**40**	**14%**
	MWh	53,904	58,423	61,405	59,404	**233,137**	**18%**
	Budget	$ 4,511,689	$ 3,159,164	$ 3,159,164	$ 3,159,164	**$ 13,989,180**	**N/A**
Commercial	MW	28	32	34	30	**123**	**43%**
	MWh	188,236	194,483	194,700	188,453	**765,871**	**59%**
	Budget	$ 5,348,611	$ 8,950,186	$ 8,950,186	$ 8,950,186	**$ 32,199,168**	**N/A**
Industrial	MW	7	14	19	18	**58**	**20%**
	MWh	25,084	38,500	45,409	32,796	**141,790**	**11%**
	Budget	$ 1,582,650	$ 807,908	$ 807,908	$ 807,908	**$ 4,006,373**	**N/A**
Total	**MW**	**45**	**57**	**64**	**56**	**221**	**77%**
	MWh	**267,224**	**291,406**	**301,514**	**280,654**	**1,140,798**	**87%**
	Budget	**$ 11,442,950**	**$ 12,917,257**	**$ 12,917,257**	**$ 12,917,257**	**$ 50,194,721**	**N/A**

e) THESL is unable to provide Province-Wide Low Income program targets and budgets allocated to THESL at this time, as the program has not been finalized by the OPA.

f) Please refer to the table below:

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

Program		2011	2012	2013	2014	**Total**
OPA-Contracted Programs	MW	45	57	64	56	**221**
	MWh	267,224	291,406	301,514	280,654	**1,140,798**
Board-Approved Programs	MW	2	7	10	8	**24**
	MWh	3,266	24,425	65,183	106,158	**127,248**
Total	**MW**	**46**	**64**	**74**	**64**	**245**
	MWh	**270,490**	**315,832**	**366,697**	**386,812**	**1,268,047**

Ontario
Executive Council
Conseil des ministres

Order in Council
Décret

On the recommendation of the undersigned, the Lieutenant Governor, by and with the advice and concurrence of the Executive Council, orders that:

Sur la recommandation du soussigné, le lieutenant-gouverneur, sur l'avis et avec le con- sentement du Conseil des ministres, décrète ce qui suit:

WHEREAS it is desirable to achieve reductions in electricity consumption and reductions in peak provincial electricity demand.

AND WHEREAS the Minister may, with the approval of the Lieutenant Governor in Council, issue directives under section 27.1 of the *Ontario Energy Board Act, 1998* in order to direct the Board to take steps to promote energy conservation, energy efficiency, load management or the use of cleaner energy sources, including alternative and renewable energy sources.

AND WHEREAS the Minister may, with the approval of the Lieutenant Governor in Council, issue directives under section 27.2 of the *Ontario Energy Board Act, 1998* in order to direct the Board to establish conservation and demand management targets to be met by distributors and other licensees.

NOW THEREFORE the Directive attached hereto is approved and shall be and is effective as of the date hereof.

Recommended: ____________________
Minister of Energy
and Infrastructure

Concurred: ____________________
Chair of Cabinet

Approved and Ordered: MAR 3 1 2010
Date

____
Lieutenant Governor

O.C./Décret 437/2010

MINISTER'S DIRECTIVE

TO: THE ONTARIO ENERGY BOARD

I, Brad Duguid, Minister of Energy and Infrastructure, hereby direct the Ontario Energy Board pursuant to sections 27.1 and 27.2 of the *Ontario Energy Board Act, 1998*, as described below.

The Board shall take the following steps in order to establish electricity conservation and demand management ("CDM") targets to be met by licensed electricity distributors ("distributors") within the timeframe specified herein:

1. Subject to paragraph 5, the Board shall, without a hearing and in accordance with the requirements of this Directive, which relate to the conservation and demand-management targets to be met by distributors and other licensees including the OPA, amend each distributor's licence to add a condition requiring the distributor to achieve reductions in electricity consumption and reductions in peak provincial electricity demand through the delivery of CDM programs ("CDM Programs") by the amounts specified by the Board (the "CDM Targets"), over a four-year period beginning January 1, 2011.

2. In establishing CDM Targets for each distributor, the Board shall:

    (a) ensure that the total of the CDM Targets established for all distributors is equal to 1330 megawatts (MW) of provincial peak demand persisting at the end of the four-year period and 6000 gigawatt hours (GWh) of reduced electricity consumption accumulated over the four-year period;

    (b) specify for each distributor, a CDM Target for the reduction of provincial peak electricity demand and a CDM Target for the reduction of electricity consumption, each of which must be greater than zero; and,

    (c) have regard to information obtained from the Ontario Power Authority ("OPA"), developed in consultation with distributors, regarding the reductions in provincial peak electricity demand and electricity consumption that could be achieved by individual distributors through the delivery of CDM Programs.

3. The Board shall amend the licence of each distributor as follows:

    (a) by adding a condition that specifies each distributor must meet its CDM Targets through:

        (i) the delivery of Board approved CDM Programs delivered in the distributor's service area ("Board-Approved CDM Programs");

(ii) the delivery of CDM Programs that are made available by the OPA to distributors in the distributor's service area under contract with the OPA ("OPA-Contracted Province-Wide CDM Programs"); or,

(iii) a combination of (i) and (ii)

(b) by adding a condition that specifies that the distributor must deliver a mix of CDM Programs to all consumer types in the distributor's service area, whether through Board-Approved CDM Programs, OPA-Contracted Province-Wide CDM Programs or a combination of the two, as far as is appropriate and reasonable having regard to the composition of the distributor's consumer base;

(c) by adding a condition that requires the distributor to comply with rules mandated by a code issued by the Board.

4. The Board shall amend licenses of distributors to ensure that:

(a) distributors utilize the same common Provincial brand (which includes any mark or logo that the Province has used or is using, created or to be created by or on behalf of the Province, and which will be identified to the Board by the Ministry as a provincial mark or logo for its conservation programs) with all Board-Approved CDM Programs;

(b) that the brand identified in (a) shall be the same brand utilized by the OPA and distributors for OPA-Contracted Province-Wide CDM Programs, once those programs have been created; and,

(c) that the brand shall be used by distributors in conjunction with or co-branded with distributor's own brand or marks.

and the Board shall, upon receipt of written direction from the Ministry, which may be issued from time to time, and as a condition of license, require any one or more distributors to cease using the Provincial brand described in this paragraph at such time or in such way as may be specified in such direction.

5. The Board shall not amend the licence of any distributor that meets the conditions set out below:

(a) with the exception of embedded distributors the distributor is not connected to the Independent Electricity System Operator (IESO)-controlled grid; or,

(b) the distributor's rates are not regulated by the Board.

6. The Board shall issue a code that includes rules relating to the reporting requirements and performance incentives associated with CDM Programs and to the planning, design, approval, implementation and the evaluation, measurement and verification ("EM&V") of Board-Approved CDM Programs and to such other matters as the Board considers appropriate.

In developing such rules, the Board shall have regard to the following objectives of the government in addition to such other factors as the Board considers appropriate:

(a) that Board-Approved CDM Programs shall not duplicate OPA-Contracted Province-Wide CDM Programs that are available from the OPA at the time of Board approval;

(b) that the Board shall encourage opportunities for coordinating CDM Programs between the distributor and other relevant entities such as other electricity distributors, natural gas distributors and the OPA;

(c) that the Board shall not preclude consideration of CDM Programs or funding for CDM Programs on the basis that a distributor's CDM Targets have been or are expected to be exceeded;

(d) that a tiered performance incentive mechanism shall be available to distributors for verified electricity savings with incentives beginning to accrue once a distributor meets 80% of each CDM Target; performance incentives shall not be offered for electricity savings achieved beyond 150% of each CDM Target;

(e) that Board approval for funding of any given Board-Approved CDM Program shall correspond to the period in which the Board-Approved CDM Program is offered, provided that the period is no longer than the period for which CDM Targets are established;

(f) that the Board shall require distributors to use OPA cost-effectiveness tests, as modified by the OPA from time to time, for assessing the cost-effectiveness of Board-Approved CDM Programs;

(g) that the Board shall require distributors to use the OPA protocol process and third-party vendor of record list, as modified by the OPA from time to time, when conducting EM&V of Board-Approved CDM Programs;

(h) that the Board shall consider the definition of CDM to be inclusive of load reduction from initiatives, such as geothermal heating and cooling, solar heating and fuel switching, but exclusive of initiatives that are associated with the OPA Feed-in Tariff Program and the OPA Micro Feed-in Tariff Program; and,

(i) that all Board-Approved CDM Programs shall utilize the same common provincial brand (which includes any mark or logo that the Province has used or is using, created or to be created by or on behalf of the Province, and which will be identified to the Board by the Ministry as a provincial mark or logo for conservation) used for OPA-Contracted Province-Wide CDM Programs, once such programs are created, and used in conjunction with or co-branded with any brand or mark used by the distributor.

7. The Board shall not approve CDM Programs until OPA-Contracted Province-Wide CDM Programs have been established.

8. The Board shall, in approving Board-Approved CDM Programs, continue to have regard to its statutory objectives, including protecting the interests of consumers with respect to prices.

9. The Board shall conduct, or cause to be conducted, targeted audits of EM&V carried out by the distributor or third-parties on behalf of the distributor, as necessary.

10. The Board shall annually review and publish the verified results of each individual distributor's CDM Programs and the consolidated results of all distributor CDM Programs, both Board-Approved CDM Programs and OPA-Contracted Province-Wide CDM Programs and take steps to encourage distributors to improve CDM Program performance.

11. The Board shall permit distributors to meet a portion of their CDM Targets through the delivery of CDM Programs targeted to low-income consumers.

12. The Board shall have regard to the objective that lost revenues that result from CDM Programs should not act as a disincentive to a distributor.

Minister of Energy and Infrastructure

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORY 2:

Reference(s): **none provided**

In developing a CDM strategy a key step is to examine THESLs service territory and customer base from a CDM perspective.

a) Provide copies of the report(s) and/or analysis that THESL prepared to understand its residential customer base. If not available provide information on, residential customer average uses for electric and non electric space and hot water.

b) Provide all reports prepared for either OPA and/or THESL that establish the profile of THESLs Residential Customer base in terms of:

   i) numbers
   ii) domicile-archetype
   iii) own/rent
   iv) income level
   v) annual electricity consumption
   vi) types of end use (profile)

c) Provide similar Province-wide data to position THESL within the totals.

d) How will THESL customers access the programs- will there be a similar registration system to OPA and will customers need to register twice (once with OPA and once with THESL)?

RESPONSE:

a) General information on the residential customer base was gleaned from the following websites:
   http://app.toronto.ca/wards/jsp/wards.jsp

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

http://www.ieso.ca/imoweb/transInfo/demand.asp#RG

Reports on residential usage patterns and electrical equipment loads:

1) *The Rising Cost of Power in Ontario: Residential Ratepayers* is provided as Appendix A to this Schedule. It is also available online at: http://www.caealliance.com/THE_RISING_COST_OF_POWER_IN_ONTARIO_RESIDENTIAL_2.pdf
2) *MSA Report: Residential Load Profiles* is provided as Appendix B to this Schedule. It is also available online at: http://albertamsa.ca/files/ResidentialLoadProfiles042804.pdf
3) *Synthetically Derived Profiles for Representing Occupant-Driven Electric Loads in Canadian Housing* is provided as Appendix C to this Schedule. It is also available online at: http://www.nrc-cnrc.gc.ca/obj/irc/doc/pubs/nrcc50858/nrcc50858.pdf

Technical References:

1) ASHRAE HVAC Applications Handbook 2007, Comfort Applications, Chapter 1: Residences
2) ASHRAE HVAC Applications Handbook 2007, General Applications, Chapter 49: Service Water Heating
3) ASHRAE Fundaments Handbook 2005, Load and Energy Calculations, Chapter 29: Residential Heating and Cooling Calculations
4) ASHRAE Fundaments Handbook 2005, Load and Energy Calculations, Chapter 32: Energy Estimating and Modeling Methods

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

5) ASHRAE HVAC Systems and Equipment 2008, Heating Equipment and Components, Chapter 33: Residential In-Space Heating Equipment
6) ASHRAE HVAC Systems and Equipment 2008, Package, Unitary and Split-System Equipment, Chapter 48: Unitary Air Conditioners and Heat Pumps
7) ASHRAE HVAC Systems and Equipment 2008, Package, Unitary and Split-System Equipment, Chapter 49: Room Air Conditioners and Packaged terminal Air Conditioners

b) Residential customer profiles and demographics were ascertained by using:

1) THESL's customer billing system, BANNER, data downloads – The BANNER system allows derivation of the total annual electricity consumption for the residential class.

2) City of Toronto Ward profiles – these are available by logging into the following location:
http://app.toronto.ca/wards/jsp/wards.jsp
Ward profiles allowed THESL to ascertain the specific number of customers, domicile-archetype, own/rent ratio and income levels. The profile used is provided as Appendix D to this Schedule.

3) Residential loadshape profiles – The daily profiles can be found by logging into the IESO website at:
http://www.ieso.ca/imoweb/transInfo/demand.asp#RG

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

The IESO profiles supplied information on types of end use for specific electrical equipment with associated load profiles. The graphs of the normalized residential load profiles for Baseboard, Baseload, Central Air, Electric Furnace, Space Heating and Water Heating are provided as Appendices to this Schedule, and labelled E to J, respectively.

4) OPA MPAC Database: Toronto Hydro Property Utilization – OPA MPAC database supplied additional information on residential building sizes and age.

c) Analysis was only completed for the THESL service territory.

d) Customers will be required to apply directly to THESL. As with the different initiatives under the OPA program, the customer will have to apply to THESL programs individually. There is no provision in the existing OPA programs for multiple initiatives requiring a single application. Customers will apply for the proposed programs using a web-based system. Program descriptions and applications forms would be available for download through THESL's website. A separate email dedicated for customer submission of application forms to THESL would also be available through the website.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

Category	Total Number of Units	Owned	Rented	Income Level*	Annual Electricity Consumption kWh**	Typical Average Energy End Use Profile for Sector*** - Annual kWh						
						Space Heating	Cooling	DHW Heating	Appliances	Lighting	Electronics	Other
Single House	347,625	336,345	11,280		11,957	2,212	2,469	1,375	2,493	1,375	1,118	915
Condominiums	196,245	196,245			6,057	****	****	****	2,559	1,411	1,148	939
Apartments	435,575		435,575		4,377	****	****	****	1,849	1,020	829	679
TOTAL	979,445	532,590	446,855									

*Information not available per category, see attached summary table

**Average based on total sector usage and number of units

***Distribution of electricity usage has been applied to the entire sector and are weighted average values

****Typically usage is allocated to the common area of the facility

Source: Statistics Canada, Census 2006

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

Household Income				
			# of Units	%
Under		$10,000	64,835	6.6
$10,000	-	$19,999	103,850	10.6
$20,000	-	$29,999	101,340	10.3
$30,000	-	$39,999	102,875	10.5
$40,000	-	$49,999	91,980	9.4
$50,000	-	$59,999	80,580	8.2
$60,000	-	$69,999	71,125	7.3
$70,000	-	$79,999	61,050	6.2
$80,000	-	$89,999	50,980	5.2
$90,000	-	$99,999	41,360	4.2
$100,000	and	over	209,470	21.4
Total Number of Households			979,445	100
Average household Income			$80,343	
Median household Income			$52,833	

Source: Statistics Canada, Census 2006

THE RISING COST OF POWER IN ONTARIO:

RESIDENTIAL RATEPAYERS

OCTOBER, 2009

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 10
Schedule 2
Appendix A
Filed: 2011 Apr 1
(12 pages)

BOX 931, CORUNNA, ONTARIO, N0N 1G0
(519) 862-9296
caealliance@sympatico.ca
www.caealliance.com

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Preserving Economic Sustainability

THE RISING COST OF POWER IN ONTARIO
IMPACT ON RESIDENTIAL CONSUMERS

Since the breakup of the former Ontario Hydro and the move to a market pricing formula (1999-2002), electricity prices for the average consumer increased 30%-50%. (4.3 ¢/kWh in 2002 to 5.8-6.7 ¢/kWh current)

In 2005 the provincial government began a program of further restructuring in the electricity system. The resulting changes have brought price increases which are just now being felt.

Another wave of changes – with the potential to create the most significant price increases – will hit over the next few years. Costs to all consumers will rise as a result of the Green Energy Act, Smart Meters, the Harmonized Sales Tax, and Private Power Generation Contracts.

BILLIONS upon BILLIONS of dollars is being spent on electricity restructuring and we will have little to show for it.

- $45 billion for new/refurbished resources
- $10.2 billion for conservation/demand management programs – with unclear and uncertain results
- $9+ billion for transmission infrastructure
- $20 billion stranded debt (although we have been paying $1.085 Billion/year since 2001)
- $2.3 billion for smart meters (plus monthly fees)
- $18 - $46 billion cost to consumers as a result of the Green Energy Act - Plus resulting job losses

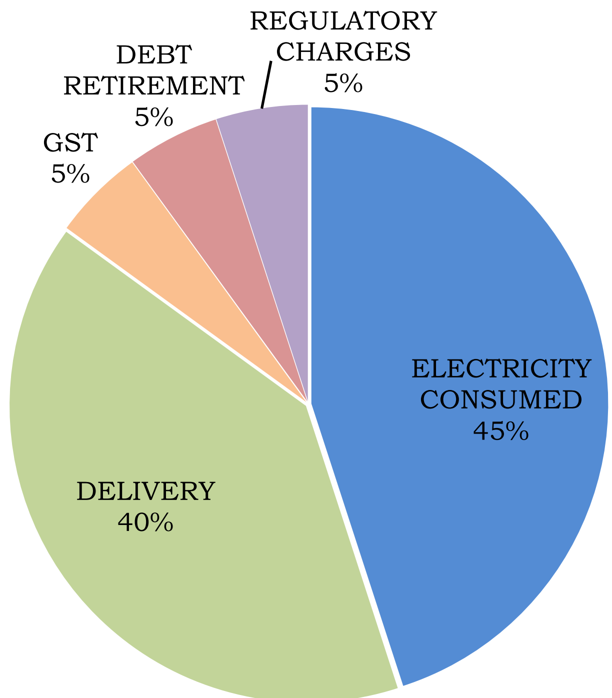
The percentage increases on power rates to consumers is distressing:

- 30%-150% higher electricity costs from new power generation – 80% of resources are to be new or refurbished
- 30% increase in administration costs for the electricity system in 1 year ($2.5 Billion 2007 - $3.5 Billion 2008 - approximately 20% of electricity revenue is spent on administration costs)
- 8.8% -10.6% increase in delivery costs in 2009-2010 - 20%-25% in some areas
- 13.3% increase in delivery costs in 2011 **in addition** to the above rate increases
- 33%-60% increase on residential electricity costs during normal waking hours through the week
- 8% increase on bills when the HST is introduced next year
- 5^{+}% increase for natural gas support payments
- 5% increase to fund conservation programs

These costs are indicative, not exhaustive.

In addition, homeowners will be impacted by the higher rates paid by industry, business, the farming community and the sector supported by taxpayer dollars such as hospitals, schools, municipal and government offices and agencies. Ontario's ratepayers will be reeling with the costs of an electricity system that is neither reliable, nor affordable. Industry and manufacturing will continue to move out or simply close shop.

YOUR ELECTRICITY BILL BREAKDOWN

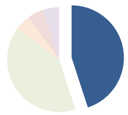


The above chart shows a breakdown, by percentage, of the costs included on an average residential consumer's bill. Only ½ of the costs cover the actual electricity used. (Based on average homeowner use of 1,000 kWh/month)

REGULATORY CHARGES – Fixed rate of $0.25/month (service administration charge) plus an additional charge of 0.65¢/kWh to operate the electricity system & market – 6 categories including Ontario Power Authority and Independent Electricity System Operator costs

DEBT RETIREMENT - 0.7¢/kWh – To pay down the debt of the former Ontario and other costs that were added to the debt (i.e. to offset costs associated with government funded price freeze).

GST – A 5% tax calculated on all the other categories of charges.



ELECTRICITY USED/CONSUMED (45% +/- of Total Bill)

Residential consumers pay for electricity used according to rates set by the Ontario Energy Board (Regulated Price Plan or RPP).

♦ Rates are reviewed and adjusted twice a year in the spring (May 1) and in the fall (Nov. 1).

♦ The set price per kWh of electricity use is based on a forecast of electricity supply costs anticipated for the upcoming year, as well as adjustments to account for the differences between what was paid and what the electricity supply actually cost over the previous 6 month period.

♦ In addition to price, the OEB sets a price threshold. Electricity consumption above the monthly threshold is priced at a higher rate.

♦ The monthly threshold for the lower price is set at 1,000 kWh per month during the winter season, from November 1 to April 30 and at 600 kWh per month for the summer season of May 1 to October 31.

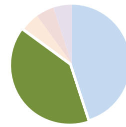
Summer Cost (May 1- Oct 31)
5.8 ¢/kWh for the first 600 kWh in a month
6.7 ¢/kWh for each additional kWh

Winter Cost (Nov 1 – April 30)
5.8 ¢/kWh for the first 1000 kWh in a month
6.7 ¢/kWh for each additional kWh

These rates, effective November 1, 2009, are 4% higher than last year and 17% higher than 2005 when restructuring began.

♦ Electricity consumed – shown on the electricity bill as kWh usage - is multiplied by an “adjustment factor” which is paid by consumers to compensate for “line losses” - electricity consumed by the transmission equipment, wires and transformers. This is calculated by Hydro One, comparing the total amount of electricity purchased from power generators to the amount of electricity delivered to customers. The difference represents how much electricity was lost during delivery. Adjustment factors are reviewed and approved by the OEB.

The present adjustment rate is:
1.078 cents/kWh for urban density;
1.085 cents/kWh for high density residential users; and
1.092 cents for every kWh for normal density residential users.
(See below for explanation of density.)



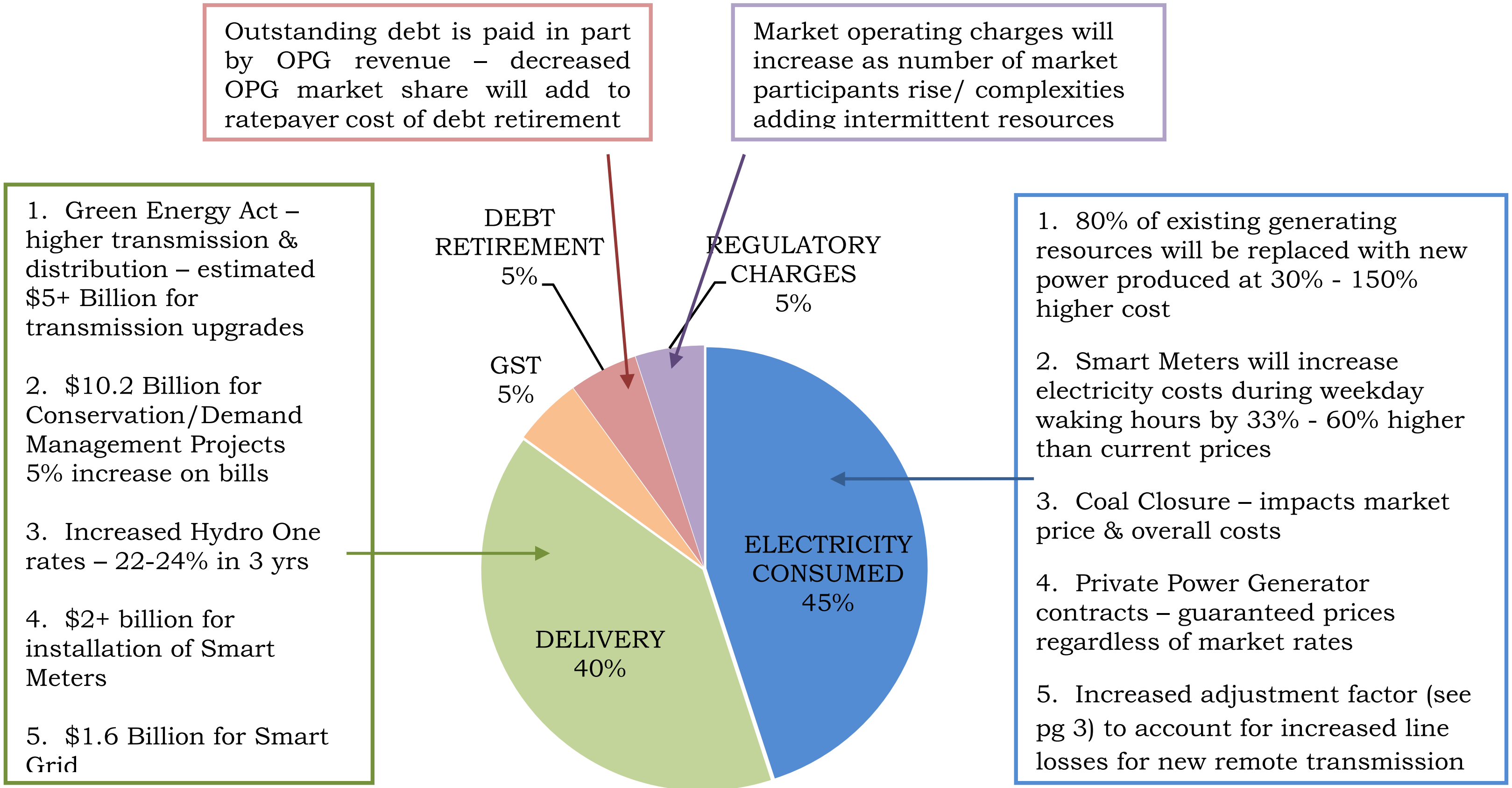
DELIVERY (40% +/- of Total Bill)

Delivery charges include transmission and distribution costs – from point of generation to home. The charge varies according to the classification or type of electricity service at your residence. The classification is based on customer density in your area – either urban, high residential density or normal residential density. Rates are higher in less densely populated areas. (Hydro One) Your classification is shown on your monthly bill.

A portion of your Delivery Costs are fixed regardless of how much electricity you use. Other charges are based on the volume of electricity used as follows:

	Urban Density	High Density	Normal Density
Delivery:			
- Distribution service charge Fixed Rate ($/month)	$16.35	$21.31	$27.16
- Distribution volume charge (metered usage - ¢/kWh)	2.37¢	2.73¢	2.78¢
- Transmission connection charge (adjusted usage - ¢/kWh)	0.47¢	0.48¢	0.45¢
- Transmission network charge (adjusted usage - ¢/kWh)	0.52¢	0.53¢	0.52¢

THE RISING COST OF POWER



The chart above shows the breakdown of items included on your bill. We have included an assessment of some of the costs that will impact each of these items. Further explanation is included on the following pages.

♦ An **8%** increase on the total bill will come into effect July, 2010 with the introduction of the Harmonized Sales Tax (HST)

FACTORS IMPACTING THE COST OF POWER

Electricity prices are rising for a number of reasons. Some of the factors cause a compound, cumulative effect. We have included the following 6 reasons. For further information, please review the full document available on our website.

1. HIGHER COST OF NEW AND REPLACEMENT RESOURCES

♦ Ontario operates on a market system where electricity is bought and sold, as required. The Independent Electricity System Operator (IESO) determines power needs and power generators determine how much of the required load they can supply, and at what price. Offers are accepted from lowest cost to highest bid until the electricity demands are met.

♦ In order to protect residential consumers from the constantly varying prices, the Ontario Energy Board sets a flat rate for power used, every 6 months. Those rates, revised in May and November, are based on the actual costs for power during the previous 6 month period, together with anticipated costs for the next period.
Therefore, the residential consumer price is tied in to the price actually paid to the power producers.

♦ Power producers in Ontario include a mix of:
- Ontario Power Generation (OPG) – resources include nuclear, hydraulic, coal, natural gas;
- private power producers who had existing contracts prior to deregulation in 2002 (NUGS);
- private power producers who have made contracts with the Ontario Power Authority since 2004; and
- renewable electricity producers who are paid a set rate for each kWh of electricity generated, i.e. wind, solar.

♦ The cost to produce electricity is rising, as 80% of the resource supply will be replaced with higher cost renewable energy, natural gas, new/refurbished nuclear, conservation/demand management programs, example

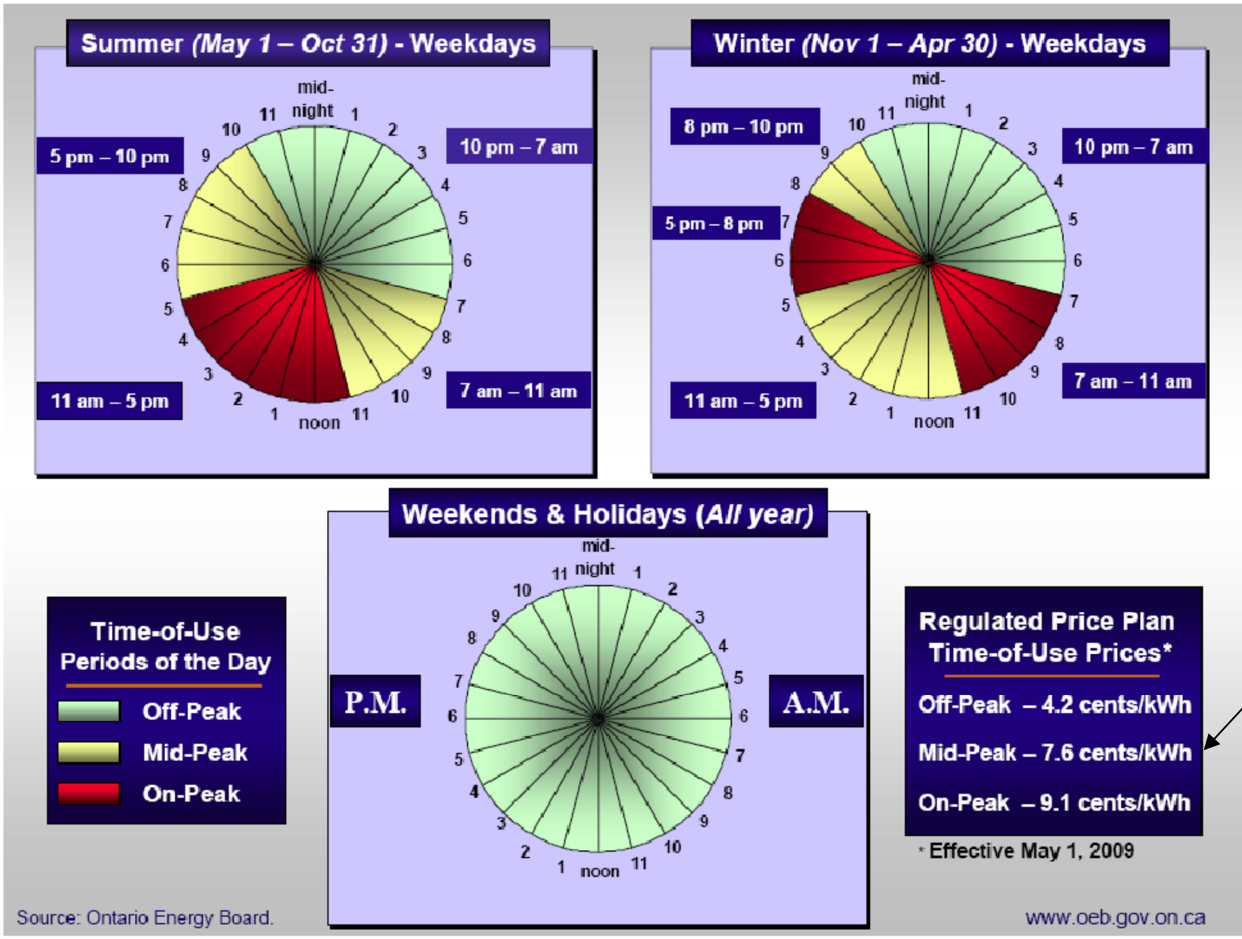
EXISTING		NEW	
Coal-fired	4.8 ¢/kWh	Natural gas-fired	10.0+ ¢/kWh
Hydro	3.3 - 4.8 ¢/kWh	Wind	13.5 - 19¢/kWh*
Nuclear	4.95 - 6.3¢/kWh	Solar	44.3 - 80.2¢/kWh

(*New renewable generation increases based on the Consumer Price Index)

♦ The Ontario Energy Board forecast that an additional $25 million per month was required for conservation programs, natural gas-fired power contracts and the renewable energy to come into service by October, 2009.

2. SMART METERS – TIME OF USE PRICING

2010-2011, all residences and small businesses will be equipped with smart meters. Government regulations allow for the costs of smart meters to be recovered through the local distribution companies. The OEB has estimated that cost to be $2.3 Billion, plus monthly fees for information processing.
The following charts show the impact of time of use pricing.



As of November, 2009 rates will change as follows:

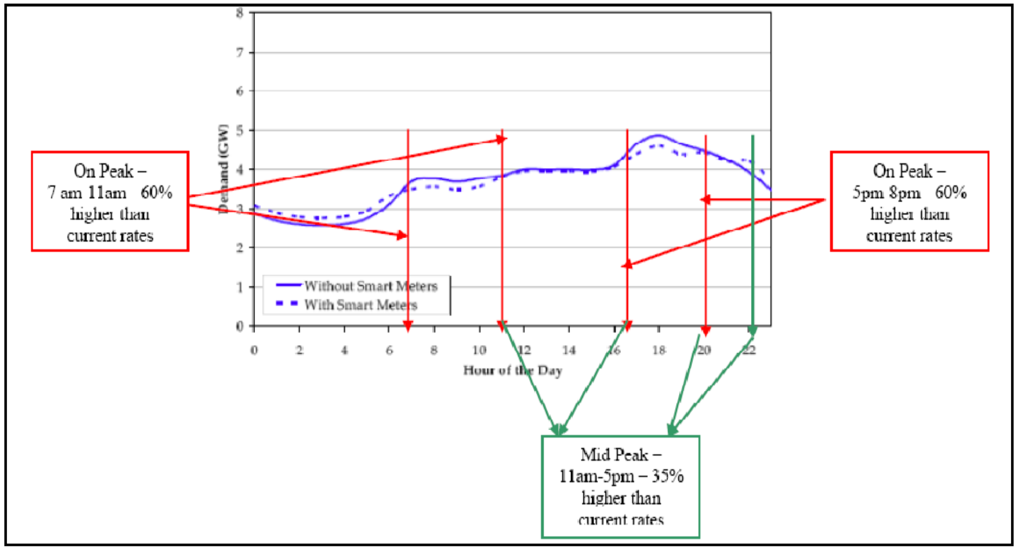
- Off-Peak – 4.4 cents/kWh
- Mid-Peak – 8.0 cents/kWh
- On-Peak – 9.3 cents/kWh

(Off peak was originally estimated at 2.7 cents/kWh)

The charts following show the impact of pricing during times of normal electricity. The dotted blue line shows the anticipated changes in power use as a result of smart meters (marginal). Small business will be tied in to the same pricing scheme resulting in significant cost increases during normal business hours.

Chart 1 – November 1 to April 30 – "Winter" Use

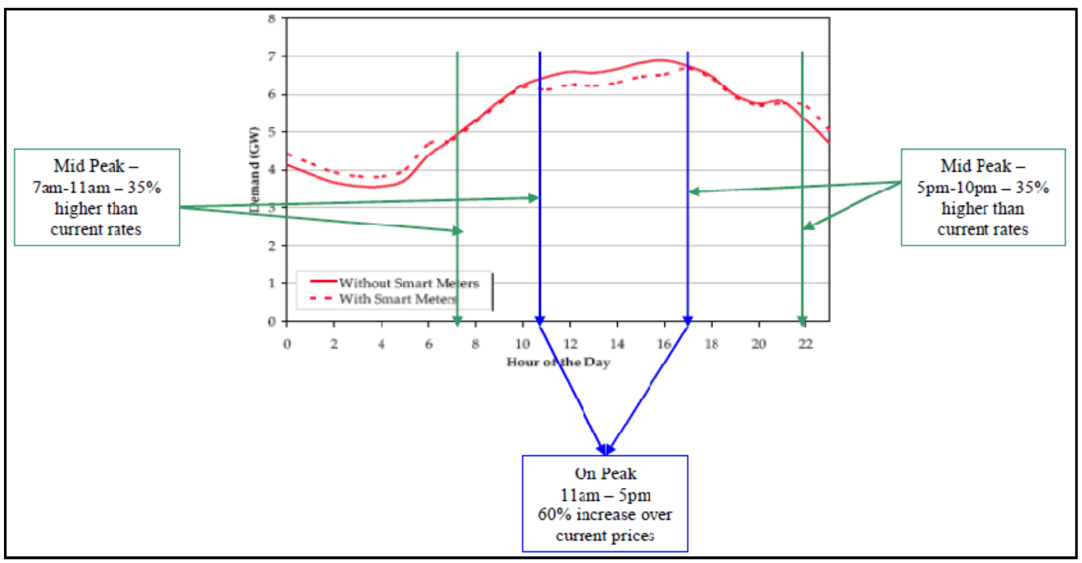
Average January Load Profile for Residential Users – With and Without Smart Meters



As this chart demonstrates, the highest TOU pricing coincides with increased demand in residential use due to normal activities during waking and pre-work/school preparation, etc. in the morning and arrival home, meal preparation, etc. during early evening hours. The blue lines, comparison of use with and without smart meters, shows that much of this energy use cannot be shifted.

Chart 2 – May 1 to October 31 – "Summer" Use

Average July Load Profile for Residential Users – With and Without Smart Meters



Managing summer and winter peak loads are two different challenges. Air-conditioning is the key focus in the summer and ratepayers have some ability to respond to demand. In the winter there is little opportunity to load shift and conservation is the target. The Smart Meter Program is a very expensive way to address these challenges and has marginal impact.

The cost of this program is approximately 50% more than the cost of refurbishing a nuclear reactor equivalent to the capacity of the "hoped for" demand reduction.

3. COST INCREASES RESULTING FROM COAL CLOSURE

♦ Coal - low cost supply – publicly owned, paid-for assets – mitigates the higher cost of other generating resources

♦ With coal removed, natural gas-fired generation will set the market price 85% of the time at much higher cost.
For every 10% increase in natural gas prices, Ontario electricity spot market price rises 6%
Although gas prices are low at present, they are not expected to remain so.
Assuming a cost of $7.50 to $8.50/MMBtu for natural gas, the removal of coal power will result in an electricity price increase of $6 to $13/MWh.

♦ Ratepayer Impact - By 2015 natural gas generators contingent support payments will = $10,000/MW/month – total annual payment $775 million. The Global Adjustment impact = $5.34/MWh = 5.1% (Aegent Energy Advisors)

♦ The premature retirement of coal fired units will incur decommissioning costs payable by ratepayers.

♦ OPA has initiated purchase of "Black Start" for system reliability which coal units currently provide. This cost is part of the "wholesale market charges"

4. COST IMPACTS OF THE GREEN ENERGY ACT

Impacts all of the cost items – electricity, transmission, delivery, regulatory

♦ Estimated $18 - $46 BILLION over a 15 year period

♦ Guaranteed right to connect into transmission – $5+ BILLION to accommodate new renewable generation

♦ Price for power - Wind @ 13.5 - 19¢/kWh; Solar @ 44.3 - 80.2¢/kWh (Compared to existing Coal @ 4.8 ¢/kWh; Hydro @ 3.3 - 4.8 ¢/kWh; Nuclear 4.95-6.3 ¢/kWh)
Natural gas-fired @ 10.0+ ¢/kWh is being installed to replace coal and backup intermittent wind and solar.

♦ The Act allows for **<u>all</u>** the costs associated with all aspects of the government's plans for the acquisition of renewable energy, conservation, the reduction of coal use, etc. to be fully recovered from ratepayers. This is – in effect – another tax without having any oversight by or approval of the Legislature. These costs will be high! These costs are totally at the discretion of the Minister of Energy, without any accountability, including the right to make loans and grants to whomever.

♦ Removal of safeguards for cost protection for Ontario consumers. As financial regulator, the Ontario Energy Board had a responsibility to review power projects and transmission expansion to ensure cost effectiveness and economic prudence. Now, the Board is tasked with promoting renewal energy development and delivery regardless of cost.

♦ Additional erosion of price protection includes:
- Decreased public assets – more for-profit private power generation
- Price setting will be via contract and tariff - removes competitive factor - public assumes some of risk that should fall to private generators
- Amending the Mandate of OEB so no agency accountable for protecting consumers re: price and reliability
- Inducements to encourage investment in green energy in Ontario at expense of ratepayers
- The government is making 20 year contracts for technologies that may well be obsolete or outdated in the near future. Renewable energy is expected to decrease in price and increase in technological advancement. We will be tied in to contracts for highly expensive, passé technologies with no financing available to pursue advancements.

♦ Studies (U.S., Germany, Spain) indicate that jobs created in the renewable energy sector are essentially expensive, non-productive adding cost to consumers not benefit to the economy. The economies of these countries has suffered as a result of much higher energy costs, and erosion of industrial base as a result. A Spanish study suggests 2.2 jobs lost for each "green" job added.

♦ New agencies to be created in addition to the $3.5 billion/year spent on administration

5. PROVINCIAL BENEFIT/GLOBAL ADJUSTMENT

♦ Price guarantees – whether by contract with the OPA, by regulation of OPG's assets, or by the new "Feed in Tariffs" promised to new renewable generators – will impact the rising cost of power regardless of the market price. According to the OPA, Global Adjustment "With each new contract for conservation and supply, the cost of electricity and GA may increase."

♦ When market prices are high merchant power generators benefit but consumers pay higher prices. When market prices are low merchant power generators are guaranteed a set income regardless of whether they generate much, little, or none. The ratepayer makes up the difference.

♦ The Global Adjustment is also the mechanism for the OPA to recover costs of the Conservation/Demand Management programs and incentives – such as the "Great Refrigerator Roundup", "PeakSaver" and the costs for commercial retrofits. Cost estimates suggest an additional 2.5% increase on consumer bills by 2008, and double that, or 5% by 2015. (Aegent Energy Advisors Inc.)

6. HAMONIZED SALES TAX

8% PST will be included in overall billing once the harmonized sales tax is introduced next year.

COMMENTS:

We are often asked to suggest a number - a percentage rise overall in electricity costs - going forward. Unfortunately, that is impossible. For example:

Costs are compounded – a 13% increase in Hydro One costs in 2011 will be on top of 10% increases in 2009-2010; HST at 8% will be on all costs as they rise, etc.;

Prices paid for new and refurbished generation are subject to increases based on the Consumer Price Index;

A significant amount of natural-gas fired generation is being added to the electricity supply mix. We will be dependant on this fuel which is considered the most volatile in terms of pricing and uncertainty in terms of future supply;

Contracts made with private power producers (not open to public scrutiny) and a lack of transparency regarding debt, assets and accounting in the provincial energy sector muddies any cost evaluations;

Ontario consumers are paying close to $4 Billion each year for the administration of our electricity system, 5 agencies with overlapping functions. Recent changes will add more administration;

The Green Energy Act directs the Ontario Energy Board to pass on to ratepayers all costs associated with the development of renewable energy regardless of cost effectiveness or overall benefit to the province. International travel, PR functions and a host of other costs will be borne by ratepayers and taxpayers with little scrutiny and accountability.

What we have tried to demonstrate are the real numbers and percentages that are now impacting cost - and those on the horizon. The interaction of these costs, and the cumulative impact point to certain – hefty - increases that will impact homeowners, will impact the viability of industry and business, will drive up the price of consumer goods, and will become an additional burden on taxpayers who bear the costs of municipal governments, schools, hospitals and other vital services whose additional costs will be passed on.
Affordability and reliability of stable electricity supply are vital to this Province! Environmental gains are marginal, are overstated and can be achieved in other, more prudent and cost-effective ways.

Contact your MPP, contact your Premier and those responsible in the Ministry of Energy, the Ontario Energy Board and the Ontario Power Authority. Ask for answers! Ask for accountability!

For more information review the CAE Alliance Presentation/Submission to the Standing Committee on General Government regarding the Green Energy Act and the expanded version of this document, "The Rising Cost of Power in Ontario" which highlights concerns for all sector ratepayers on our website.

Toronto Hydro-Electric System Limited
EB-2011-0011
Exhibit J
Tab 10
Schedule 2
Appendix B
Filed: 2011 Apr 1
(14 pages)

www.albertaMSA.ca

MSA REPORT

Residential Load Profiles

28 April, 2004

MARKET SURVEILLANCE ADMINISTRATOR

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1 BACKGROUND

In the province of Alberta, customers are billed for their electricity consumption which is measured by either an interval meter or a cumulative meter. Interval meter customers are billed based on their actual consumption in any given hour. Cumulative meter customers are billed for their consumption based on infrequent meter readings ranging in frequency from monthly to once every six months. As the distribution of each customer's consumption between meter reads is not measured, it is assumed through the use of a load profile.

Almost all residential customers in the province have cumulative meters and are therefore billed based on a load profile. Residential load profiles differ depending on which settlement zone a customer lives in. In Alberta, residential customers are billed based on two different types of load profiles. Customers in ENMAX's Calgary service area and in the ATCO service area are billed based on a residential load profile[1]. Customers in the remainder of the province are billed based on the Net System Load Shape (NSLS)[2] for their service area. Note that each residential and NSLS profile is different and is calculated based on actual consumption within a settlement zone.

One day it is likely that residential customers who have not chosen to sign up for a long-term electricity contract will pay for their electricity consumption based on a Pool price flow-through rate. The purpose of this exercise was to determine the effect of load profiling and location on these customer's bills and to assess the effect of Pool price volatility on the variability of their monthly electricity bills based on an assumed monthly electricity consumption. Note that the analysis is not intended to mimic actual events. It is purely theoretical and results should be considered directional in nature rather than absolute.

2 DATA COLLECTION AND ASSUMPTIONS

Load profiles for residential customers were collected from the four Load Settlement Agents (LSAs)/Wire Service Providers (WSPs) in the province for six different zones, as follows:

- ENMAX - Calgary (residential profile)
- ENMAX – Lethbridge (NSLS profile)
- ENMAX – Red Deer (NSLS profile)
- EPCOR – Edmonton (NSLS profile)
- ATCO – Fort McMurray (residential profile)[3]
- Aquila – Rocky Mountain House (NSLS profile)[3]

Note that each of the WSPs serves locations other than those identified above. These six municipalities were chosen to be representative of various locations across the province.

[1] Residential load profiles are calculated based actual measured consumption from a number of interval meters at sample sites which are assumed to be representative of residential consumption in that area.

[2] NSLS is calculated based on total metered consumption in a service area minus the sum of all known consumption (interval meters + deemed consumption + other profiled consumption + unaccounted for energy (UFE)). NSLS is essentially what is left over after all the known consumption has been accounted for.

[3] Note that ATCO and Aquila only have one service area each. A specific location within each service area had to be selected in order to properly calculate some charges on representative bills in these territories.

The data was collected in the form of Settlement Profile Information (SPI) files, as defined in section B.6.2.3 of the Settlement System Code. All SPI files used were those issued for final settlement (rather than initial, monthly or interim settlement).

For this exercise it was assumed that each theoretical customer consumed exactly 600 kWh of electricity in each month and the consumption was distributed equally over each of the days in that month[4]. Daily consumption was then distributed amongst the 24 hours in the day based on the load profile for the service area. It was also assumed that each customer was on a Pool price flow-through rate for electricity. Pool prices for 2002 and 2003 were used for the simulation.

3 ANALYSIS AND RESULTS

3.1 Load Profiles

Load profiles were collected for the six service areas noted above for the 2002-2003 period and the average profile for the entire period (730 days) was calculated. Average profiles are plotted in **Figure 1**. As noted above, specific profiles for residential customers are calculated for the ENMAX Calgary service area and the ATCO service area. All other residential customers are billed based on the NSLS for their service area. The shape of the profiles is actually quite different, as shown in the figure.

The two residential profiles are quite similar with a morning peak around HE08 and an evening peak around HE18-HE20 with a slight drop off in consumption between HE10 and HE16. The NSLS profiles have a more prolonged morning ramp up and are somewhat higher during the mid-day hours. They also have a slightly muted evening peak compared to the residential profiles. The difference in shape of the two types of profiles can primarily be attributed to the types of customers included in each profile. For example, the NSLS profile would likely contain a lot of small commercial (office buildings, shopping malls, etc…) load as well as residential load. The operating hours of these facilities account for the elevated consumption during the mid-day hours in comparison to the residential profile.

Note that the load profile in each zone is different for every day of the period. Profiles can actually change quite a lot from day to day and season to season as shown in **Figure 2** which plots the actual daily residential profiles for the ENMAX – Calgary service area for a typical winter day and a typical summer day in the period. The seasonality of the profiles can clearly been seen in the figure.

[4] For example, for the month of January, the customer consumed 600 kWh total which equals 19.35 kWh per day. In a shorter month like February, daily consumption would increase to 21.43 kWh to reach the total of 600 kWh for the month.

Figure 1 - Comparison of Average Load Profiles for Residential Customers

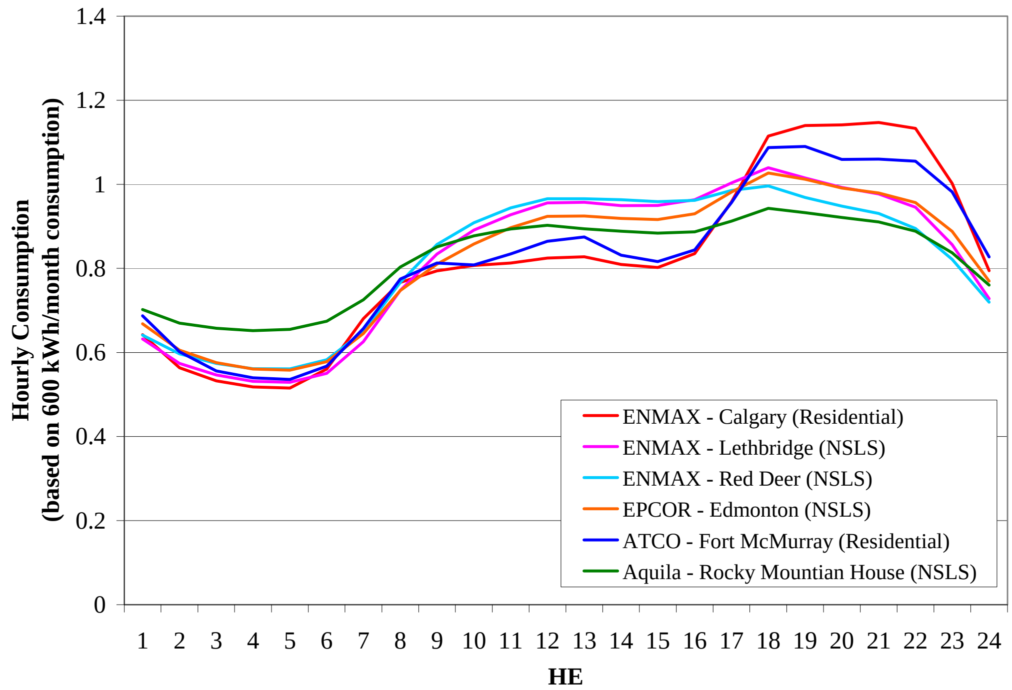
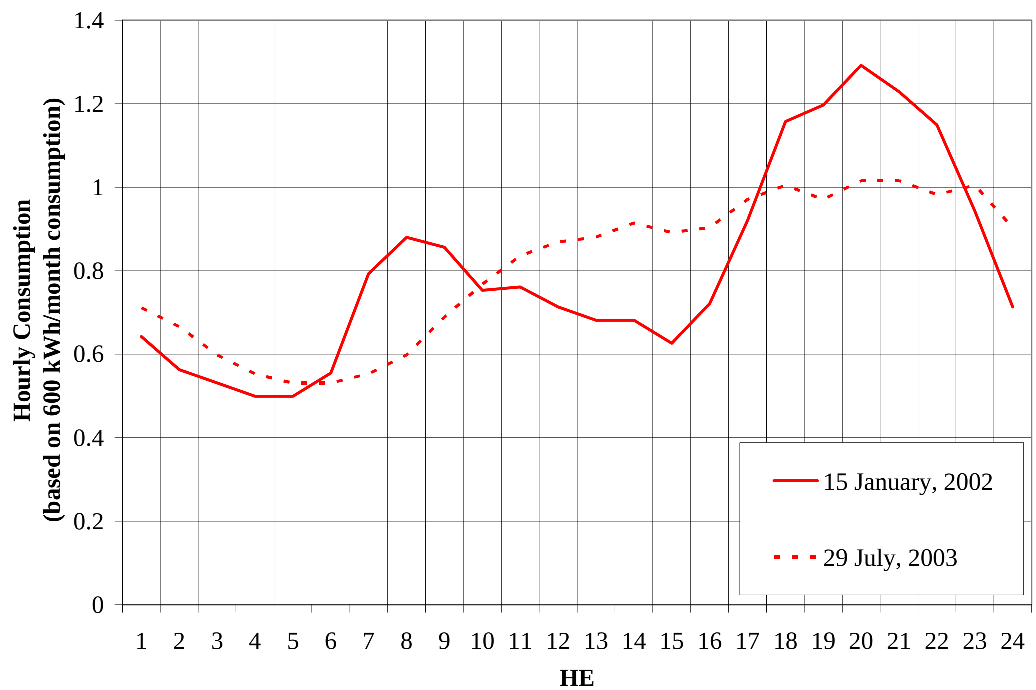


Figure 2 - Comparison of ENMAX Calgary Residential Load Profiles



3.2 Calculation of Monthly Electricity Bills

The calculation of monthly electricity bills was split into two components: energy charges and other charges. The impact of each type of charge on the bottom line of the monthly electricity bill is discussed in the following sections.

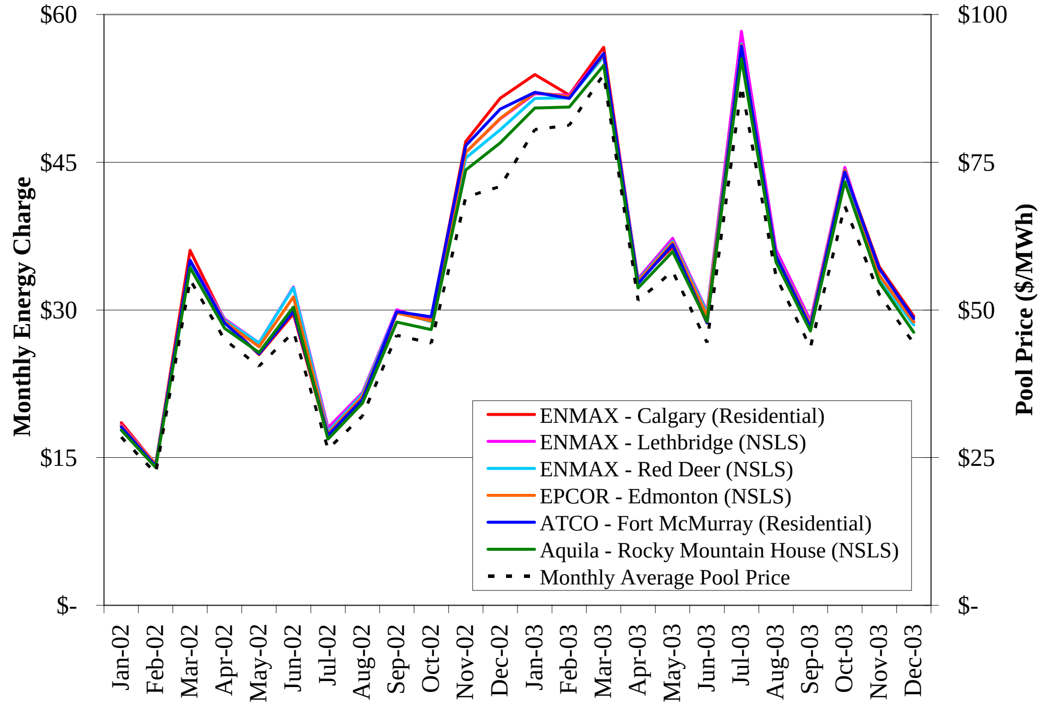
3.2.1 Calculation of Monthly Energy Charges

Monthly energy charges were calculated for the six service areas examined based on 600 kWh/month consumption and 2002-2003 Pool price flow-through rates. The results of the calculation are tabulated in **Table 1**. **Figure 3** plots the monthly energy charges along with monthly average Pool price.

Table 1 – Monthly Energy Charges

	ENMAX			EPCOR	ATCO	Aquila
Month	**Calgary Residential**	**Lethbridge NSLS**	**Red Deer NSLS**	**Edmonton NSLS**	**Fort McMurray Residential**	**Rocky Mountain House NSLS**
Jan-02	$18.54	$18.32	$18.18	$18.23	$18.11	$17.80
Feb-02	$14.30	$14.41	$14.34	$14.33	$14.16	$13.99
Mar-02	$36.05	$35.06	$34.83	$35.02	$35.06	$34.28
Apr-02	$28.91	$29.08	$28.94	$28.82	$28.66	$28.13
May-02	$25.46	$26.66	$26.66	$26.27	$25.54	$25.67
Jun-02	$29.60	$32.33	$32.27	$31.32	$29.85	$30.30
Jul-02	$17.04	$18.03	$17.63	$17.43	$17.27	$16.89
Aug-02	$20.64	$21.60	$21.43	$21.20	$20.91	$20.51
Sep-02	$29.75	$30.01	$29.81	$29.69	$29.82	$28.76
Oct-02	$29.22	$28.89	$28.79	$28.88	$29.30	$27.99
Nov-02	$47.09	$46.01	$45.42	$45.99	$46.67	$44.22
Dec-02	$51.50	$49.39	$48.28	$49.46	$50.40	$46.97
2002 Total	**$348.11**	**$349.77**	**$346.60**	**$346.64**	**$345.74**	**$335.52**
2002 Average	**$29.01**	**$29.15**	**$28.88**	**$28.89**	**$28.81**	**$27.96**
Jan-03	$53.90	$51.97	$51.47	$52.05	$52.10	$50.51
Feb-03	$51.81	$51.80	$51.54	$51.66	$51.47	$50.60
Mar-03	$56.66	$56.00	$55.73	$55.91	$56.04	$54.84
Apr-03	$32.93	$33.17	$33.00	$32.90	$32.69	$32.23
May-03	$36.40	$37.27	$36.98	$36.85	$36.64	$35.93
Jun-03	$28.66	$29.87	$29.72	$29.43	$28.68	$28.80
Jul-03	$55.97	$58.30	$57.01	$56.89	$56.79	$55.50
Aug-03	$35.15	$36.10	$35.59	$35.52	$35.46	$34.86
Sep-03	$28.13	$28.91	$28.57	$28.48	$28.24	$27.84
Oct-03	$44.06	$44.46	$44.19	$44.16	$43.99	$43.02
Nov-03	$34.36	$33.46	$33.17	$33.52	$34.18	$32.80
Dec-03	$29.37	$28.84	$28.48	$28.76	$29.11	$27.71
2003 Total	**$487.40**	**$490.17**	**$485.44**	**$486.15**	**$485.39**	**$474.64**
2003 Average	**$40.62**	**$40.85**	**$40.45**	**$40.51**	**$40.45**	**$39.55**

Figure 3 - Monthly Energy Charge Comparison



The figure shows that (as one might expect) energy charges track Pool price very closely. However, there is definitely some variation in the monthly energy charges that is a result of the profile being applied. For example, although on an annual total basis (for both years) customers in the ENMAX – Lethbridge service area would have paid the highest energy charge, the energy charge in November 2002 through March 2003 is clearly higher in the ENMAX – Calgary service area than in any other of the service areas. Conversely, while the lowest energy charge is in the Aquila service area for the majority of the two year period, during May and June 2002 the lowest energy charge is in the ENMAX – Calgary service area. The average difference between the highest monthly energy charge and the lowest monthly energy charge is only $1.65/month. The monthly energy charges are not clearly higher or lower in any given service area than in another.

As the energy charges are highly dependent on Pool price, there is a corresponding degree of volatility in the monthly values. Monthly energy charges range from a low of $13.99 (February 2002, Aquila) to a high of $58.30 (July 2003, ENMAX – Lethbridge). Volatility in monthly energy charges (as measured by the coefficient of variation) for the entire 2002-2003 period was 0.35 for all of the service areas profiled on NSLS and was slightly higher at 0.36 for the two service areas with residential profiles. When examined on an annual basis, volatility averaged 0.38 in 2002 and 0.27 in 2003. (Monthly average Pool price volatility measured 0.35 in 2002 and 0.28 in 2003.) In general, energy charge volatility (based on Pool price flow-through) is not highly dependent on they type of profile (residential or NSLS) used in the service area.

Comparison to Pool Price

A comparison of what residential customers would have paid annually for their electricity and annual average Pool price was made by calculating profile-weighted Pool prices for the six service areas. **Table 2** shows the profile-weighted average Pool price for each of the service areas for 2002 and 2003 and compares it to the annual average Pool price. The table shows that on average, residential customers on a Pool price flow-through rate would have paid approximately 7% more than average Pool price for electricity. This again shows the effect of the profiling and indicates that residential customers generally consume more energy in higher priced hours than in lower priced hours.

Table 2 - Profile-Weighted Average Pool Prices

Service Area	**Profile-Weighted Average Pool Price ($/MWh)**	
	2002 (Average = $43.93/MWh)	**2003 (Average = $63.99/MWh)**
ENMAX – Calgary	48.35	67.69
ENMAX – Lethbridge	48.58	68.08
ENMAX – Red Deer	48.14	67.41
EPCOR – Edmonton	48.14	67.52
ATCO – Fort McMurray	48.02	67.41
Aquila – Rocky Mountain House	46.60	65.91
Average	47.97	67.34
% of Pool Price paid by Residential Customers	109%	105%

Comparison of Pool Price Flow-Through and RRO

The difference in energy charges using a Pool price flow-through and the 2003[5] regulated rate option (RRO) was also studied. Total annual energy charges for 2003 (based on 600 kWh/month consumption) were calculated for Pool price flow-through and RRO and compared. Results are shown in **Table 3** along with the 2003 RRO rates. (Note that residential customers in the ATCO service area were moved to a Pool price flow-through RRO in April 2003 and therefore this comparison was not conducted for the ATCO territory.)

[5] RRO as in place in December 2003.

Table 3 - 2003 RRO Rates and Annual Energy Charge Comparison

Service Area	2003 RRO (c/kWh)	Total Annual Energy Charge		Difference (F-T – RRO)
		Flow-Through	RRO	
ENMAX – Calgary	5.482	$487.40	$394.70	$92.70
ENMAX – Lethbridge	5.985	$490.17	$430.92	$59.25
ENMAX – Red Deer	6.348	$485.44	$457.05	$28.39
EPCOR – Edmonton	5.960	$486.15	$429.12	$57.03
Aquila – Rocky Mountain House	6.179	$474.64	$444.89	$29.75

The table shows that customers on RRO would have fared better in 2003 than customers on Pool price flow-through in each of the service areas. This indicates that in the time period studied it would have been very hard for a competitive retailer to compete with the RRO. Note that with an average Pool price of $62.99/MWh in 2003; assuming RRO providers bought their energy in the spot market they would have had to pay more to procure the energy than they could sell the energy for in all service areas.

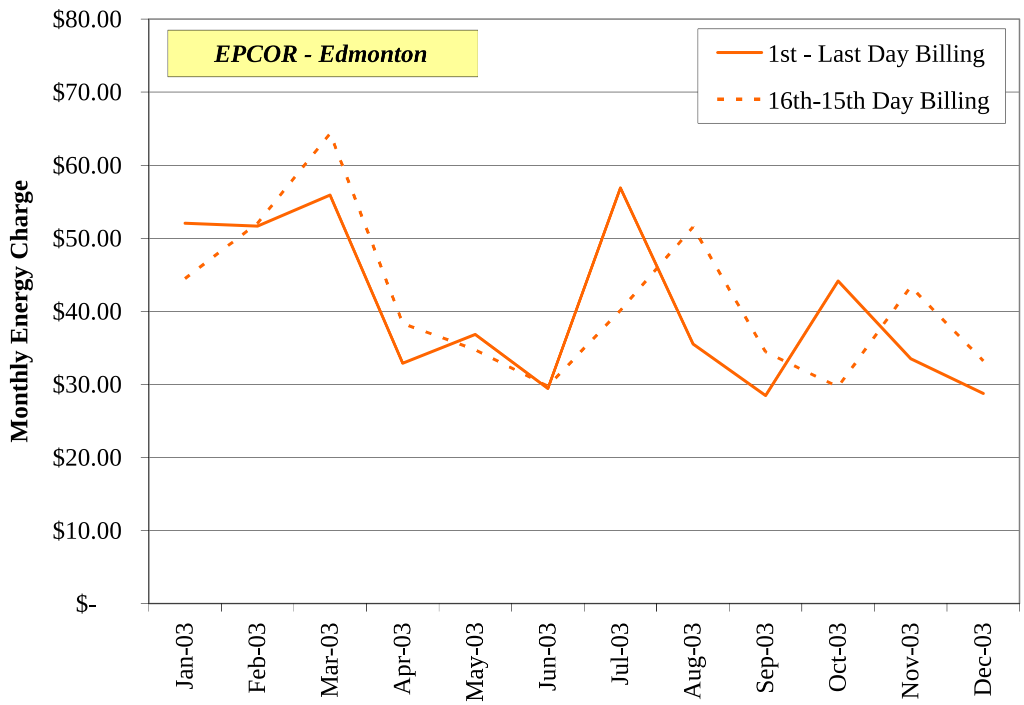
Note that when the RRO is fixed for a period of time it takes into account known and expected influences on the price of electricity. If, for example, gas prices are unexpectedly high in a period, resulting in higher than expected (real-time) electricity prices, the RRO might be artificially lower than the real cost of acquisition for that period. For example, the RRO charged to ENMAX's Calgary residential customers in 2002 was 6.1c/kWh ($61.00/MWh). This RRO would have resulted in an annual energy charge of $439.20 based on 600 kWh/month consumption. A customer on Pool price flow-through would have paid only $348.11 for energy during the same time frame. The difference in annual energy charges is -$91.09 (RRO customers would have paid more than flow-through customers). This demonstrates that RRO prices will not always be better than Pool price flow-through.

As the above analysis is based on an assumed monthly consumption of 600 kWh/month, there is no volatility in the monthly energy charge of customers on RRO. The monthly energy charge would simply be 1/12 of the annual energy charge. Volatility in monthly energy charges would be purely due to variability in consumption.

Sensitivity of the Billing Cycle

The effect of different billing cycles was examined by comparing monthly energy charges representing consumption from the first to the last day of the month with monthly energy charges representing consumption from the 16^{th} day of the month to the 15^{th} day of the following month. This analysis was conducted using the same assumptions as the original analysis but only for the 2003 period[6]. Monthly energy charges for the two different billing cycles are compared in **Figure 4** for the EPCOR – Edmonton service area to illustrate an example of the differences between the billing cycles.

Figure 4 - Comparison of Monthly Energy Charges on Different Billing Cycles



The figure shows that with billing from the 16th of the month to the 15th of the month, monthly energy charges would have been slightly different on a monthly basis. However, there is very little difference in energy charge volatility between the two different billing cycles. Volatility averaged 0.27 for both billing cycles – slightly lower than the measured volatility of 2003 Pool price (0.28). The difference in the prices shown in the figure is primarily due to higher prices in the last half of December 2002 (included in January 2003 for the 16th to the 15th billing cycle) compared to the last half of December 2003 (included in December 2003 for the first of the month to the last of the month billing cycle). This effect can be seen in the figure as there are the same numbers of spikes in each series but the timing of the spikes is sometimes offset depending on when during the month the higher prices occurred.

On a cumulative basis, the customer who was billed at the end of the month paid a total of $486.15 for their electricity. The customer who was billed on the 15th of the month paid a total of $496.05 for their electricity. The difference of less than $10.00/year is due to the higher prices which occurred in the last half of

[6] The January 2003 bill is based on consumption from December 16th 2002 through January 15th 2003.

December 2002 (included in the total for the customer who was billed on the 15th of the month) relative to prices which occurred in the last half of December 2003 (included in the total for the customer who was billed at the end of the month).

3.2.2 Other Charges

To simulate the total monthly bill to the customer, data on system access, distribution, billing, franchise/local access fees and administration fees (other charges) was also gathered. The transmission tariffs in effect in each of the service areas in December 2003 were used to approximate these charges for the entire 2002-2003 period. Note that no rate riders or taxes were added to the bottom line of the bill.

Table 4 shows the values used in the calculation of other charges for each of the six service areas examined as well as the typical charge that would be added to the energy component of a bill for a month with 31 days and a monthly consumption of 600 kWh.

Table 4 - System Access, Distribution, Billing, Franchise and Administration Fees

		ENMAX			EPCOR	ATCO	Aquila
		Calgary Residential	Lethbridge NSLS	Red Deer NSLS	Edmonton NSLS	Fort McMurray Residential	Rocky Mountain House NSLS
System Access	$/kWh	$ 0.0029	$ 0.0038	$ 0.0031	$ 0.0081	$ 0.0093	$ 0.0072
	$/day	$ 0.1000	$ 0.1138	$ 0.0816			
Distribution	$/month				$ 9.1100	$ 21.0600	$ 12.0000
	$/day	$ 0.1968	$ 0.3287	$ 0.3077			
	$/kWh	$ 0.0118	$ 0.0077	$ 0.0092	$ 0.0010	$ 0.0369	$ 0.0124
Billing	$/month				$ 1.0600	$ 1.8400	$ 4.0600
	$/day	$ 0.1841	$ 0.0756	$ 0.1006			
Franchise Fee	$/kWh				$ 0.0037		
	% of dist. Charges	11.10%	31.00%	17.00%		7.60%	2.90%
Admin. Fee[7]	% of SA and D						3.75%
Monthly Charge (31 days)		**$ 25.72**	**$ 29.35**	**$ 25.87**	**$ 17.88**	**$ 54.33**	**$ 29.41**

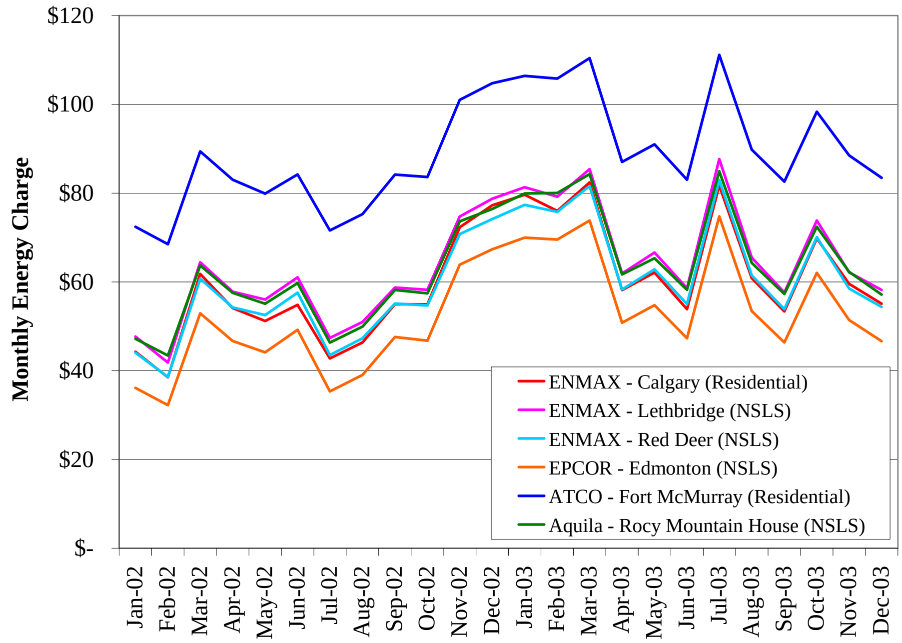
Note the large difference in these charges between the six service areas. Costs range from $17.88/month in the EPCOR – Edmonton service area to $54.33/month in the ATCO – Fort McMurray service area. Other charges in the four other service areas studied are not as diverse and are clustered in the $25 - $30/month range. Once again, this comparison should be considered direction in nature. In reality, the non-energy components of electricity bills are derived from a combination of government policies and EUB decisions on rate schedules and tariffs – the timing of which may vary between different service areas.

[7] EPCOR has been contracted to oversee billing in the Aquila service area. An administration fee of 3.75% of System Access and Distribution charges is applied to each customer's bill to cover the cost incurred by EPCOR.

3.2.3 Total Monthly Billing

Monthly total electricity bills were then calculated for each of the six service areas for each of the 24 months in the 2002-2003 period. Billing was based on actual calendar months (the bill would represent consumption from the first day of the month to the last day of the month). **Table 5** lists the monthly and annual energy charges, other charges and total bill amount for each month for the six areas examined. **Figure 5** plots the total monthly bill amounts.

Figure 5 - Total Monthly Bill Comparison



The table and figure show that electricity bills were the highest for the ATCO service area and the lowest in the EPCOR-Edmonton service area for each month in the entire period. The average difference between the total monthly ATCO and EPCOR bills for the entire two year period was $36.68/month. Bills for the four other service areas studied were more closely clustered between the ATCO and EPCOR extremes.

The comparison of the energy charges and the total bill amounts clearly shows that it is in fact the other charges and not the energy charge component of the bill that have a larger impact on the total amount of the monthly electricity bill.

Table 5 - Comparison of Monthly Electricity Bills

	ENMAX									EPCOR			ATCO			Aquila		
	Calgary Residential			Lethbridge NSLS			Red Deer NSLS			Edmonton NSLS			Fort McMurray Residential			Rocky Mountain House NSLS		
Month	**Energy**	**Other**	**Total**	**Energy**	**Other**	**Total**	**Energy**	**Other**	**Total**	**Energy**	**Other**	**Total**	**Energy**	**Other**	**Total**	**Energy**	**Other**	**Total**
Jan-02	$18.54	$25.72	$44.26	$18.32	$29.35	$47.67	$18.18	$25.87	$44.06	$18.23	$17.88	$36.11	$18.11	$54.33	$72.43	$17.80	$29.41	$47.21
Feb-02	$14.30	$24.18	$38.48	$14.41	$27.39	$41.79	$14.34	$24.20	$38.54	$14.33	$17.88	$32.21	$14.16	$54.33	$68.49	$13.99	$29.41	$43.41
Mar-02	$36.05	$25.72	$61.77	$35.06	$29.35	$64.41	$34.83	$25.87	$60.70	$35.02	$17.88	$52.90	$35.06	$54.33	$89.38	$34.28	$29.41	$63.70
Apr-02	$28.91	$25.21	$54.11	$29.08	$28.70	$57.78	$28.94	$25.32	$54.26	$28.82	$17.88	$46.70	$28.66	$54.33	$82.99	$28.13	$29.41	$57.55
May-02	$25.46	$25.72	$51.18	$26.66	$29.35	$56.01	$26.66	$25.87	$52.53	$26.27	$17.88	$44.15	$25.54	$54.33	$79.87	$25.67	$29.41	$55.09
Jun-02	$29.60	$25.21	$54.81	$32.33	$28.70	$61.03	$32.27	$25.32	$57.59	$31.32	$17.88	$49.20	$29.85	$54.33	$84.18	$30.30	$29.41	$59.72
Jul-02	$17.04	$25.72	$42.77	$18.03	$29.35	$47.38	$17.63	$25.87	$43.51	$17.43	$17.88	$35.31	$17.27	$54.33	$71.60	$16.89	$29.41	$46.30
Aug-02	$20.64	$25.72	$46.36	$21.60	$29.35	$50.95	$21.43	$25.87	$47.30	$21.20	$17.88	$39.08	$20.91	$54.33	$75.24	$20.51	$29.41	$49.92
Sep-02	$29.75	$25.21	$54.96	$30.01	$28.70	$58.71	$29.81	$25.32	$55.13	$29.69	$17.88	$47.57	$29.82	$54.33	$84.14	$28.76	$29.41	$58.17
Oct-02	$29.22	$25.72	$54.94	$28.89	$29.35	$58.24	$28.79	$25.87	$54.66	$28.88	$17.88	$46.76	$29.30	$54.33	$83.63	$27.99	$29.41	$57.41
Nov-02	$47.09	$25.21	$72.30	$46.01	$28.70	$74.70	$45.42	$25.32	$70.74	$45.99	$17.88	$63.87	$46.67	$54.33	$101.00	$44.22	$29.41	$73.63
Dec-02	$51.50	$25.72	$77.22	$49.39	$29.35	$78.74	$48.28	$25.87	$74.16	$49.46	$17.88	$67.34	$50.40	$54.33	$104.73	$46.97	$29.41	$76.38
2002 Total	**$348.11**	**$305.06**	**$653.17**	**$349.77**	**$347.65**	**$697.42**	**$346.60**	**$306.58**	**$653.18**	**$346.64**	**$214.56**	**$561.20**	**$345.74**	**$651.93**	**$997.67**	**$335.52**	**$352.96**	**$688.48**
2002 Average	**$29.01**	**$25.42**	**$54.43**	**$29.15**	**$28.97**	**$58.12**	**$28.88**	**$25.55**	**$54.43**	**$28.89**	**$17.88**	**$46.77**	**$28.81**	**$54.33**	**$83.14**	**$27.96**	**$29.41**	**$57.37**
Jan-03	$53.90	$25.72	$79.62	$51.97	$29.35	$81.33	$51.47	$25.87	$77.34	$52.05	$17.88	$69.93	$52.10	$54.33	$106.42	$50.51	$29.41	$79.92
Feb-03	$51.81	$24.18	$75.99	$51.80	$27.39	$79.19	$51.54	$24.20	$75.75	$51.66	$17.88	$69.54	$51.47	$54.33	$105.80	$50.60	$29.41	$80.02
Mar-03	$56.66	$25.72	$82.38	$56.00	$29.35	$85.35	$55.73	$25.87	$81.60	$55.91	$17.88	$73.79	$56.04	$54.33	$110.37	$54.84	$29.41	$84.25
Apr-03	$32.93	$25.21	$58.14	$33.17	$28.70	$61.87	$33.00	$25.32	$58.31	$32.90	$17.88	$50.78	$32.69	$54.33	$87.01	$32.23	$29.41	$61.65
May-03	$36.40	$25.72	$62.12	$37.27	$29.35	$66.62	$36.98	$25.87	$62.85	$36.85	$17.88	$54.73	$36.64	$54.33	$90.97	$35.93	$29.41	$65.34
Jun-03	$28.66	$25.21	$53.86	$29.87	$28.70	$58.56	$29.72	$25.32	$55.03	$29.43	$17.88	$47.31	$28.68	$54.33	$83.01	$28.80	$29.41	$58.21
Jul-03	$55.97	$25.72	$81.69	$58.30	$29.35	$87.65	$57.01	$25.87	$82.88	$56.89	$17.88	$74.77	$56.79	$54.33	$111.12	$55.50	$29.41	$84.92
Aug-03	$35.15	$25.72	$60.87	$36.10	$29.35	$65.46	$35.59	$25.87	$61.46	$35.52	$17.88	$53.40	$35.46	$54.33	$89.79	$34.86	$29.41	$64.27
Sep-03	$28.13	$25.21	$53.34	$28.91	$28.70	$57.61	$28.57	$25.32	$53.88	$28.48	$17.88	$46.36	$28.24	$54.33	$82.57	$27.84	$29.41	$57.25
Oct-03	$44.06	$25.72	$69.78	$44.46	$29.35	$73.82	$44.19	$25.87	$70.06	$44.16	$17.88	$62.04	$43.99	$54.33	$98.32	$43.02	$29.41	$72.43
Nov-03	$34.36	$25.21	$59.57	$33.46	$28.70	$62.16	$33.17	$25.32	$58.49	$33.52	$17.88	$51.40	$34.18	$54.33	$88.51	$32.80	$29.41	$62.22
Dec-03	$29.37	$25.72	$55.09	$28.84	$29.35	$58.20	$28.48	$25.87	$54.35	$28.76	$17.88	$46.64	$29.11	$54.33	$83.44	$27.71	$29.41	$57.13
2003 Total	**$487.40**	**$305.06**	**$792.46**	**$490.17**	**$347.65**	**$837.82**	**$485.44**	**$306.58**	**$792.02**	**$486.15**	**$214.56**	**$700.71**	**$485.39**	**$651.93**	**$1137.32**	**$474.64**	**$352.96**	**$827.61**
2003 Average	**$40.62**	**$25.42**	**$66.04**	**$40.85**	**$28.97**	**$69.82**	**$40.45**	**$25.55**	**$66.00**	**$40.51**	**$17.88**	**$58.39**	**$40.45**	**$54.33**	**$94.78**	**$39.55**	**$29.41**	**$68.97**

4 CONCLUSIONS

The results of the foregoing analysis have clearly shown the effect of location and the variability of residential electricity bills throughout the province. The analysis shows the following:

- Differences in total monthly electricity bills for residential customers are more dependent on other (system access, distribution, etc…) charges than they are on the energy charge.
- While residential and NSLS load profiles appear quite different on an hourly basis, when the energy component for monthly billing is calculated, the differences are actually quite small. This indicates that profile type does not have a large impact on energy charges.
- Variability in monthly energy charges is highly dependent on Pool price (when energy charges are calculated using a Pool price flow-through) but does not appear to be dependent on the timing of the bill (billing cycle).
- The 2003 (residential) profile-weighted average Pool price was higher than the average Pool price for the year in each service area. This indicates that residential customers tend to consume more energy during higher priced hours.
- Customers on 2003 RRO rates paid less for the energy they consumed than customers would have on Pool price flow-through in their respective service areas. This shows that RRO rates are relatively low and are difficult for other retailers to beat. This is not necessarily the case in all years.

Synthetically Derived Profiles for Representing Occupant-Driven Electric Loads in Canadian Housing

Marianne M. Armstrong[a], Mike C. Swinton[a], Hajo Ribberink[b], Ian Beausoleil-Morrison[c], Jocelyn Millette[d]

[a]National Research Council Canada, Institute for Research in Construction, Ottawa, Ontario, Canada; [b]Natural Resources Canada, CANMET Energy Technology Centre, Ottawa, Ontario, Canada; [c]Department of Mechanical and Aerospace Engineering, Carleton University, Ottawa, Canada; [d]Hydro-Québec, LTE, Shawinigan, Quebec, Canada

ABSTRACT

As one objective of IEA/ECBCS Annex 42, detailed Canadian household electrical demand profiles were created using a bottom-up approach from available inputs including a detailed appliance set, annual consumption targets, and occupancy patterns. These profiles were created for use in the simulation of residential cogeneration devices to examine issues of system performance, efficiency and emission reduction potential. This paper describes the steps taken to generate these 5-minute electrical consumption profiles for three target single-family detached households – low, medium and high consumers, a comparison of the generated output with measured data from Hydro Québec, and a demonstration of the use of the new profiles in building performance simulations of residential cogeneration devices.

Keywords*:* electric load profiles; demand modelling; residential electrical consumption; residential cogeneration; combined heat and power

1 INTRODUCTION

The combined production of heat and electricity from distributed generation technologies such as fuel cells, Stirling engines, and internal combustion engines offers the potential for energy savings. Since these devices provide both electrical and thermal outputs, an accurate assessment of their performance requires a realistic prediction of the electrical and thermal loads demanded by the host building.

Building performance simulation is an ideal analysis method to assess these technologies. Well-developed methodologies exist to predict temporal thermal demands for space heating and cooling. Models also exist to predict the temporal electrical demands of HVAC (Heating Ventilation and Air Conditioning) equipment that operate in response to thermal demands (e.g. pumps and fans). Building performance simulation, however, lacks the predictive capabilities for occupant-driven or discretionary electrical loads (e.g. lighting and appliances). The creation of representative occupant-driven electric load profiles for residential buildings was one objective of Annex 42 of the International Energy Agency's Energy Conservation in Buildings and Community Systems Programme (IEA/ECBCS). This paper treats the development of such profiles for Canadian housing.

A survey of existing electrical load profiles for Canada revealed that detailed measured data was limited (Aydinalp, 2001). In most cases, data from only a small number of houses was available. A number of data sets were for the whole house, making it difficult to differentiate between HVAC and non-HVAC loads. Additionally, small communities of houses were often combined, creating an "average" data set. By this aggregation of data, consumption peaks and valleys were rounded out. The data collection intervals were usually large – hourly data sets. As shown in Figure 1, these long sampling intervals result in a smoothing of the load profile, and overall lower magnitude of peaks. The impact of this smoothing can be highlighted by an example: if a grid-connected residential cogeneration system supplied a constant 800W of electricity to the loads in Figure 1, by the hourly data we would predict that 24% of the electricity would be exported to the grid this day. However, if the higher resolution 5-minute data is used for the same calculation, a much higher 30% export of the generated electricity is predicted. Depending on the shape of the consumption profile and the shape of the generated electricity profile, the difference could be even greater. This difference in exported electricity caused by the resolution of data has a direct impact on economic and emission calculations.

Rather than use limited existing measured data, the objective of the current work was to synthetically generate a new set of representative profiles at 5-minute time resolution for the occupant-driven electrical loads in Canadian housing.

This paper first reviews previous efforts to synthetically generate electric load profiles. This is followed by a description of the methodology employed in the current study. Following this, the new synthetically generated profiles are compared to measured data. The use of the new profiles in building performance simulations of residential cogeneration devices is then demonstrated. Finally, concluding remarks are provided.

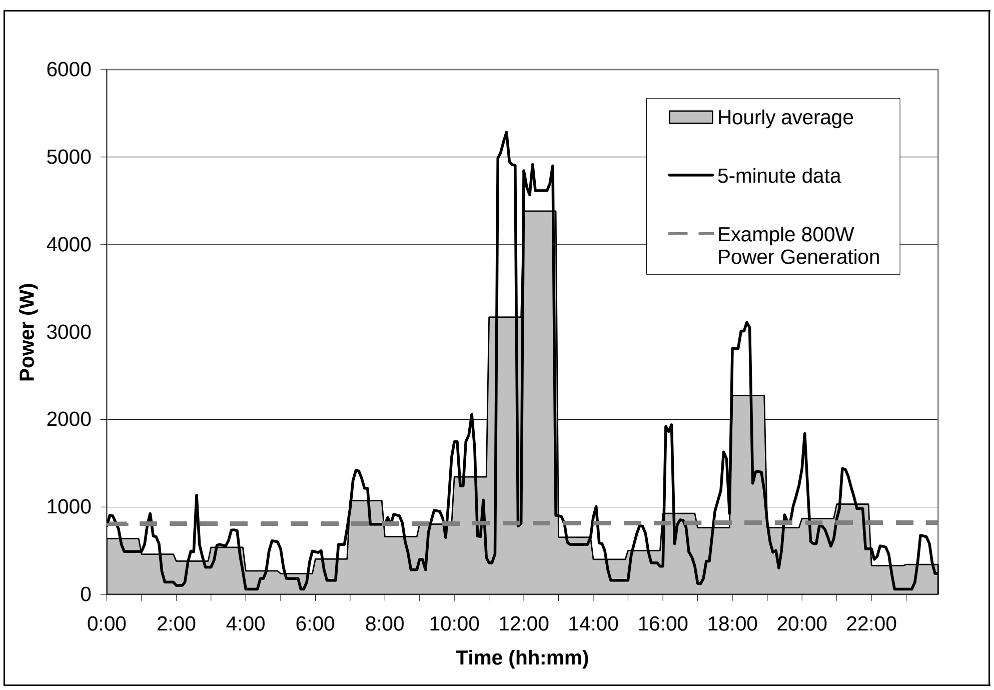


Figure 1 - Generated Load Profile Example – averaging the data hourly smoothes out peaks and valleys

2 Previous Efforts to Synthetically Derive Electric Load Profiles

Work has been performed by a number of researchers to develop detailed residential electrical load profiles from limited sources of data using a bottom-up approach: reconstructing the expected daily electrical loads of a household based on appliance sets, occupancy patterns, and statistical data.

In 1985, Walker and Pokoski constructed electric load profiles from individual appliance profiles. They introduced the concept of using "availability" and "proclivity" functions to predict whether someone is available (at home and awake) and their tendency to use an appliance at any given time. These functions were applied to predict individual appliance events, which were then aggregated into a load profile. Profiles were simulated and then compared to measured data from the Connecticut Light and Power Company. This preliminary modelling work was conducted for the purpose of predicting loads and load changes due to social and economic factors, in order for power generation planning.

In 1994, Capasso *et al.* created household load profiles beginning with detailed information on human behaviour and also appliances. Functions in Capasso's model were based on such factors as occupant availability, activities, human resources (including number of hands, eyes, etc.), and also appliance ownership. The detailed data on occupant actions was readily available thanks to an extensive time of use survey in Italy 1988-89, which included activity diaries from 40 000 individuals. While Capasso did generate profiles for individual houses, the goal was then to aggregate the profiles to predict the overall consumption of a group of households in a given area based on socioeconomics and demographics. This information could then be used to predict the response to rate policies and demand side management strategies.

Similarly, Paatero and Lund (2005) created electrical profiles to examine demand side management strategies for Finland. However, they used a different bottom-up approach based on statistical consumption data, and not detailed occupant behaviour. Electrical data from hundreds of apartments in Finland formed the basis for the statistics used to fabricate these hourly demand profiles.

Yao and Steemers (2004) created a simple method of predicting household electrical loads for the design of renewable energy systems in the UK. Their load prediction was based on detailed inputs including the number of occupants, occupied hours, the time period when each appliance will be used, and the number of hours of use per day. This is a simpler method to the one described herein for creating the Canadian load profiles. Where Yao and Steemers' generator allows an appliance event to occur with equal probability at any time during a designated time period (an input that needs to be specified of each appliance and household), the Canadian synthetic profiles depend on statistical use curves to weigh the likelihood of appliance events occurring throughout the day.

The main thrust of recent work in load profile generation has been towards examining grid effects of distributed generation systems including renewable energy technologies.

For this, a large number (thousands) of diverse and detailed residential electrical load profiles are required. Since the collection of such a vast amount of data is costly, being able to predict these loads is essential.

Researchers in the UK have been generating UK-specific detailed load profiles to examine grid effects from the use of highly distributed power systems. The modelling of occupancy behaviour is key to creating the diversity of profiles required for assessing grid impact of multiple residences with generation systems. This work relies on a bottom-up approach beginning with understanding occupancy patterns – predicting both the availability of occupants and activity levels. Jardine's (2008) occupancy model relies on identifying periods of activity where the electrical load is above the baseload, based on a sample of 100 measured domestic electricity load profiles. While Richardson *et al.*'s (2008) occupancy model draws on a UK Time-Use Survey from 2000, with thousands of participants keeping diaries of their activities every 10 minutes.

Despite this wealth of knowledge and the resulting high-resolution profiles for the UK, the UK electrical profiles are not of use for simulations of Canadian homes. The differences between Canadian and UK consumption patterns at the household level are large. Notwithstanding socioeconomic and demographical differences, the annual non-HVAC electrical consumption in the typical Canadian home is 6567 kWh/year, roughly twice that of the typical UK home (Knight et al. 2007).

The purpose of generating Canadian load profiles for the Annex 42 work is not to examine grid effects or demand side management, but for the simulation of residential cogeneration technologies: to look at system performance in terms of ability to meet heating and electrical requirements of the house, and to examine system efficiency and emission reduction potential. Instead of a large number of diverse profiles, a limited number of *typical* Canadian load profiles are required. A single such profile needs to embody the characteristics of an average house, but also represent the variation of actions possible in a number of households. By achieving this, the set of profiles will be useful to compare the ability of different technologies and control strategies to meet a variety of demand scenarios.

3 METHOD FOR PROFILE GENERATION

The generated profiles described herein are not the first set of generated electrical profiles for Canadian homes. One set of non-HVAC electrical profiles was generated by Canadian company, Kinectrics, to simulate the occupant-driven loads. Annual electrical data sets were produced based on engineering assumptions as to the kind of appliances and lighting that are inside the home and when the occupants are expected to turn them on. Different annual profiles were created for combinations of 2 or 4 occupants, high/low energy users, and young/old occupants in an urban/rural setting. Each data set featured only a few different daily load profiles that were organized to form a full year of data: a weekday, Saturday, Sunday, laundry day and vacation days. The disadvantage to this approach is that this represents a limited number of scenarios, which may not necessarily challenge a system as in the real world. Also the profiles were produced at a 15-minute resolution: a resolution of 5-minutes or lower is desirable for the simulation of residential cogeneration technologies.

In order to generate load profiles for Canadian households, information was compiled on the expected annual consumption of the households, the appliance stock and characteristics, and occupant usage patterns. Where no data was available, it was necessary to make educated assumptions. This section outlines the inputs for profile generation, and also the logic behind the generated profiles.

Detailed 5-minute non-HVAC electrical load data were desired for three different typical families/households:

1. Low electricity demand. An energy conscious family in an average detached house.
2. Medium electricity demand. A regular family in an average detached house.
3. High electricity demand. A large family with no interest in energy conservation, living in a large detached house.

3.1 Inputs

3.1.1 Annual Consumption Targets

Average values for the total annual consumption as well as for major appliances and lighting in Canada were obtained from the Comprehensive Energy Use Database of the Office of Energy Efficiency of Natural Resources Canada (NRCan, 2005). This database contains information on the electricity use of the average Canadian household based upon data from surveys and other sources (manufacturers, electricity distribution companies, government surveys, etc). The database gives the type and average number of appliances per household, and the average electricity use for appliances and lighting (for average stock as well as for new ones). Table 1 presents the electricity use for appliances and lighting for the average Canadian household, based upon data for 2003 for the average stock of appliances.

Table 1 - Electricity use for appliances and lighting for the average Canadian household (average stock of appliances) (NRCan, 2005)

	Nr of appl	kWh/y	kWh/appl
Refrigerator	1.24	992	801
Freezer	0.56	346	614
Dishwasher	0.55	39	72
Clothes washer	0.81	62	76
Clothes dryer	0.79	780	988
Range	0.92	711	769
Other appliances	8.98	1896	
Lighting (/m^2)	121 m^2	1742	14.4
Total		**6567**	

This data for the average Canadian household formed the basis for setting electricity use targets. According to the 2006 Census of Canada (as reported by the Canada Mortgage and Housing Corporation, 2008), the Canadian housing stock consists of 55.2% single-detached homes, 4.8% semi-detached and duplex, 5.6% row housing, and 34.4% apartment and other dwellings. Since the average Canadian household as detailed in Table 1 includes all these dwelling types and the target household for profile generation is the single-detached home, adjustments to the targets were made. A separate set of targets was developed for each of the three households (low, medium and high energy) as follows.

The Energy Use Database tells us that the average Canadian household (including detached home, row houses and apartments) has 121 m^2 of floor area, whereas the average area for a detached house is 141 m^2. Since a detached house is larger than the average household (which includes a substantial amount of apartments), a detached house can also be assumed to have more occupants. Both the low and medium energy households assumed the average detached house size with a liveable space of 141 m^2, while 282 m^2 of floor space (twice the area of the average detached home) was chosen for the high energy target household.

The average number of appliances per household, as listed in Table 1 is less than one for most appliances. This again is due to the mix of households that make up the average Canadian household, including apartments with smaller appliance sets. It was assumed for the purposes of simulation that each of the three types of single-family detached households has a refrigerator, dishwasher, clothes washer, dryer and range. Since the average number of freezers per household was low, only the medium and high electricity demand households were assumed to have a freezer. The high demand household was assigned a second fridge, given that the average number of fridges per household exceeded one.

In addition to adjusting the number of appliances per household, the electricity consumption data for appliances and lighting have been adjusted to reflect the differences between households by the introduction of a 'use factor' for the appliances. The use factor presents the use of the appliance compared to average use. No data was available for the use factors, therefore they were assumed based upon common ideas about the differences between the average house and the average detached house. The use factors are not validated through any available data. The end result is a set of appliances and annual consumption targets for each of the three households, as listed in Table 2.

Table 2 - Energy Targets for the Profile Generator

Load	Medium Energy Detached House			Low Energy Detached House			High Energy Detached House		
	Appl per hh	Factor	kWh per hh	Appl per hh	Factor	kWh per hh	Appl per hh	Factor	kWh per hh
Refrigerator	1	1.0	801	1	1.0	801	2	1.0	1601
Freezer	1	1.0	614	0	0.0	0	1	1.3	798
Dishwasher	1	1.3	94	1	0.8	58	1	1.7	122
Clothes Washer	1	1.3	99	1	0.8	61	1	2.0	152
Clothes Dryer	1	1.3	1284	1	0.6	593	1	2.0	1976
Range	1	1.0	769	1	1.0	769	1	1.4	1077
Other Appliances		1.3	2465		0.8	1517		1.7	3223
Lighting	141 m^2	1.0	2030	141 m^2	0.5	1015	282 m^2	1.0	4061
Total (kWh/year)			**8156**			**4813**			**13011**
Average Daily (kWh/day)			**22.3**			**13.2**			**35.6**

3.1.2 Appliance Characteristics

In order to generate profiles, information was required on the size, duration and shape of the individual electrical loads. Each of the eight loads listed in Table 1 (refrigerator, freezer, dishwasher, clothes washer, clothes dryer, range, other appliances and lighting) were simulated individually and then combined to create daily 5-minute non-HVAC load profiles.

For the dishwasher, washer, range and dryer, the electrical draw was calculated using the cycle duration, the cycles per year for the average house, and the target annual consumption (kWh/year) as described in Equation 1. The target annual for the medium energy house was chosen for this calculation, since the medium house is assumed to be an average single detached home. The average cycles per year were derived from standard appliance test methods of the Canadian Standards Association (CAN/CSA-C373-92, CAN/CSA-C361-92 and CAN/CSA-C360-98). Cycle duration was chosen based on measured data from the Canadian Centre for Housing Technology (CCHT) twin house research facility. At the CCHT, a simulated occupancy system triggers daily lighting and appliance events in a real single detached home. Appliance consumption data is captured on a 5-minute basis by individual electric meters with a resolution of 6 Wh per pulse (Swinton, 2001).

Equation 1

$$\text{Average Appliance Electrical Draw} = \frac{\text{Annual Consumption}}{\text{Cycle Duration} * \text{Cycles per year}}$$

The calculated electrical draw was compared to data from the Canadian Renewable Energy Network (Natural Resources Canada, 2004), thus ensuring that the consumption targets, cycle duration, cycles per year and electrical draw were all realistic and properly related as in Equation 1. To match the target annual consumptions for the low and high electricity demand profiles, the number of cycles per year was varied. Details of appliance loads and cycles are presented in Table 3.

Table 3 - Appliance Characteristics for Generated Profiles

Appliance	Power (W)	Cycle Duration (min)	Cycles per year	Target Annual Consumption (kWh/year)
Dishwasher	467	30 to 45	200 (low) 322 (medium) 418 (high)	58 (low) 94 (medium) 122 (high)
Washer	505	30 (two 15-minute cycles)	242 (low) 392 (medium) 601 (high)	61 (low) 99 (medium) 152 (high)
Dryer	4115	30 to 60	192 (low) 416 (medium) 640 (high)	593 (low) 1284 (medium) 1976 (high)
Range	1600	15 to 70	678 (low) 678 (medium) 950 (high)	769 (low) 769 (medium) 1077 (high)
Refrigerator	265 (peak)	----	----	801 (low) 801 (medium) 1602 (high: 2 fridges)
Freezer	 202 (peak) 263 (peak)	----	----	0 (low) 614 (medium) 798 (high)

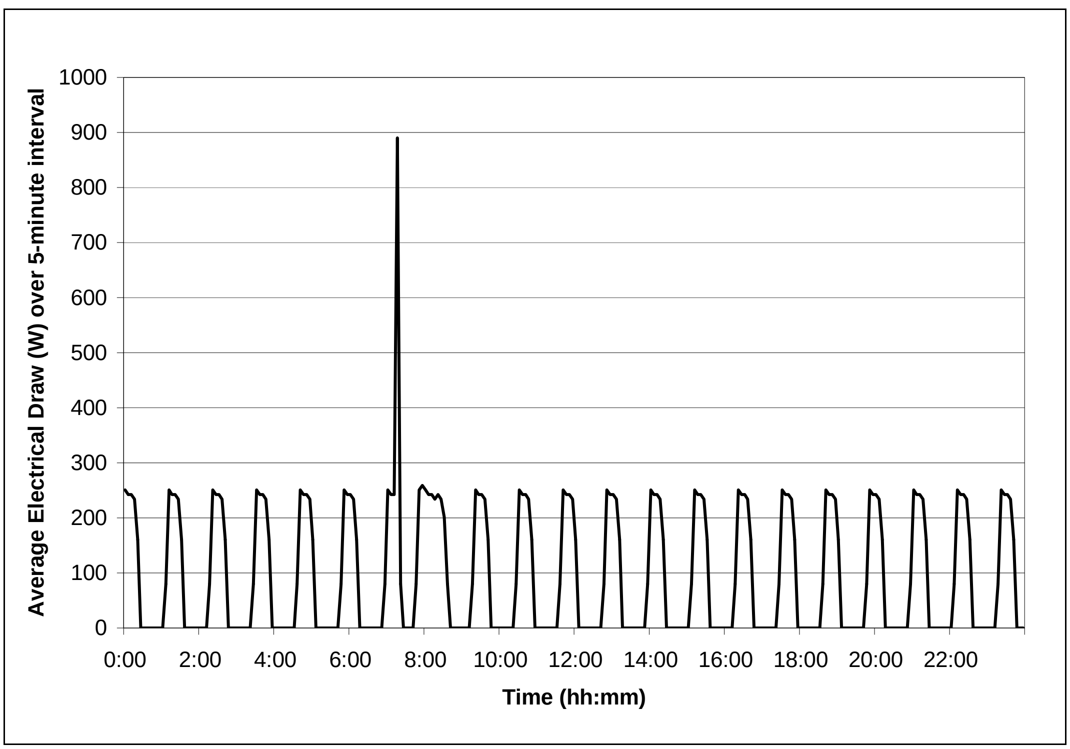


Figure 2 - Sample Daily Refrigerator Consumption Profile

It was assumed that both the low and medium target houses were equipped with identical refrigerators, while the high energy house contained two of the same model. The shape of the refrigerator and freezer profile was based on measured refrigerator data from the CCHT. The shape of the CCHT profile was scaled to match the target annual consumption. The same 70-minute cycling sequence, as observed and measured in the CCHT refrigerator data, was repeated throughout the day and randomly offset forward or back to ensure a different starting point each day. A single 105 minute defrost cycle was also added randomly during the day, matching the cycle sequence. A sample daily refrigerator consumption profile is shown in Figure 2.

A wide variety of loads fit in the category "Other appliances". To simulate these loads, a list was compiled from a series of buyers guides published by Natural Resources Canada (2002 and 2004). This list of appliances with their power rating and expected hours of operation per month is presented in Table 4. Additionally, a constant baseload of 65 Watts was chosen based on Natural Resources Canada (2002) data and applied to account for standby loads from appliances such as microwaves, telephones, clocks and VCRs.

Table 4 – Other Appliance loads (NRCan, 2004)

	Appliance	Power Rating (W)	Hours per month
Kitchen	Blender	350	3
	Coffee Maker	900	12
	Deep Fryer	1500	8
	Exhaust fan	250	30
	Electric kettle	1500	15
	Hot plate (one burner)	1250	14
	Microwave oven	1500	10
	Mixer	175	6
	Toaster	1200	4
Laundry	Iron	1000	12
Comfort and Health	Electric blanket	180	180
	Fan	120	6
	Hair dryer	1000	5
Entertainment	Computer (desktop)	250	240
	Computer (laptop)	30	240
	Laptop charger	100	240
	Radio	5	120
	Stereo	120	120
	Television	100	125
	VCR	40	100
Outdoors	Lawn mower	1000	10
Tools	Drill	250	4
	Circular saw	1000	6
	Table saw	1000	4
	Lathe	460	2
Other	Sewing Machine	100	10
	Vacuum cleaner	800	10

The list of lighting loads is presented in Table 5. These loads were assumed based on reasonable lighting loads, as measured at the CCHT. It was also assumed that the low energy house would be using more efficient light bulbs, while the high-energy house would simply have more lighting loads based on its larger floor area.

Table 5 - Lighting loads

Name	Average House Load (W)	High Energy House Load (W)	Low Energy House Load (W)
Lighting Load 1	60	120	30
Lighting Load 2	100	200	50
Lighting Load 3	120	240	60
Lighting Load 4	410	820	205
Lighting Load 5	200	400	100
Target Annual Consumption (kWh/year)	**2030**	**4061**	**1015**

3.1.3 Time of Use Probability Profiles

In order to create realistic load profiles, knowledge of occupancy patterns is required. Canadian occupancy information was limited, so a simpler approach was taken to occupancy driven control than the methods used by Jardine (2008) and Richardson et al. (2008).

The range, dishwasher, and washer events were guided using normalized energy use profiles from Pratt et al.(1989), as found in the Building America Research Benchmark Definition (Hendron, 2006), see Figure 3. These curves were applied to predict the occupants' actions, and to control the probability of an event occurring. The higher the fraction of total daily usage, the higher the probability that an event occurs. For example, a range event would be far more likely to occur at 17:00 than at 4:00. Since there is only one range, one dishwasher and one washer per house, only a single event from each appliance was allowed to occur at any one time: a new event could only be triggered if the appliance was in an "off" state. The time of use curve for the dryer was not used to control its operation. Instead, since the time of use profiles for the dryer was the same shape and offset from the time of use profile for the washer, dryer events were coupled to washer operation. Dryer cycles were allowed to trigger between 30 and 120 minutes following the end of the washer cycle.

The "Other appliance" time of use curve controlled the probability of a small appliance being activated. Events were allowed to overlap, and whenever an appliance was randomly activated, the load was chosen from the list in Table 4. The likelihood of a small appliance being chosen from the list is based on the listed hours of operation per month. For instance, an iron event – with only 12 hours of operation per month, was four times more likely to occur than a mixer event – with only 3 hours per month of operation. Each appliance event was assigned a random duration between 5 and 120 minutes.

Lights were controlled in a similar manner. Three different lighting profiles were implemented: one for winter, one for summer, and one for the shoulder period (Figure 4). December through February were considered winter, and June through August were considered summer, with the remaining six months considered as the shoulder season. Lighting events were allowed to overlap, and the load for each event was chosen randomly from the lighting loads listed in Table 5. Each lighting event was assigned a random duration between 5 and 120 minutes.

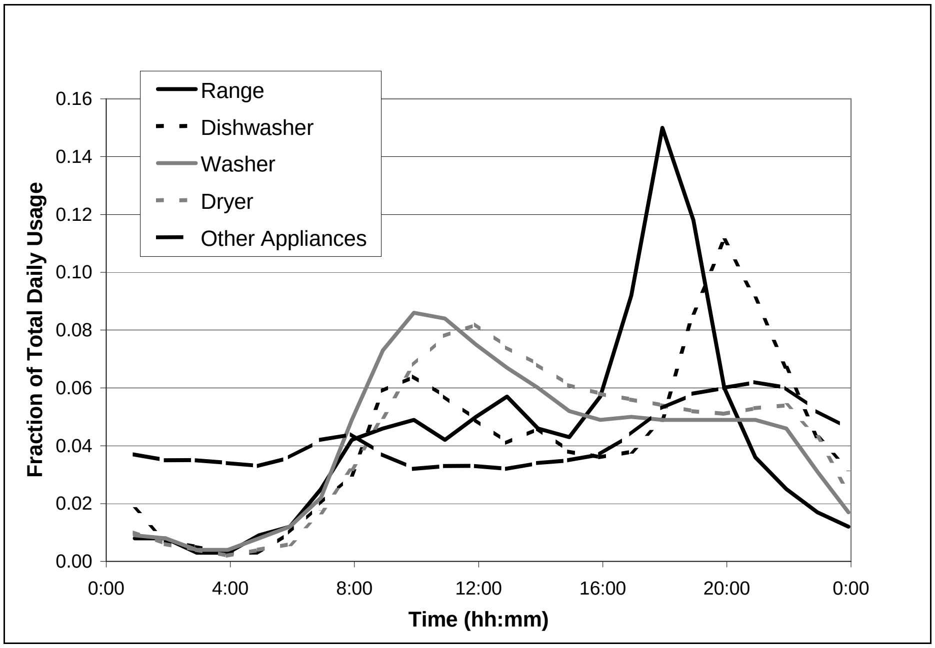


Figure 3 - Time of use curves for different loads (Pratt, 1989)

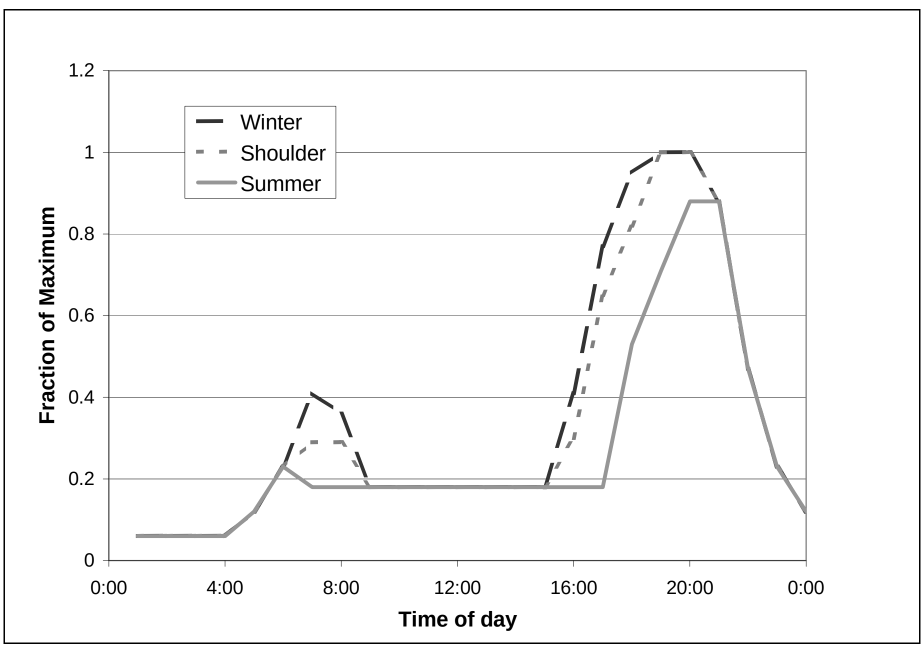


Figure 4 - Lighting Time of Use Curves for Winter, Summer and Shoulder seasons (Pratt, 1989)

3.2 Logic

By combining the appliance characteristics, the time of use probability curves and the annual consumption targets, realistic 5-minute non-HVAC load profiles can be created. The control logic for generating load profiles allowed an appliance to come on by chance at any time throughout the day. The probability of any event happening in any 5-minute period is controlled by the fraction of total daily usage for that hour (from the time of use curves) and a variable arbitrarily named the "chance factor" *c*, as shown in Equation 2. As *c* is increased, the probability of the event occurring decreases. Thus, by varying *c* the total number of annual events changes, and thus the desired annual consumption target can be attained. For each appliance, *c* was sought through iteration, as outlined in Figure 5.

Equation 2 Probability = f/c

Where

- P is the probability,
- f is the fraction of total daily usage – from the time of use curves
- c is the chance factor – chosen to attain the desired annual consumption target

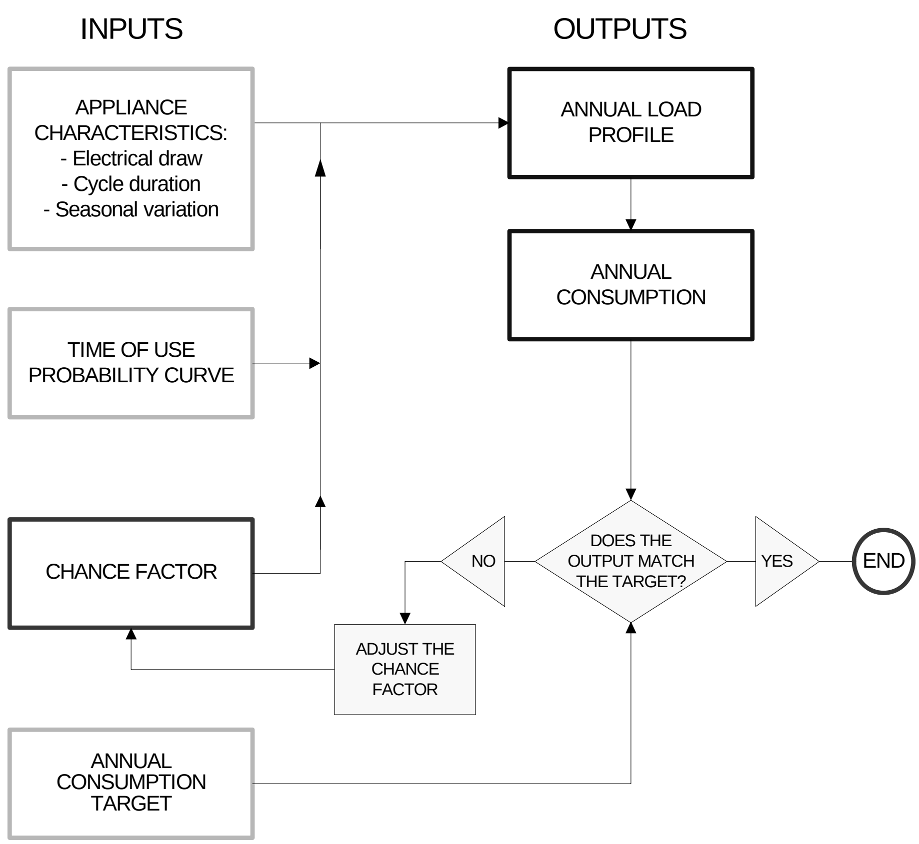


Figure 5 - Flow Chart for Selecting the Chance Factor

When controlled in this manner, the average electrical draw of an appliance over a large number of days will tend towards the shape of the time of use curve. Figure 6 illustrates the result from applying the washer time of use curve to generate data for the high energy, average energy and low energy target households. While an identical washer is operated in each of the three households, the number of events is adjusted to meet the target annual appliance consumption by changing the chance factor.

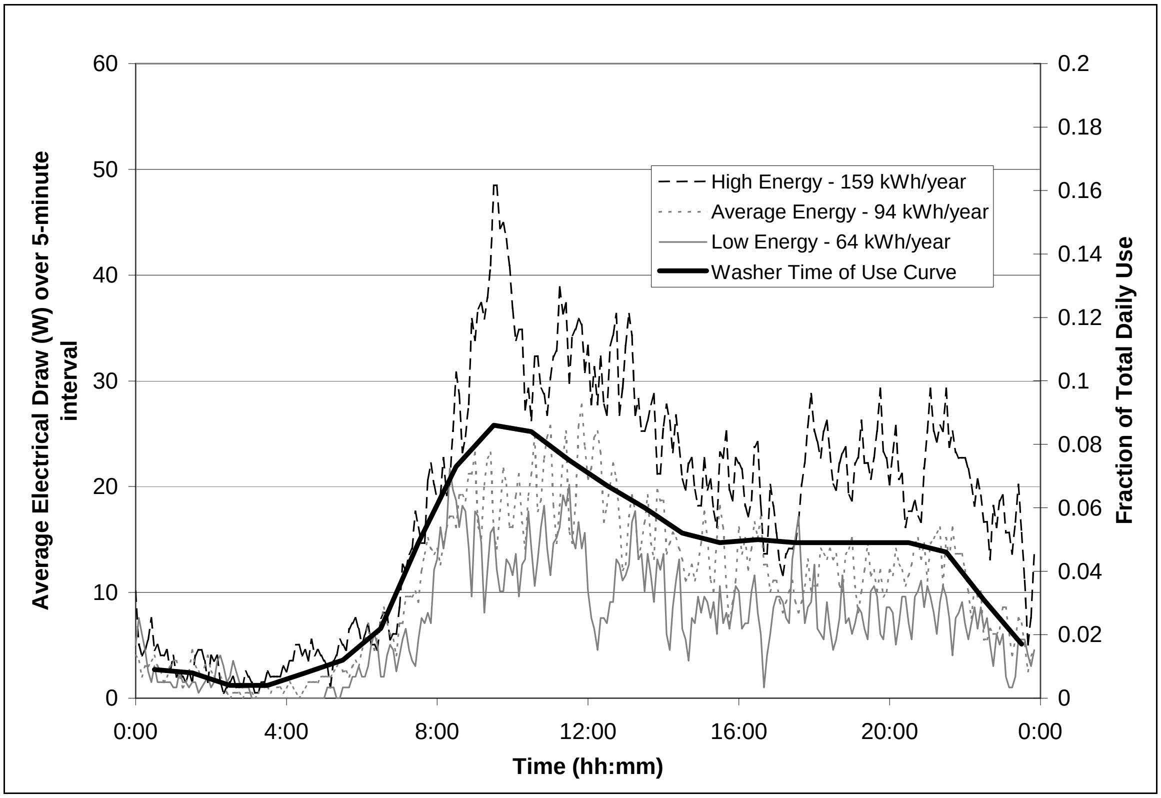


Figure 6 - Average Daily Washer Consumption - based on 1000 randomly generated daily profiles

3.3 Output

The eight loads were generated individually and then combined on a daily basis to create a random 5-minute daily load profile for the house. Although there is no change in the controlling assumptions of the profile generator for weekend and weekday operation, the stochastic variations produced through the generation process create a wide range of daily profiles. When used in simulation, these profiles will expose CHP devices to a variety of test conditions.

A sample of the generated daily profiles from Year 1 of the medium energy house is represented in Figure 7. These figures present the minimum (7a), average (7b) and maximum (7c) daily profiles from a constant set of inputs. In these figures, individual loads are presented stacked one upon another, accumulating to the total 5-minute electrical draw shown on the y-axis.

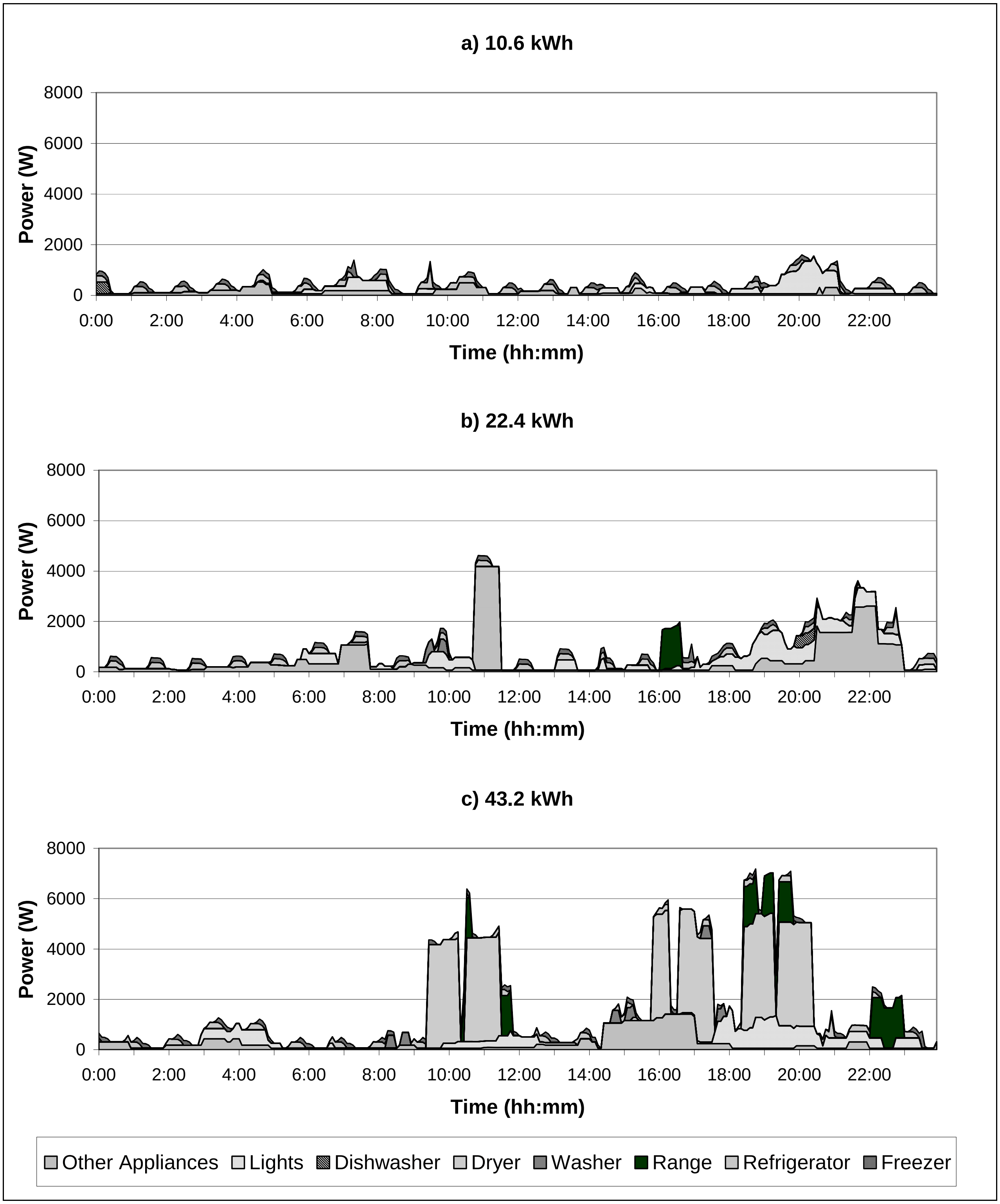


Figure 7 - Sample Daily Profiles from Year 1 of the medium energy house, for a) minimum daily consumption b) average daily consumption c) maximum daily consumption

A total of 365 days were produced from each set of the three sets of inputs (low, medium and high energy households), with seasonal variations for lighting. These generated days were strung together to produce an annual set of 5-minute data. Three yearly profiles were created for each household type. The resulting annual profiles are compared in Table 6.

Figure 8 presents the average hourly load from the yearly profiles in graphic form. Note the small variation between the three years of data for each household. This is a result of the stochastic generation process and the degrees of freedom available during the profile generation.

Table 6 - Comparison of Annual Profiles

	Low Energy Detached House			**Average Detached House**			**High Energy Detached House**		
	Year 1	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**	**Year 1**	**Year 2**	**Year 3**
Annual Consumption Target (kWh/year)	4813	4813	4813	8156	8156	8156	13011	13011	13011
Annual Consumption (kWh/year)	**4762**	**4672**	**4837**	**8159**	**8218**	**8112**	**12956**	**13140**	**13044**
Average Daily Consumption (kWh/day)	**13.1**	**12.8**	**13.3**	**22.4**	**22.5**	**22.2**	**35.5**	**36.0**	**35.7**
Maximum Daily Consumption (kWh/day)	28.0	24.8	26.2	43.2	39.2	42.3	53.1	58.4	55.4
Minimum Daily Consumption (kWh/day)	6.4	6.9	6.9	10.7	10.4	11.7	21.2	19.9	20.6
Average Daily Draw (W)	544	533	552	931	938	926	1479	1500	1489
Maximum Yearly 5-minute peak (W)	8099	7432	6973	8808	8313	8760	10480	10927	10047

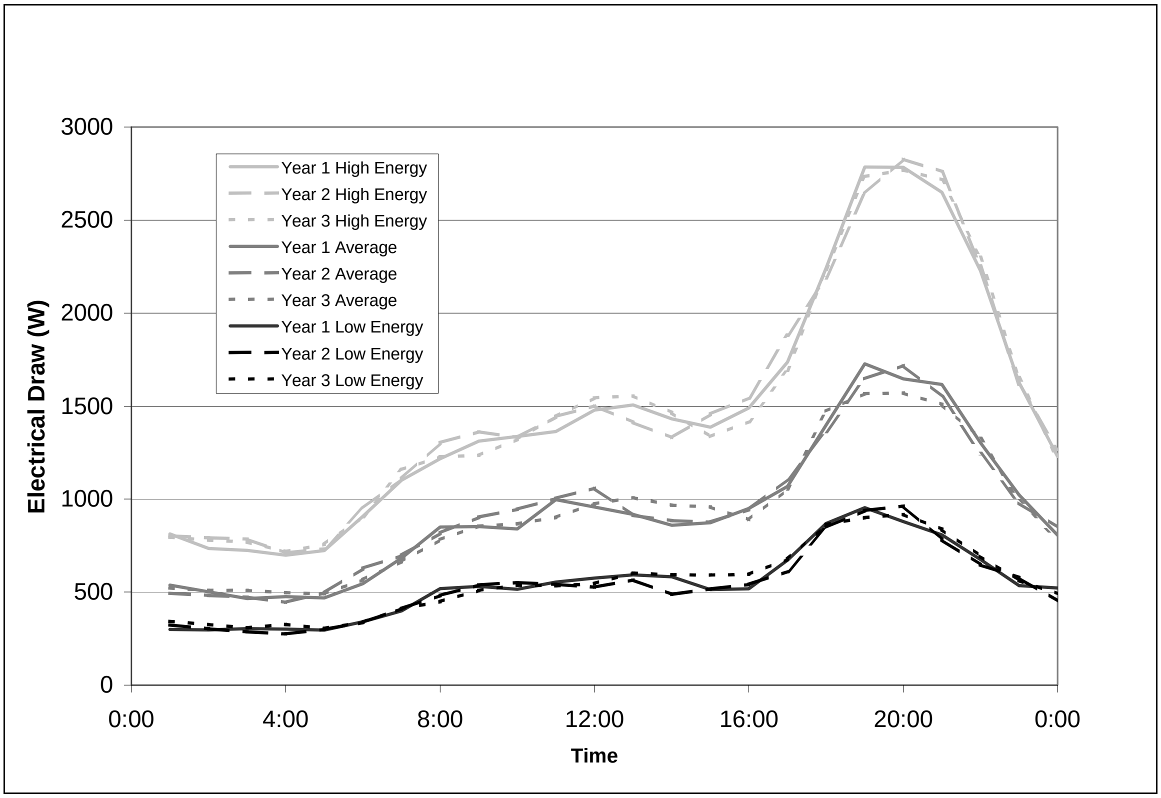


Figure 8 - Yearly Average Profiles for Low, Average and High Energy Houses, Hourly data

4 COMPARISON OF THE GENERATED PROFILES WITH MEASURED DATA

During the mid 1990s, Hydro Québec performed an experimental program to assess the impact of energy saving measures in electrically heated houses in Quebec. For 2.5 years, the total cumulative electricity consumption over 15 minute periods was measured, as well as the separate amounts for space heating and for domestic hot water heating. The balance between the total electric consumption and the latter two quantities provided suitable non-HVAC electricity demand profiles for use in building simulation.

These measured demand profiles contained data samples at 15-minute intervals between 1994 and 1996. Houses were selected for comparison to the generated data based on their total annual consumption and the annual targets already established. Low energy and medium energy measured profiles were chosen as listed in Table 7. While two houses from the survey had annual consumptions in the range of the low electricity demand target, and two survey houses were in the range of the medium electricity demand target, there was no house in the survey that showed consumption comparable to the high electricity demand target.

Table 7 - Comparison of Characteristics of Generated and Measured Profiles

Profile	Dates	Annual Consumption kWh/y	5-minute peak load Watts	15-minute peak load Watts	Average load Watts
Low Energy					
Generated Y1	**----**	4762	8099	7834	544
Generated Y2	**----**	4672	7432	7065	533
Generated Y3	**----**	4837	6973	6549	552
House #21 Y1	(Jan 01 – Dec 31, 1994)	4460	----	5620	532
House #21 Y2	(Jan 01 – Dec 31, 1995)	4750	----	5080	542
House #40 Y1	(Jan 01 – Jul 31, 1995 + Aug 01 – Dec 31, 1994)	5223	----	8100	596
Medium Energy					
Generated Y1	----	8159	8808	8070	931
Generated Y2	----	8218	8313	8038	938
Generated Y3	----	8112	8760	8328	926
House #30 Y1	(Jan 01 – Feb 28, 1996 + Mar 01 – Dec 31, 1994)	8265	----	8080	943
House #30 Y2	(Jan 01 – Dec 31, 1995)	8426	----	7020	962
House #45 Y1	(Jan 01 – Feb 28, 1996 + Mar 01 – Dec 31, 1994)	7425	----	6568	848
House #45 Y2	(Jan 01 – Dec 31, 1995)	7713	----	7028	881
High Energy					
Generated Y1	----	12956	10480	10313	1479
Generated Y2	----	13140	10927	9910	1500
Generated Y3	----	13044	10047	9292	1489

A comparison of the generated data to real life consumption curves provided by Hydro Québec (15-minute data) has shown that they are similar in terms of peaks, averages, and total yearly consumption. A visual comparison of one week of measured and generated profile data for a medium energy house is presented in Figure 9. In this figure, the 5-minute generated data has been aggregated to create 15-minute data for a better comparison. Generally, real life curves (9b) tend to be more repetitive than the generated data (9a). This is, however, not considered a fault, since the generated profiles are designed to expose CHP units to a variety of conditions in a single year.

A statistical comparison using probability curves with 100 W bins, show that there are some differences between the measured data and the generated data. In this comparison, the 5-minute generated data was first converted to 15-minute averaged data – to match the time step of the measured data.

For the low energy use households (Figure 10), the measured data show a concentration of loads around 400W and a lack of loads below 200W, whereas, the generated data has a significant amount of small loads below 200W. This suggests that the generated data should likely have a higher constant baseload to match these particular measured profiles.

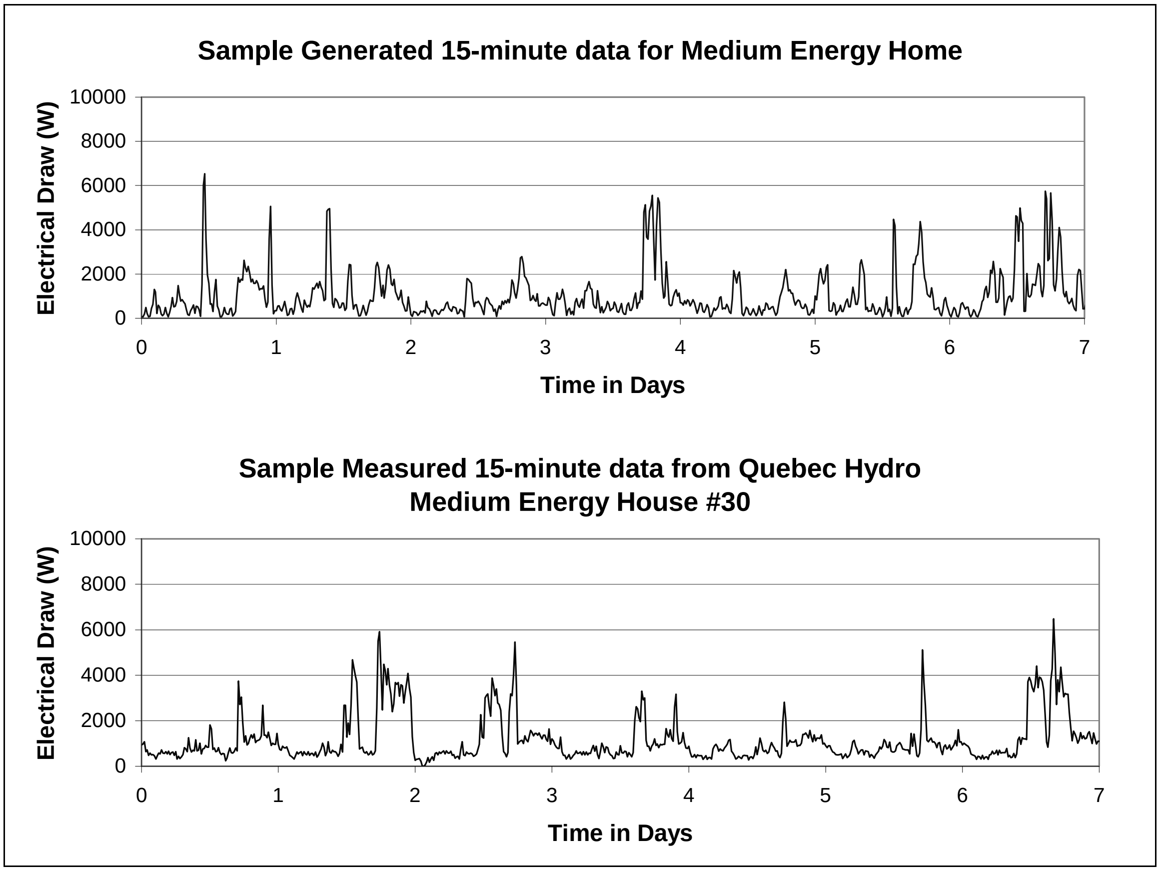


Figure 9 – Sample Generated and Measured non-HVAC loads for a medium energy home

In the comparison of measured to generated data for the medium energy households (Figure 11), the generated data resembles the probability curve of Houses 30 and 48. Once again, a higher baseload would help improve the fit of the generated data to the measured data. Interestingly, there are two "dead zones" in the measured data, at 800 and 1600 Watts. Apparently, loads from 701 to 800, and 1501 to 1600 Watts are not attainable with the lighting and appliance set in this home.

This measured data represents a very small subset of houses. The lack of detailed measured data is the reason that generated profiles were created – to simulate the large variation of possible daily loads in current housing stock. There is a need for greater understanding of the appliance sets and loads found in houses as well as occupancy patterns. With updated information, the simulated profiles could be improved.

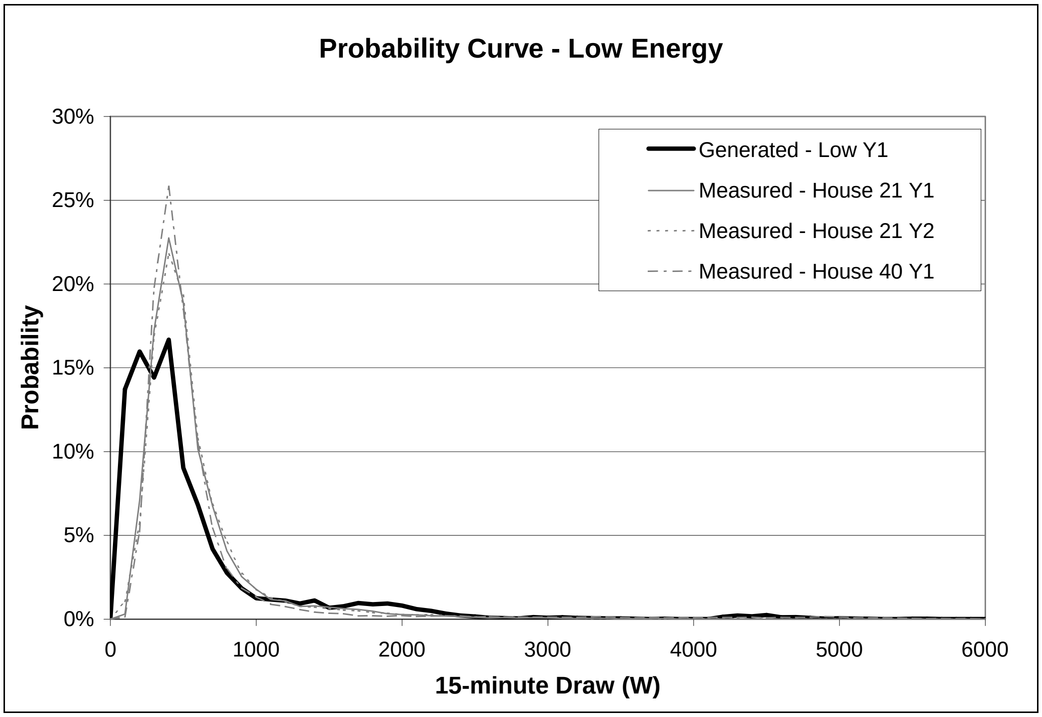


Figure 10 - Statistical comparison of generated and measured data for low energy homes, 100W bins

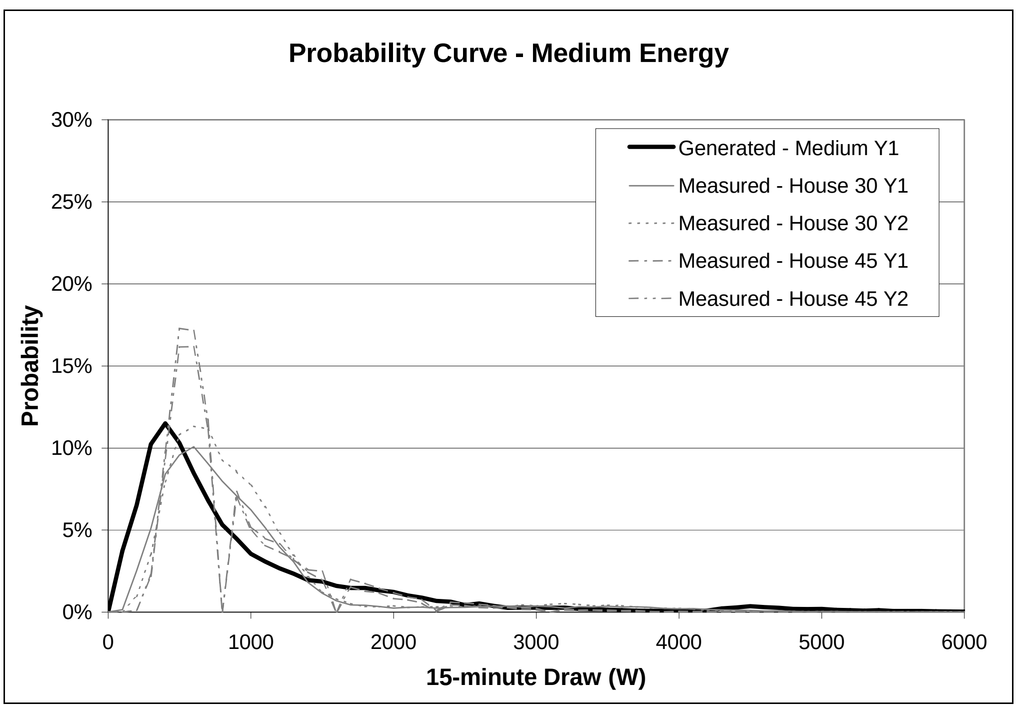


Figure 11 - Statistical comparison of generated and measured data for medium energy homes, 100W bins

5 SENSITIVITY ANALYSIS ON THE USE OF GENERATED PROFILES VERSUS MEASURED PROFILES

A performance assessment study of a Stirling engine residential cogeneration system was performed as part of the work for IEA/ECBCS Annex 42. In this study, a comparison was made between a new technology for the combined production of heat and power at the scale of a single residence (a prototype Stirling engine system) and the conventional way of separate production of heat (in a natural gas-fired furnace) and electricity (using large scale power plants). The generated electricity demand profiles presented in section 3.3 had been used as inputs to the simulations in this study. The availability of the set of measured 15-minute electricity consumption profiles from Hydro Quebec (see section 4) now allowed the comparison of the simulation results for generated electricity demand profiles to those using measured profiles. All simulations were conducted using ESP-r, a whole-building simulation program (Clarke, 2001). Further details on the simulated systems can be found in the Annex 42 report (Ribberink et al., 2007).

For this comparison between the use of generated and measured profiles, the three medium energy-use generated profiles (5-minute time basis) were selected together with four measured non-HVAC simulation profiles (15-minute time basis), which had annual electricity consumption close to those of the selected generated profiles. Table 8 presents the most important characteristics of the seven selected profiles.

Table 8 – Characteristics of generated profiles and measured profiles

Profile name	Annual electricity consumption (kWh)	Peak electricity consumption (W)	Heating season* electr. consumption (kWh)
Generated profiles (5-minute)			
Medium Y1	8159	8808	4861
Medium Y2	8218	8313	4790
Medium Y3	8112	8760	4802
Measured profiles (15-minute)			
House #30 Y1	8265	8080	4957
House #30 Y2	8426	7020	5147
House #45 Y1	7425	6568	4494
House #45 Y2	7713	7028	4687

* Heating season is defined here as the period October through April.

The three generated and four measured electricity demand profiles were used as inputs to annual simulations of the prototype Stirling engine residential cogeneration system and the conventional reference system of separate production of heat and power. For these seven cases, the difference in performance between the Stirling engine system and the conventional alternative was expressed in the reduction of GHG emissions due to the application of the Stirling engine system and in the increase in overall efficiency of providing heat and electricity to the house (the net house efficiency). Because the Stirling engine system used was an early prototype that had not been optimized, all cases actually showed an *increase* in GHG emissions and a *decrease* in net house efficiency when the Stirling engine system was applied. For this paper, however, the focus was not the performance of the prototype Stirling engine system in comparison to the reference system, but the difference in the results between the simulation cases using the three generated profiles and those of the four measured profiles.

Figure 12 displays for all seven simulation cases the (negative) reduction of GHG emissions due to the application of the Stirling engine system compared to the reference cases using the same electric load profiles. The results for the seven cases are very similar. All cases show an increase in GHG emissions by around 1.3%. The small variation in the GHG emission reduction for the seven cases is most likely caused by the differences in emission intensity of displaced on-the-margin grid power (Mottillo at al., 2006).

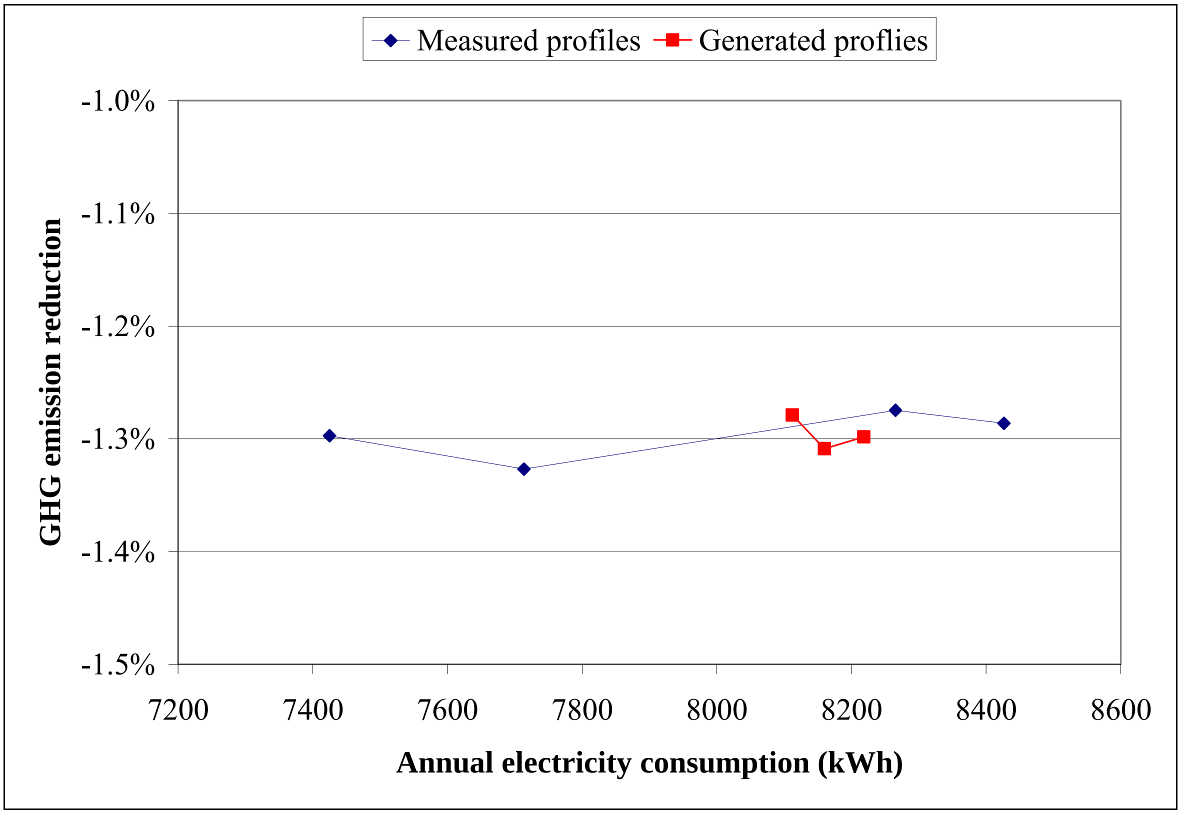


Figure 12 - Comparison of GHG emission reduction of a Stirling engine based residential cogeneration system using measured profiles and generated profiles (negative values indicate actual emissions increases).

Figure 13 presents the (also negative) improvement of the net house efficiency compared to the reference cases, assuming electricity imports to come from coal- or natural gas-based electricity production. Again, the annual simulations of the Stirling engine system using the generated and measured electricity profiles show very similar results in their comparison to the reference cases. The decrease in net house efficiency for the cases using the generated profiles are very close (≤ 0.1%-point) to the trend for the cases using measured profiles for both electricity from coal and for natural gas-fired power plants as source of grid electricity. A potential cause for these differences is displayed in Figure

14: The cases using the generated profiles appear to benefit less from the casual gain from electricity consumption during winter than the cases with the measured profiles. However, more detailed investigation is required to explain this difference based on e.g. the difference in 'peakiness' between the two sets of profiles and/or the different time bases of the generated and measured profiles. These investigations may result in general conclusions on the use of these sets of generated and measured profiles in building simulation studies. This work, however, is outside the scope of the current study.

It should also be noted that the more negative results for the system using natural gas-based electricity in Figure 13 are caused by the fact that natural gas-based system in itself was more efficient than the coal-based system. The decrease in performance due to the use of the prototype Stirling engine system therefore has a more pronounced effect on the net house efficiency for the cases using natural gas-based power production.

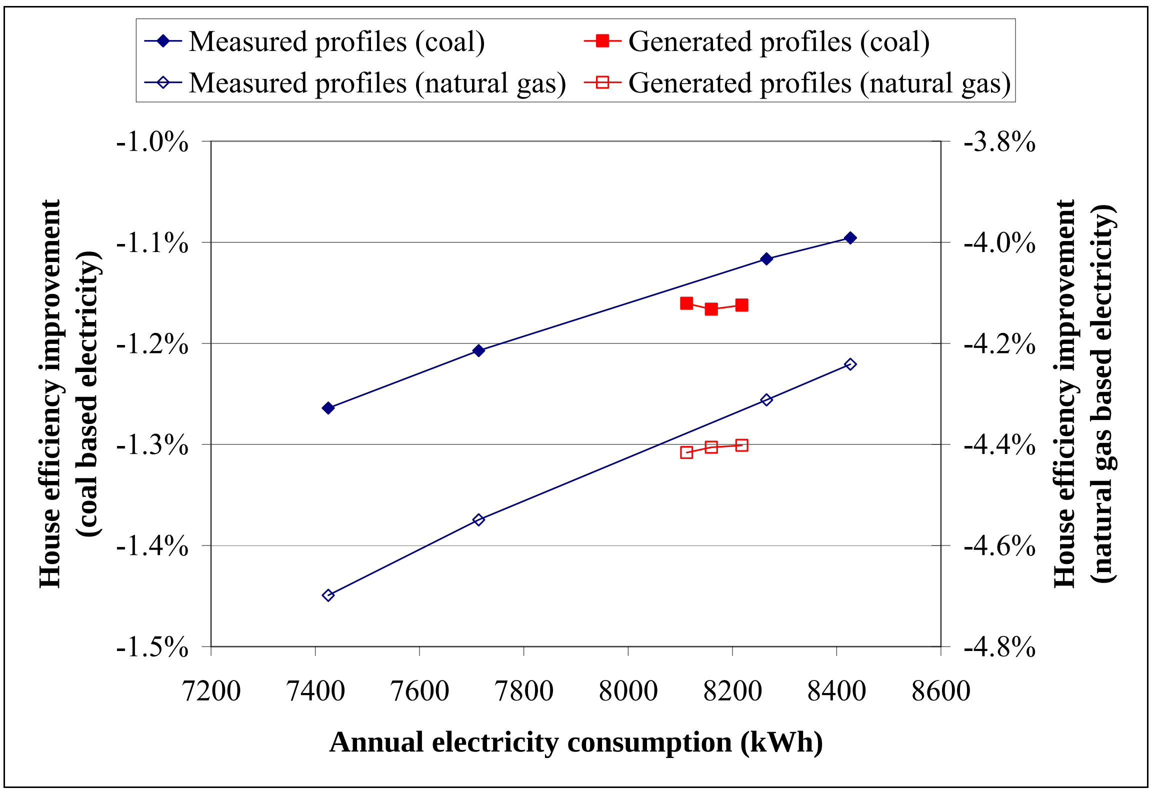


Figure 13 - Comparison of net house efficiency improvement for a Stirling engine based residential cogeneration system using measured profiles and generated profiles.

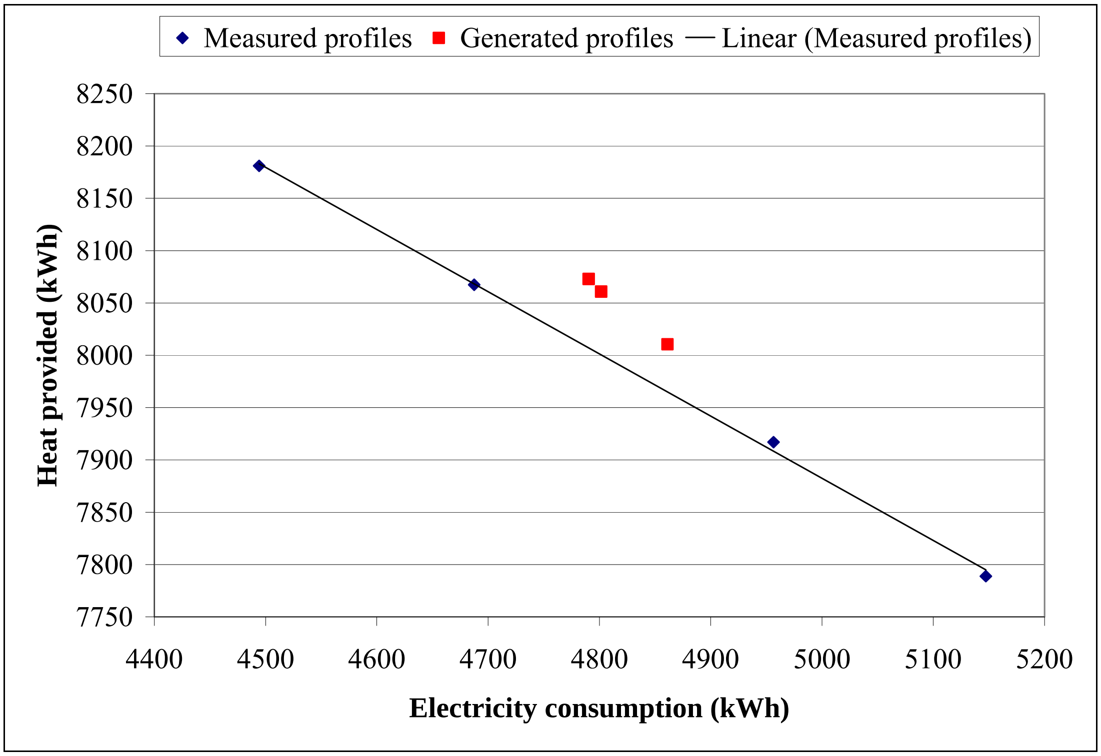


Figure 14 - Relation between electricity consumption and heat provided for space heating during the heating season using measured and generated electricity consumption profiles.

6 Conclusions

A set of three annual non-HVAC load profiles was created successfully for each of three target Canadian households (low, medium and high energy detached), based on a limited amount of available information. These profiles were applied successfully in the simulation of a Stirling engine residential co-generation system, and compared favourably to simulation results using measured non-HVAC profiles from Quebec homes.

Despite the lack of planned variations for weekdays, weekends and holidays, the current load profile generator generates a large variety of days – incorporating greater day-to-day variety than a measured profile. This variety of days is well suited to test a residential cogeneration system by exposing it to a wide range of consumption profiles. If it is still desired, the days from a year's worth of generated data could be selected to represent weekdays, weekends and holidays, and arranged accordingly.

This method of profile generation could be readily adapted to provide not only an electrical output, but also a water draw profile. Already, the performance of individual appliances such as the dishwasher and clothes washer is recorded. Thus, water consumption profiles for these individual appliances could be included at the appropriate times. More data for time of use of other water draws, not associated with appliances, would be required in order to add tap draws, shower draws, bath draws, etc.

While the synthetic Canadian profiles proved useful in simulating a residential cogeneration system, and compared favourably to simulation results with measured data, there is still room for improving the realism of the synthetic profiles. The largest limiting factor to these improvements is the availability of input data. Lighting and small appliances loads together make up over half the non-HVAC energy requirements of the average Canadian home. Unfortunately, these loads are the least understood – and required many assumptions during the profile generation process. More detail is needed on the type of small appliance and lighting loads in houses and particularly their usage patterns. Base loads are also a factor – as indicated by the statistical comparison of the generated profiles to a few measured houses – the baseload appears to be underestimated. Again, a better understanding of baseloads in houses would lead to improvements in profile generation.

The current generated profiles include only seasonal variations for lighting. Other seasonal variations could be added to improve realism. For instance: less dryer use in the summer due to drying of clothes outside, and lower refrigeration loads in winter due to increased efficiency at cooler indoor temperatures could be incorporated.

Improvements could also be made to increase the resolution of the profiles to 1-minute or even less. This would help to create profiles that show the same frequent variations as real time loads, and would be particularly useful for examining the interaction of residential renewable energy sources (particularly wind and solar), house loads and the grid.

The method of generating non-HVAC domestic load profiles could easily be applied for different target households, or even different countries. The limiting factor of applying this method is the availability of the inputs: knowledge of what are typical appliance sets, occupancy usage patterns and ranges of annual consumption is essential.

7 ACKNOWLEDGEMENTS

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2010
City of Toronto

Ward Profiles Summary

Ward	Name of Councillor	Area (hectares)	Population	Per cent of Population: Recent Immigrants	Per cent of Population: Visible Minorities	Households	Unemploy-ment Rate	Median Household Income	2007 Total Employment	2007 Total Establishments	Per cent of Work Trips: By Auto	Per cent of Work Trips: By Transit
1	Vincent Crisanti	1,736	59,830	17.8	79.5	17,465	8.5	$53,426	22,606	1,430	78%	19%
2	Doug Ford	3,183	53,660	9.8	55.5	18,140	8.3	$54,308	50,154	1,959	77%	20%
3	Doug Holyday	1,728	50,415	7.3	26.0	19,040	5.7	$66,621	11,666	664	82%	16%
4	Gloria Lindsay Luby	1,690	53,275	9.2	25.1	20,535	6.7	$62,338	5,057	508	77%	21%
5	Peter Milczyn	2,447	57,260	8.5	20.3	23,750	6.2	$64,775	58,545	3,056	71%	25%
6	Mark Grimes	1,752	56,620	6.2	21.4	26,240	6.4	$52,986	23,506	1,524	72%	22%
7	Giorgio Mammoliti	2,032	49,165	12.7	63.8	15,615	8.7	$48,366	38,480	2,599	75%	22%
8	Anthony Perruzza	1,655	47,895	14.9	74.0	16,670	10.7	$39,903	44,710	3,005	68%	29%
9	Maria Augimeri	1,459	44,920	8.6	51.1	16,105	7.7	$46,224	16,374	736	72%	25%
10	James Pasternak	1,529	61,580	17.5	27.3	24,170	7.5	$47,028	10,295	745	69%	28%
11	Frances Nunziata	1,298	59,870	8.7	52.0	23,255	9.2	$43,204	16,215	1,342	67%	29%
12	Frank Di Giorgio	1,196	53,755	9.0	49.7	19,555	7.9	$42,495	11,024	947	72%	25%
13	Sarah Doucette	1,029	50,640	5.6	16.3	22,595	6.5	$61,987	8,116	1,106	55%	38%
14	Gord Perks	542	50,640	11.7	36.8	24,125	7.5	$38,352	16,460	1,515	45%	41%
15	Josh Colle	1,246	60,545	10.1	40.4	23,900	6.4	$44,427	36,191	2,383	57%	38%
16	Karen Stintz	1,023	51,790	3.7	12.6	21,090	4.8	$85,492	17,445	1,445	67%	27%
17	Cesar Palacio	658	50,830	5.5	31.1	18,395	7.0	$50,913	6,306	1,027	61%	33%
18	Ana Bailão	474	45,620	8.1	36.0	18,390	7.7	$44,096	10,222	1,295	47%	41%
19	Mike Layton	699	49,845	5.0	29.3	22,185	5.8	$55,704	24,142	2,063	41%	34%
20	Adam Vaughan	747	59,545	8.1	39.2	31,060	7.0	$49,732	118,225	5,966	32%	32%
21	Joe Mihevc	657	47,085	7.2	23.3	21,530	6.5	$54,406	8,669	745	54%	37%
22	Josh Matlow	856	59,905	6.7	17.9	32,875	5.8	$62,494	40,023	2,867	45%	42%
23	John Filion	1,492	79,435	14.9	54.7	33,445	7.4	$55,912	39,992	1,941	58%	36%
24	David Shiner	1,769	58,805	13.7	63.2	21,935	7.7	$62,040	32,449	1,315	71%	26%
25	Jaye Robinson	2,372	55,420	6.8	28.2	22,230	5.6	$86,901	24,924	966	71%	24%
26	John Parker	1,090	60,585	19.7	56.7	23,390	8.6	$49,581	27,376	1,246	61%	32%
27	Kristyn Wong-Tam	829	67,840	7.8	32.0	39,375	7.1	$50,763	134,473	5,300	32%	31%
28	Pam McConnell	1,518	58,920	12.1	53.0	29,945	8.6	$38,479	157,920	5,137	31%	40%
29	Mary Fragedakis	790	44,420	6.7	23.6	19,600	6.5	$52,101	7,396	974	55%	36%
30	Paula Fletcher	1,204	51,235	6.3	41.8	21,230	7.2	$53,100	20,139	1,744	49%	38%
31	Janet Davis	889	52,430	11.7	40.9	21,390	7.6	$50,023	11,147	924	53%	41%
32	Mary-Margaret McMahon	948	55,410	4.5	21.2	24,645	6.5	$61,098	13,975	1,310	59%	32%
33	Shelley Carroll	1,080	57,350	24.1	65.0	19,840	9.1	$55,853	22,482	1,219	66%	30%
34	Denzil Minnan-Wong	1,591	56,895	15.2	50.3	22,580	8.4	$51,269	25,716	1,172	70%	27%
35	Michelle Berardinetti	1,374	56,750	15.1	62.6	21,290	9.4	$42,654	20,227	1,454	61%	36%
36	Gary Crawford	1,561	51,390	6.9	36.2	20,030	8.5	$52,877	6,865	761	71%	25%
37	Michael Thompson	1,894	62,325	10.5	56.8	22,220	8.3	$48,736	30,604	2,067	69%	28%
38	Glenn De Baeremaeker	1,509	63,310	14.8	66.1	22,850	9.7	$49,261	27,081	1,628	70%	27%
39	Mike Del Grande	1,087	54,545	16.6	83.7	16,850	9.4	$55,186	13,488	1,143	75%	23%
40	Norman Kelly	1,167	61,140	17.8	69.3	21,975	9.5	$46,427	13,944	935	71%	26%
41	Chin Lee	2,108	67,325	13.9	87.8	19,415	8.8	$58,822	33,156	2,711	75%	23%
42	Raymond Cho	3,928	74,075	10.4	88.7	20,720	8.6	$61,333	26,959	1,566	75%	23%
43	Paul Ainslie	1,569	53,480	11.1	59.2	18,955	8.8	$48,549	7,129	467	70%	28%
44	Ron Moeser	2,597	58,235	3.8	51.9	18,790	7.4	$76,173	6,858	605	78%	21%
City	**Mayor Rob Ford**	**64,002**	**2,503,280**	**10.8**	**46.9**	**979,440**	**7.6**	**$52,833**	**1,298,731**	**75,512**	**62%**	**30%**

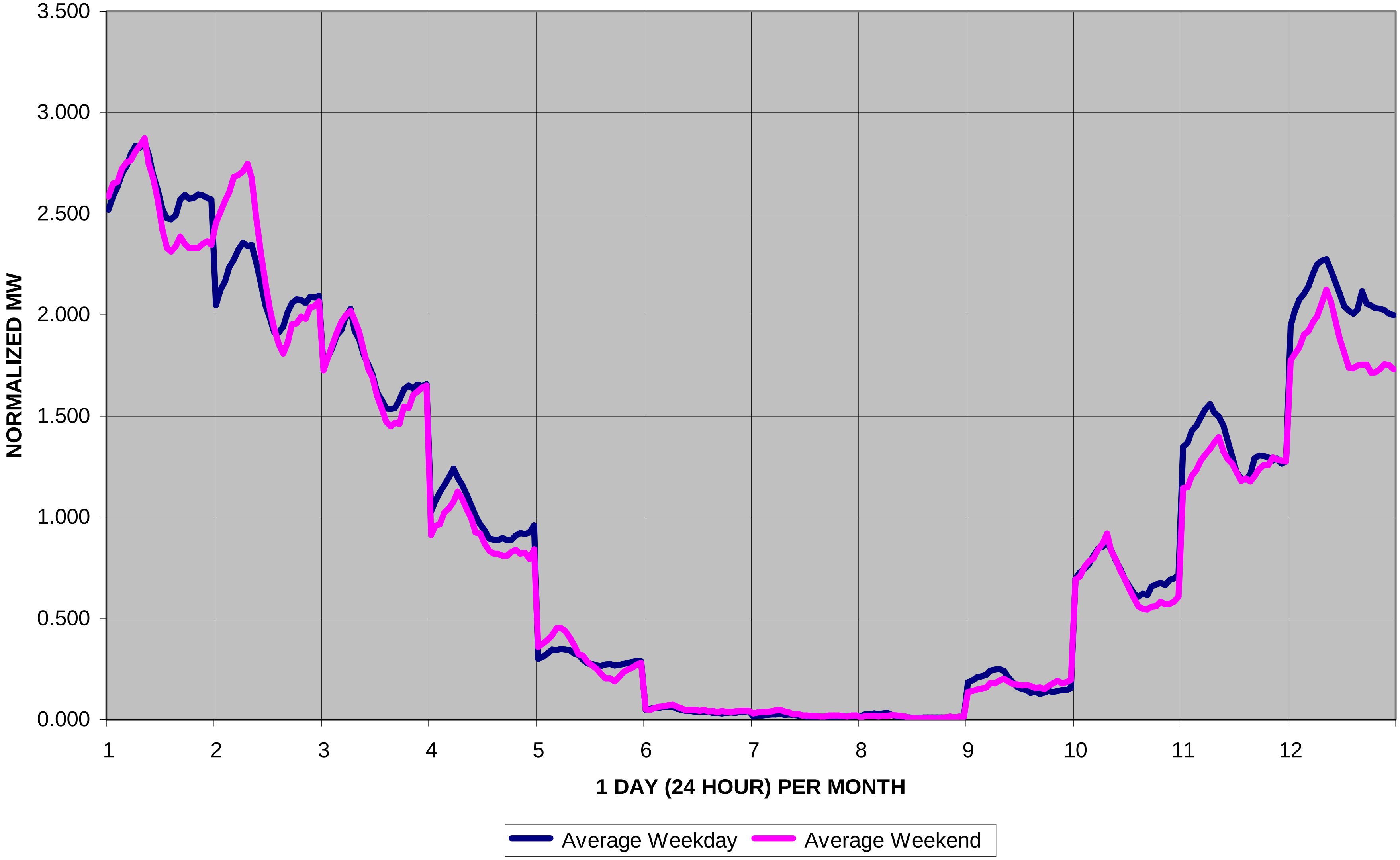
TORONTO

Sources: Statistics Canada, 2006 Census; Transportation Tomorrow Survey 2006; City of Toronto Employment Survey 2007

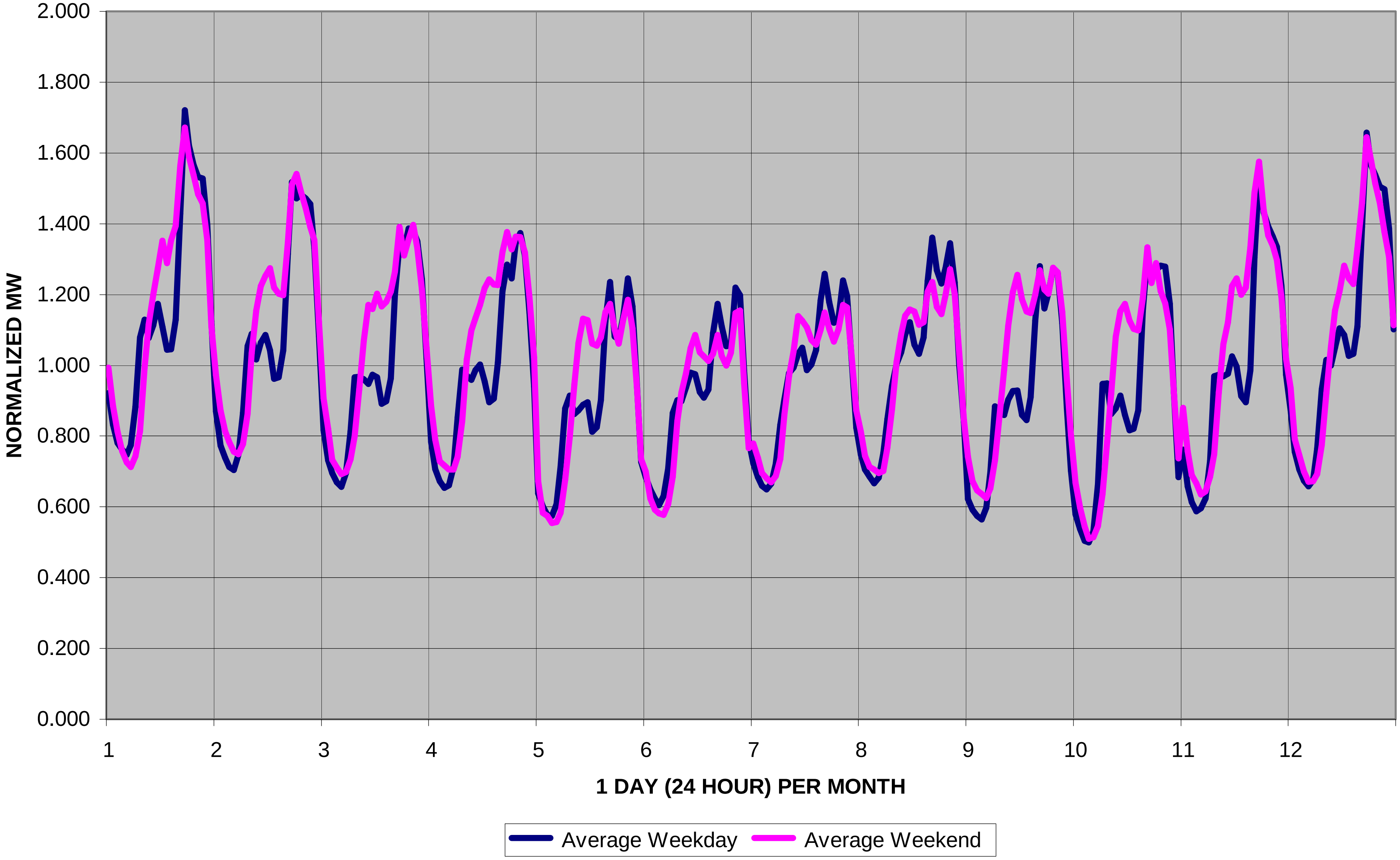
Note: Population counts for each ward exclude institutional residents. The population for the City includes approximately 27,000 institutional residents.

Produced by City Planning, Policy and Research, October 2010

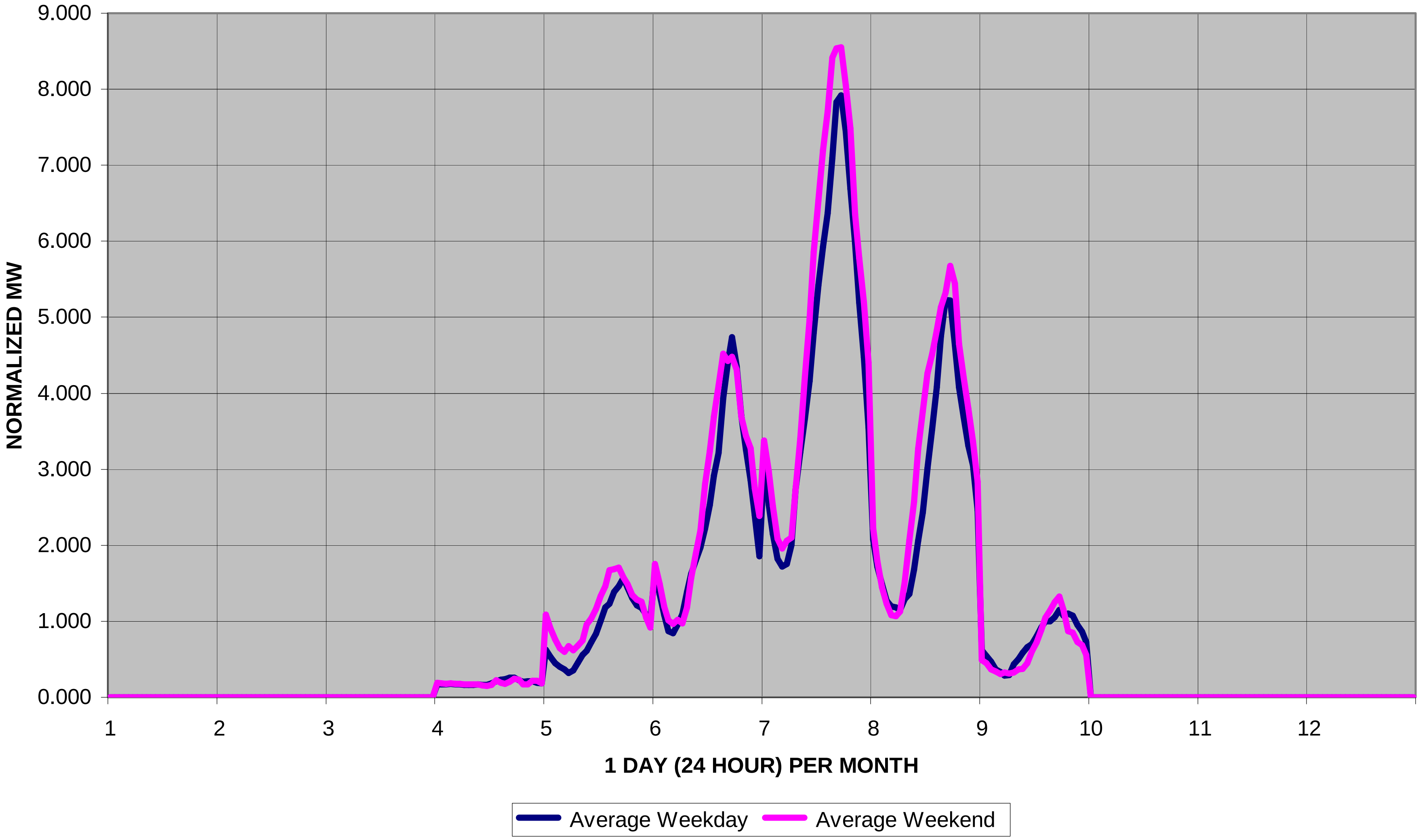
RESIDENTIAL BASEBOARD NORMALIZED DAILY LOADSHAPES BY MONTH



RESIDENTIAL BASELOAD NORMALIZED DAILY LOADSHAPES BY MONTH

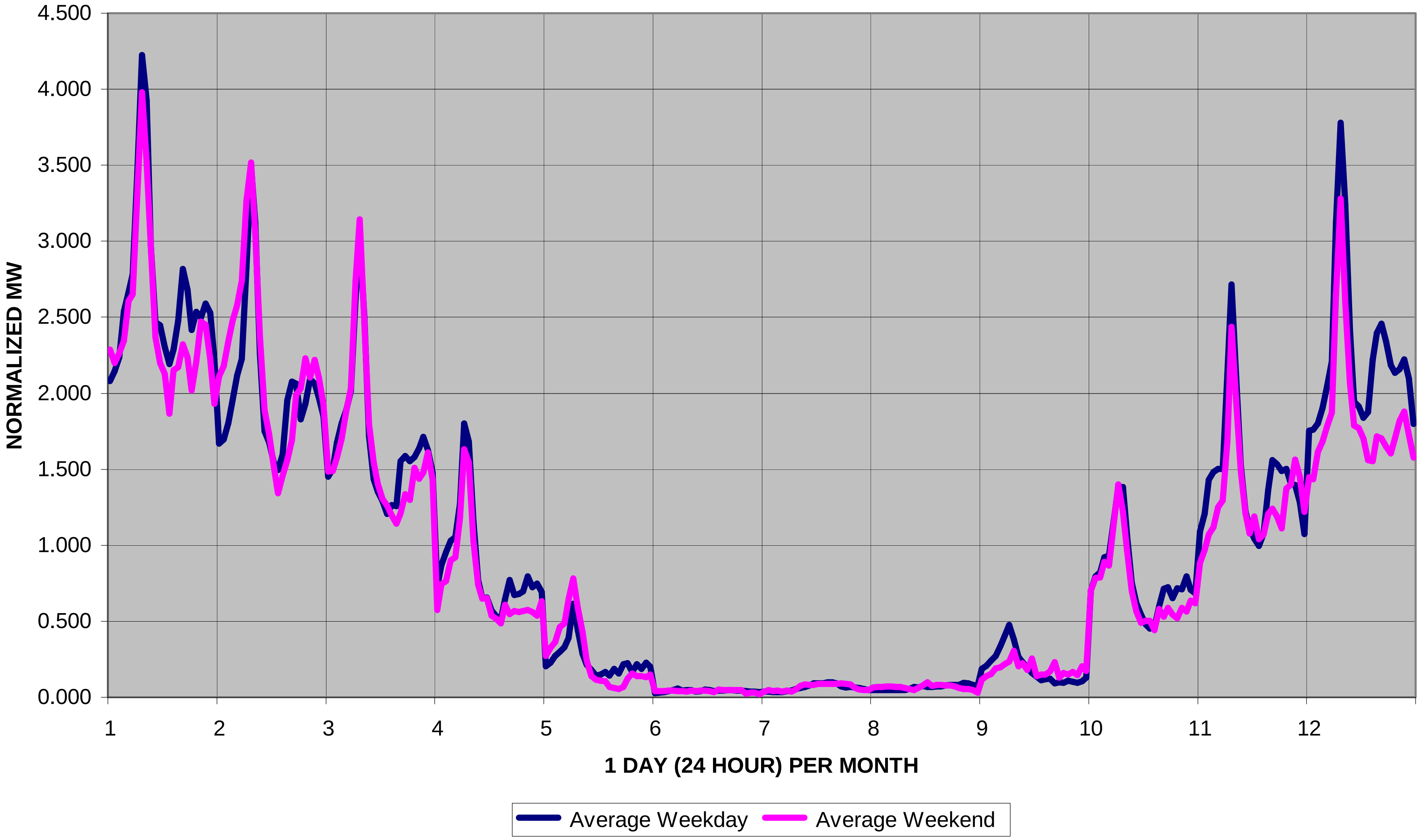


RESIDENTIAL CENTRAL AIR CONDITIONING NORMALIZED DAILY LOADSHAPES BY MONTH

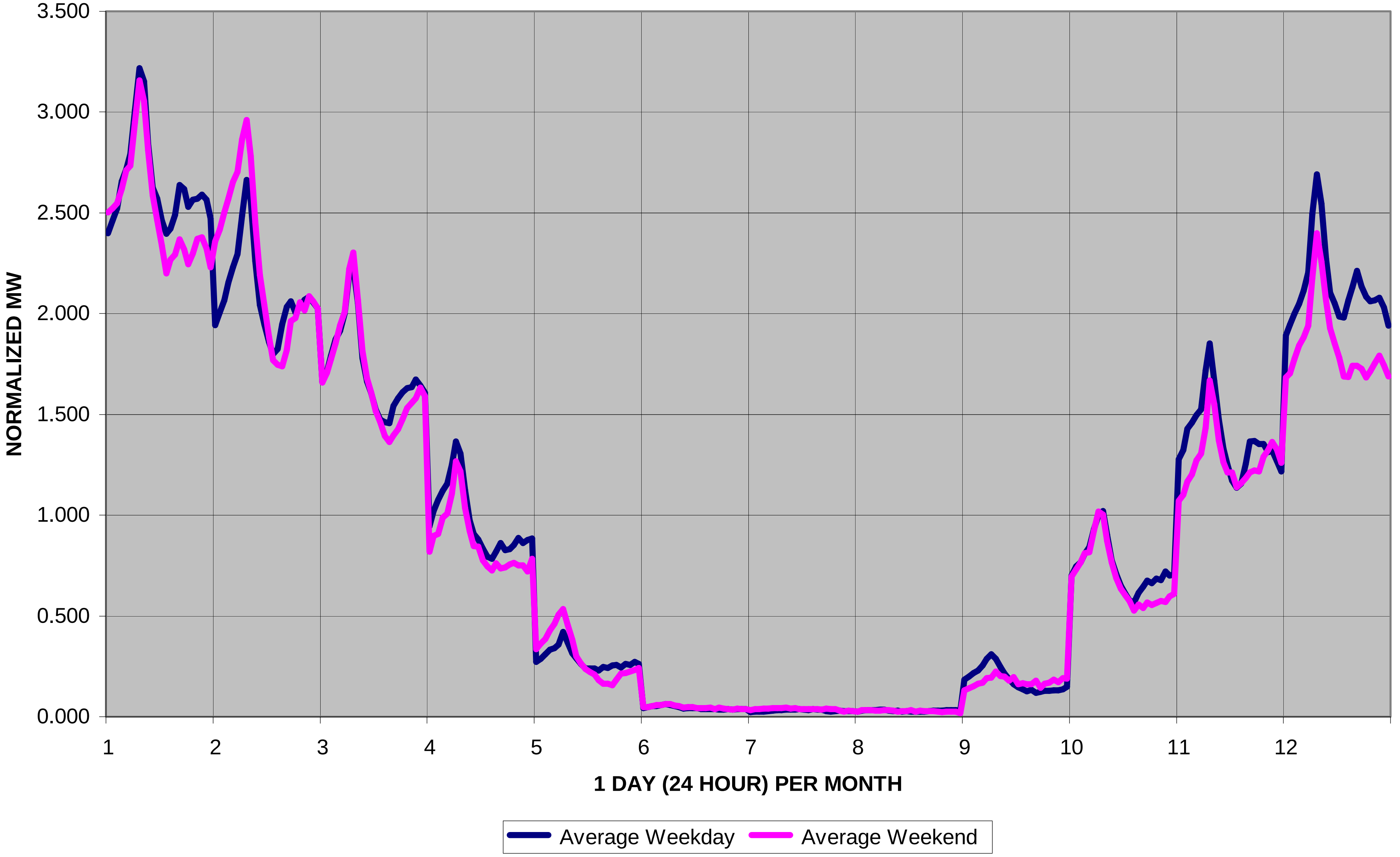


Toronto Hydro-Electric System Limited, EB-2011-0011
Exhibit J, Tab 10, Schedule 2
Appendix H
Filed: 2011 Apr 1 (1 page)

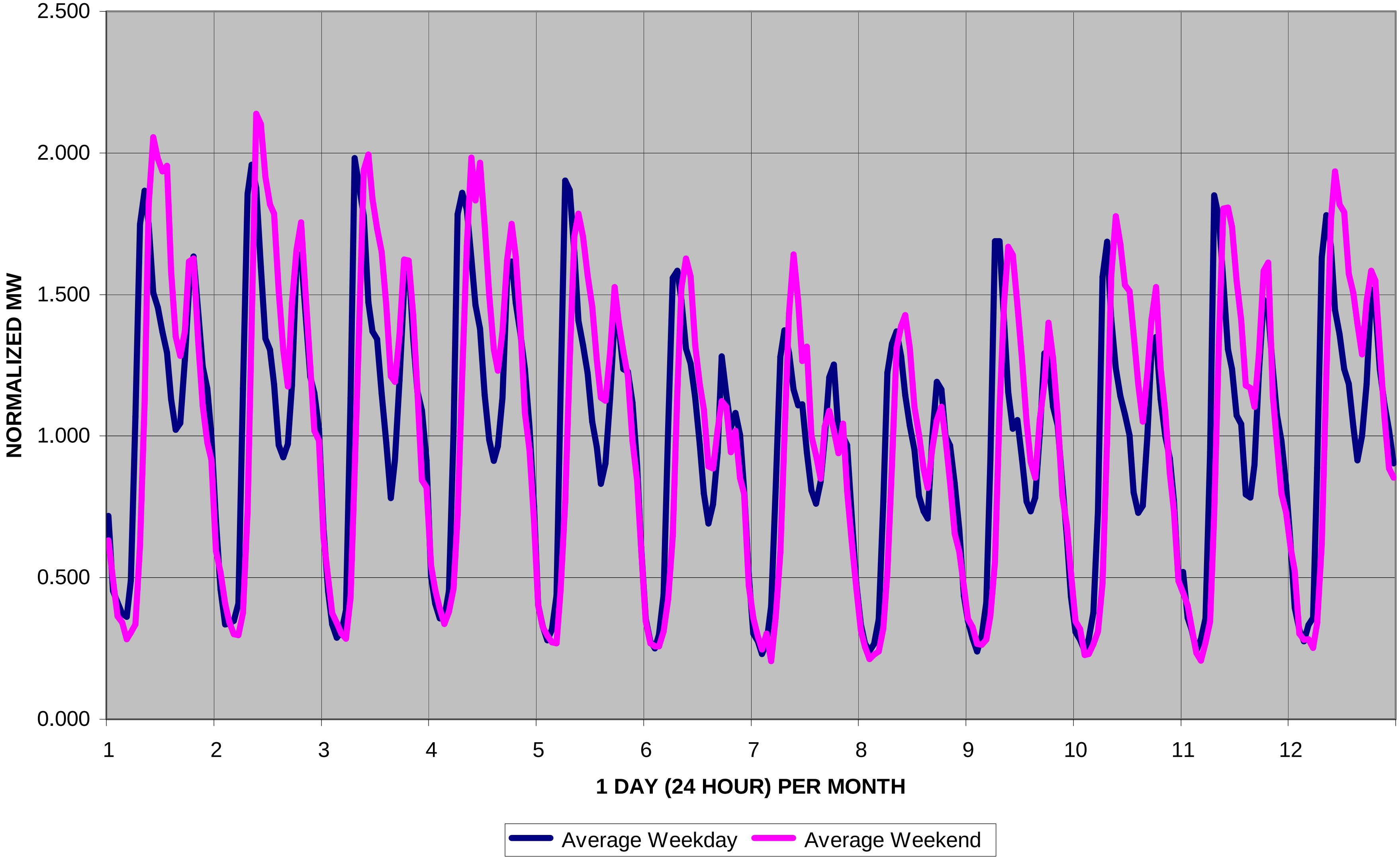
RESIDENTIAL ELECTRIC FURNACE
NORMALIZED DAILY LOADSHAPES BY MONTH



RESIDENTIAL SPACE HEATING NORMALIZED DAILY LOADSHAPES BY MONTH



RESIDENTIAL WATER HEATING NORMALIZED DAILY LOADSHAPES BY MONTH



RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORY 3:

Reference(s): Appendix A

To achieve the remaining target, THESL will undertake the applied-for CDM programs.

a) Summarize in a Table, by year, the savings and budgets for each program and the aggregate totals.

b) Provide a copy of the THESL Program Administration Budgets, including Staffing (FTE) by year and in Total.

c) Provide a copy of any consultant(s) report(s) on the Economic Potential for CDM in THESLs service territory.

d) For each proposed program provide the completed detailed evaluation plan (NOT Template) showing the specific data that will be collected for each measure, each participant and for each program.

e) For each proposed program, where applicable, describe in detail how THESL has estimated free ridership and describe how THESL will monitor free ridership.

f) For each proposed program please describe how participation rates were estimated and provide any studies or data relied upon.

g) Provide for each program a Summary of the Net TRC and Cost Effectiveness Screening of the Program.

h) Provide a Mapping of OPA and THESL programs by Sector to demonstrate the THESL programs are complementary/supplementary to OPA programs. Include target Participants, Incentives and other features.

RESPONSE:

a) Please refer to the table below.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

Program		2011	2012	2013	2014	**Total**
Commercial , Institutional & Small Commercial Monitoring & Targeting	MW	-	0.3	0.4	0.2	**0.9**
	GWh	-	5.8	15.3	19.6	**40.7**
	Budget	$ 966,752	$ 1,886,770	$ 1,615,160	$ 1,032,728	**$ 5,501,410**
Hydronic System Balancing Program	MW	0.2	1.0	1.7	0.5	**3.4**
	GWh	1.4	11.0	34.4	62.0	**62.0**
	Budget	$ 581,019	$ 1,429,673	$ 1,976,077	$ 733,398	**$ 4,720,167**
Multi-Unit Residential Demand Response	MW	0.1	2.9	4.1	4.6	**11.7**
	GWh	0.0	0.1	0.2	0.5	**0.5**
	Budget	$ 703,821	$ 4,905,100	$ 6,773,604	$ 7,532,165	**$ 19,914,690**
Flat Rate Water Heater Conversion & Demand Response	MW	0.6	1.2	1.8	1.8	**1.8**
	GWh	1.0	4.1	7.1	10.2	**10.2**
	Budget	$ 926,378	$ 1,753,110	$ -	$ -	**$ 2,679,488**
Commercial Energay Management & Load Control	MW	1.0	2.0	2.3	1.3	**6.7**
	GWh	0.9	3.5	8.1	13.9	**13.9**
	Budget	$ 1,850,756	$ 3,242,071	$ 3,903,039	$ 2,689,911	**$ 11,685,777**
Business Outreach & Education	MW					
	GWh					
	Budget	$ 467,067	$ 467,067	$ 467,067	$ 246,384	**$ 1,647,585**
Community Outreach & Education Initiative	MW	-	-	-	-	**-**
	GWh	-	-	-	-	**-**
	Budget	$ 1,424,916	$ 1,409,916	$ 1,409,916	$ 1,414,916	**$ 5,659,664**
Greening Greater Toronto	MW	-	-	-	-	**-**
	GWh	-	-	-	-	**-**
	Budget	$ 295,707	$ -	$ -	$ -	**$ 295,707**
Total	**MW**	1.9	7.4	10.3	8.4	**24.4**
	GWh	3.3	24.4	65.2	106.2	**127.2**
	Budget	$ 7,216,416	$ 15,093,707	$ 16,144,863	$ 13,649,502	**$ 52,104,488**

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

b) Please refer to the following table.

	2011	2012	2013	2014	**Total**
Program Admin Budget	$5,591,309	$ 10,017,508	$ 10,563,723	$9,075,475	**$ 35,248,015**
Non-Staffing Costs	$5,297,559	$ 9,067,508	$ 9,688,723	$8,597,975	**$ 32,651,765**
Staffing Costs	$ 293,750	$ 950,000	$ 875,000	$ 477,500	**$ 2,596,250**
# of FTEs	2.9	9.5	8.8	4.8	-

c) The Program Admin Budget in the above table represents the aggregate total program costs in the application for all Board-Approved programs (Total Budget minus Incentive). The number of equivalent full-time employees (number of FTEs) is provided as an average for each year. Staff required to implement Board-Approved programs will be hired as contract employees after Board approval is received. No external consultants were used. The analysis was conducted internally.

d) The draft evaluation plans will be provided prior to the hearing. Please refer to Board Staff Interrogatory 6(a).

e) The default free-rider factor (30%) for custom projects, as noted on page 9 of the OEB Decision and Order in the EB-2007-0096 proceeding, was applied to Hydronic System Balancing, Flat Rate Water Heaters(conversion only) and the Monitoring & Targeting programs. A nominal 10% free ridership factor has been applied to CEMLC, FRWH (*peaksaver* component) and the MURB DR programs, although, due to the unique nature of the services, those services are not available outside of the scope of these initiatives. The 10% free-ridership is consistent with the numbers used

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

by the OPA in evaluating the *peaksaver* program. Monitoring of free-ridership is incorporated in the program evaluation.

f) This information is contained in Section 2.2 of the Applications, but is summarized below:

CEMLC Program:
The proposed program combines similar elements of the Power Savings Blitz (PSB) and *peaksaver* programs that can be used to gauge the potential penetration rates.

In THESL'S service area, the *peaksaver* program was very successful with over 60,000 residential customers registered out of an eligible customer base of approximately 200,000. This equates to a penetration rate of almost 30% in the residential single family segment.

Based on consideration of the programs with similar elements, and the enhancement of providing higher incentive levels and an EMS system in the program design, an overall penetration rate of 5% is conservatively estimated.

FRWH Program:
The current approach of encouraging conversion to a metered service has relied exclusively on mail outs and other communications. This approach is reaching the limit of effectiveness as the remaining customers have more difficult conversion choices and require additional inducements to consider changing their service. It is

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

expected that the incentives will encourage 80% of the remaining 5,561 tanks to convert.

HSBP Assessment Potential:

The estimate is based on THESL's Power Saver Blitz (PSB) program that offered free lighting audits to over 44,000 customers with a resulting uptake of 74%. Although this marketing approach for this program also involves a vendor-driven "blitz" approach similar to PSB, the higher technical requirement and limited industry capacity suggest that a downgraded expected penetration of 25% is more appropriate.

HSBP Implementation Potential:

The anticipated commercial/institutional market penetration rates are based on the following observations:

- The retro-commissioning market, which has similar paybacks and goals as this program, has been evaluated in California and shows an annual 5.1% penetration rate within a much more established conservation market.
- At the same time, 80% of organizations will consider proceeding with projects having a payback of less than 1.9 years in the commercial sector.
- Studies have found that higher energy costs lead to a greater adoption of energy savings measures, which is important as electricity prices are expected to rise 46% over the next five years.
- Evaluation of energy efficiency measures completed under the IAC program in the United States yielded a predictive model[1] that indicates, for the

[1] Anderson, S.T., & Newell, R.G. (2004). Information programs for technology adoption: the case of energy-efficiency audits. Resource and Energy Economics, 26, 27-50.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

paybacks noted below, an adoption rate of 50% for the heating/cooling retrofits and 40% for the booster pump upgrades.

M & T Program:

THESL expects 5% of the commercial/institutional sector and 2% of the industrial sector will participate in the M&T program.

The anticipated commercial/institutional market penetration rates are based on the following observations:

- The retro-commissioning market, which has similar paybacks and goals as the M&T program, has been evaluated in California and shows an annual 5.1% [2] penetration rate within a much more established conservation market.
- At the same time, 80% of organizations will consider proceeding with projects having a payback of less than 1.9 years in the commercial sector[3], which is consistent with the expectations for this program.
- The REALPac initiative of 20 equivalent kilowatt-hours per square foot by 2015 will be driving the commercial sector to incorporate energy tracking and targeting into their sites to help meet objectives.

MURB DR Program:

In THESL'S service area the *peaksaver* program managed to sign-up 60,000 customers out of an eligible customer base of 200,000 for a penetration rate of almost 30% in the residential single family segment of the program.

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[2] PECI and Summit Building Engineering. California Commissioning Collaborative, (2007).California retro-commissioning market characterization

[3] DeCanio, Stephen. (1993). Barriers within firms to energy-efficient investments. Energy Policy, 21, 906-914.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

Based on the similarity of the program design elements and the penetration rates achieved with *peaksaver*, and the provision of a higher incentive rate than that paid to customers participating in the *peaksaver* program, a 30% participation rate is expected in submetered condomiums and 15% in bulk metered condominiums.

g) Please refer to the response to Board Staff Interrogatory 1.

h) Please refer to the response to Board Staff Interrogatory 4(c).

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORY 4:

Reference(s): Appendix A

VECC wishes to understand i) the OPA Low Income program(s) to be delivered by THESL ii) how the Community Outreach program targets vulnerable consumers and iii) any supplementary Low Income programs being planned by THESL.

a) Provide the OPA/HON the definition of qualifying low income customers (e.g., Low Income Families that pay their own electricity bills with an annual income < Stats Canada LICO +125%)
b) Provide a profile of THESL and Provincial Low Income customers.
c) What is THESLs percentage of residential Low income customers relative to the provincial total? Provide the data.
d) Provide the proposed OPA Low Income budget allocated to THESL.
e) Why is this appropriate to THESLs customer profile? Benchmark this budget to:
    i) The total Residential spend (OPA and HON)
    ii) the Ontario gas utilities and
    iii) other Canadian jurisdictions specifically, Manitoba BC and Quebec
f) Is THESL planning to supplement the OPA LI Programs. Please provide more details of THESL LI programs (timing budgets, etc.).

RESPONSE:

a) The program is still in development.

b) THESL does not understand the question to provide a meaningful answer.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

c) THESL does not have the requested information.

d) The program is still in development so this number is not yet available.

e) THESL does not have the requested information as the program is being developed by the OPA.

f) Given the OPA Low Income program will run until December 31, 2014 and the program is not currently in market, it is not yet known whether THESL will add Tier 2 and/or Tier 3 programs to the mix of potential low income program possibilities.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORY 5:

Reference(s): Appendix A

It appears that THESL has screened Initiatives at the Program rather than Measure Level.

a) Why is Screening at a Program Level only appropriate? Please discuss.

b) Provide details of TRC and PAC screening at a measure level for all measures in each program.

RESPONSE:

a) The CDM code requirement is to provide cost effectiveness at the program level. Screening at the Program Level is appropriate as the intent is to evaluate the impact of a program rather than an individual measure.

b) THESL is unable to provide TRC and PAC screening at measure level, as fixed program costs are allocated at program level and not measure level.

For TRC and PAC results for each Board-Approved program, please refer to the response to Board Staff Interrogatory 1.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORY 6:

Reference(s): Tab 4-Community Outreach and Education Initiative

The program objective is to proactively engage customers face-to-face, and deliver education and outreach to reach Toronto's diverse, often over-exposed and sometimes hard-to-reach population. A significant group includes a large population of vulnerable customers in designated priority neighbourhoods. Many of these residents are disconnected from mainstream marketing activity and programs because of economic, language and cultural barriers.

a) Explain whether OPA has/has not a similar initiative under either its residential (mass market) or Low Income programs

b) The program delivery is through four channels:
   - In store retail campaign
   - Festive light exchange
   - Toronto Police partnership
   - School education and outreach

   Provide estimated participants number of units (by type, CFL, etc.) and average cost/incentive for the in-store and festive light programs.

c) Provide THESLs freeridership rates for In-store and festive lights components. What was the source of the estimates – include comparison to THESL Every Kilowatt Counts results.

d) Explain why there was no TRC Screening for in-store and festive light handout/rebates components (as opposed to educational components).

e) Explain the impact of the government banning sales of incandescent bulbs (~2012) on the free-ridership for the in-store and festive light components.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

f) Is the program design aimed at Low income/vulnerable consumers? Compare the program to the desirable attributes for such programs as set out in the OEB Conservation Working Group Report – No cost, direct install, etc.

g) Is THESL seeking either an SSM or LRAM for this program? Discuss

RESPONSE:

a) THESL's Community Outreach and Education Initiative provides opportunity for greater and broader education and unique, compelling and targeted incentives (porchlights, festive lights) to support outreach activities throughout THESL's service territory. This program, (comprised of the in-store engagement, festive light exchange, Toronto Police partnership, and in-school education and outreach), is distinct and will allow THESL to reach the diverse population of its service area.

THESL programs directly engage with customers through a wider range of Toronto-centric retailers and community locations, targeting high-traffic areas (based on historical program data) as well as diverse and hard to reach neighbourhoods such as the identified 13 priority neighbourhoods.

Unlike THESL programs, OPA Tier 1 programs do not include a school outreach program, a police (porchlight) outreach and education program, or a festive light exchange. Although, OPA does have an in-store program which is discussed below. OPA programs are focused on summer peak demand savings while these THESL programs offer annual energy savings as they provide education and tools to help customers conserve year round.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

THESL notes further, that as the only LDC with the majority of its customers on Time-Of-Use (TOU) rates, THESL has a responsibility to educate and assist customers in managing these rates and does so by linking them to these programs. OPA programs do not consider nor address TOU rates.

While an in-store retail component (Exchange Events) does exist under the OPA Tier 1 residential programs, it does not:

- Provide an incentive to drive customers to events; rather it is specific to those with window air conditioners and/or dehumidifiers;
- Provide for other incentive/product giveaway to drive engagement and participation;
- Reach certain customer segments including youth and those unable to visit retailers;
- Allow for LDC input on local retailer selection. The OPA procured retail partners directly and allowed retailers to select their event dates and times. THESL's retail experience indicates consistent dates and times are critical to consumer comprehension and satisfaction with such a program and render marketing efforts more cost effective;
- Allow retail partners to simply participate in these events. OPA required retailers to participate in more than just Exchange Events, thereby limiting potential retail partner pool.

The OPA Low Income Program has yet to be finalized. Consequently, THESL is unable to address any potential duplication at this time.

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

b) The projected number of participants over the four-year period is one million people. The average costs/incentives for the in-store and festive light exchange programs are $8.00 per energy-efficient giveaway and $7.00 per LED light string.

c) Free ridership rates have not been associated with In-store and Festive Light components as kilowatt savings have not been allotted to this program. This program is focused on education and awareness and does not enforce a kilowatt savings but rather, supports behaviour change to off-peak hours.

d) There is no TRC Screening because there are no kilowatt savings for reasons stated above in response to section c).

e) Not applicable – free ridership has not been calculated for this program.

f) This program is aimed at THESL's residential customers as a whole. As such, these programs target low-income/vulnerable consumers as well. This program is not comparable to any program set out in the OEB Conservation Working Group Report. A direct install in this program pertains only to CFL light replacement on outdoor porches with an objective to improve safety and education, not to save kW.

g) Please see response to VECC Interrogatory 10 (a).

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

INTERROGATORY 7:

Reference(s): **Tab 5-Flat Rate Water Heater Conversion & Demand Response Program**

a) Based on the Table In section 1.3 Provide the current average demand, average consumption kWh and annual cost for a typical FRWH customer.
b) Provide the costs to the utility and to the customer for conversion and load control. Include the incentives.
c) Provide the post conversion estimated average demand, consumption and customer cost. Compare to the pre conversion consumption.
d) Confirm the data in Appendix A are for conversions from Unmetered to Metered FRWH customers. How does Load Control affect this comparison and Is Load control alone more or less cost-effective?
e) Provide the free ridership assumption(s) for the program.
f) Explain why tenants (directly) and/or rental premises are excluded from the program.
g) Is THESL seeking either an SSM or LRAM for this program? Discuss.

RESPONSE:

a) The typical pre-conversion usage is shown below:

RESPONSES TO INTERROGATORIES OF VULNERABLE ENERGY CONSUMERS COALITION

Gallons	Bottom Element Size (Watts)	Top Element Size (Watts)	Average Annual Consumption (kWh)	Tank Electrical Demand (kW)	Average Annual Operating Cost* ($)
40	800	800	3,468	0.80	232.36
40	1,000	1,000	4,149	1.00	277.98
40	1,000	3,000	4,417	1.00	295.94
40	3,000	1,000	5,524	3.00	370.11
40	3,000	3,000	6,619	3.00	443.47
60	1,000	3,000	4,952	1.00	331.78

*Energy charges only based on typical usage pattern with average TOU rate of 6.7¢ per kWh applied.

1 b) The typical costs for each category is shown below:

Gallons	Bottom Element Size (Watts)	Top Element Size (Watts)	Typical Cost to Consumer ($)	Incentive ($)	Total Cost to Consumer ($)
40	800	800	250	139	111
40	1,000	1,000	250	166	84
40	1,000	3,000	250	177	73
40	3,000	1,000	250	221	29
40	3,000	3,000	250	265	0
60	1,000	3,000	250	198	52

There is no cost to the consumer or utility for the load control device. The additional cost to install the additional meter is part of the operational budget of the utility.

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The estimated post conversion use is shown below.

Gallons	Bottom Element Size (Watts)	Top Element Size (Watts)	Average Annual Consumption* (kWh)	Tank Electrical Demand (kW)	Average Annual Operating Cost** ($)	Average Annual Operating Cost* ($)	Average Annual Savings ($)
40	800	800	2,774	0.80	185.88	232.36	46.47
40	1,000	1,000	3,319	1.00	222.39	277.98	55.60
40	1,000	3,000	3,534	1.00	236.75	295.94	59.19
40	3,000	1,000	4,419	3.00	296.09	370.11	74.02
40	3,000	3,000	5,295	3.00	354.78	443.47	88.69
60	1,000	3,000	3,962	1.00	265.43	331.78	66.36

c) Confirmed. Load control was not part of this comparison. Load control will reduce demand during periods activated (i.e., reduce the demand to zero during those periods); however, the impact on consumption is negligible once the initial conversion is done and gratuitous wastage is eliminated (i.e., at that point only the timing of water usage is changing).

d) Refer to answer provided in VECC Interrogatory 3.

e) There is no evidence that users that do not directly pay for their utility usage are impacted by a conversion to metered service.

f) Please see response to VECC Interrogatory 10(a).

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INTERROGATORY 8:

Reference(s): Tab 8 – In-Store Engagement and Education Initiative

Building on six years of successful retail partnerships and retail-based events, THESL will continue to deliver its award-winning in-store educational outreach that has proven so successful in the past. A small energy efficient product giveaway is used as the "hook" (such as CFLs, LEDs, programmable thermostats, etc.) to create excitement and 'buzz' and drive traffic to retail locations. An integrated communications strategy is developed to create awareness, provide details of the offer and event logistics (date, location, time). In addition to local mass market, direct mail drops and public relations strategies are used.

a) Explain/discuss whether OPA has//has not a similar initiative under its residential (mass market) initiatives.
b) How will this program be branded promoted relative to OPA sponsored programs? Is it a Co-branded program or not?
c) For handouts what free ridership assumption(s) have been made?
d) Why are there no estimates of kW and kWh reductions attributable to the program?
e) What coordination/collaboration is planned with Enbridge Gas Distribution?

RESPONSE:

THESL has withdrawn the In-Store Engagement and Education program application for consideration by the Board in this proceeding. Please refer to THESL's letter filed April 1, 2011.

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INTERROGATORY 9:

Reference(s): none provided

a) Demonstrate how the costs of the programs will be allocated to THESL's Customer classes via the Global Adjustment.

b) Provide the annual cost of the programs 2011-2014 on a per customer basis for THESL residential customers given the proposed allocation of budgets for both OPA and THESL programs separately.

c) Provide an estimate of the impact of the total CDM spend on THESL residential customers with consumption of 250, 500, 750 and 1000 kWh per month assuming average load profiles.

RESPONSE:

Please see response to Board Staff Interrogatory 1(b).

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INTERROGATORY 10:

Reference(s): Appendix B

a) Confirm whether THESL planning to claim an SSM or LRAM for its CDM programs?

b) If so will there be an independent audit or will OPA perform this function. Please discuss how accountability to ratepayers will be achieved.

c) Will OPA and THESL conduct one set of E&V activities for all programs?

d) How will E&V be coordinated with OPA?

e) What is the annual cost of the E&V? Provide a breakdown by activity and year.

RESPONSE:

a) THESL will not be seeking an SSM, as the CDM Code (EB-2010-0215) specifies an alternative incentive mechanism (Appendix D) to be used for utility CDM efforts under the 2011-2014 time frame.

THESL may file an LRAM claim for these CDM programs, largely depending on whether or not there will be a material difference between the actual program savings achieved and the forecast CDM savings embedded within THESL's overall annual load forecast.

b) In accordance with the OEB's CDM Guidelines (EB-2008-0037), THESL would rely on the OPA to audit program results for OPA province-wide programs, and utilize an independent third party auditor to audit THESL's Board-Approved CDM programs. In any case, THESL would ensure that it would be fully compliant with all

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requirements concerning LRAM claims, as outlined in section 7.5 of the CDM Guidelines.

c) THESL will be required to report on the results of the annual EM&V evaluation and will be responsible for retaining independent third party firms to undertake this work.

d) The program evaluation conducted on the OEB approved programs will use the OPA EM&V protocols. The program evaluation will be conducted using independent third-party firms and will not be completed in conjunction with the OPA. The EM&V budgets are summarized below:

Program Name	2011	2012	2013	2014	Total
Business Outreach	$15,000	$15,000	$15,000	$20,000	$65,000
CEMLC	$0	$60,000	$60,000	$120,000	$240,000
M&T	$68,250	$68,250	$68,250	$68,250	$273,000
Community Outreach	$10,000	$10,000	$10,000	$10,000	$40,000
FRWH	$15,000	$15,000	$0	$0	$30,000
Greening Greater Toronto	$1,445	$0	$0	$0	$1,445
HSBP	$25,000	$25,000	$25,000	$25,000	$100,000
In Store Engagement	$16,500	$16,500	$16,500	$22,000	$66,000
MURB DR	$0	$60,000	$60,000	$60,000	$180,000
Total	**$136,195**	**$254,750**	**$239,750**	**$299,750**	**$930,445**

e) The first year activities are:

- Develop RFPs for each program
- Procure third party EM&V providers

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- Incorporate EM&V elements into project M&V plans
- Measure results

For each subsequent year:

- Provide annual EM&V reports to THESL for incorporation into OEB annual reports
- Following the final year a Final program report

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INTERROGATORY 11:

Reference(s): Appendix B

a) Has OPA endorsed THESLs Programs as non-duplicative? Provide the relevant correspondence.

b) Has THESL entered into a cooperative arrangement on Program Delivery with Enbridge Gas Distribution. If not why not. If so provide details.

c) When is THESL going to launch its programs and how will this mesh with OPA?

RESPONSE:

a) See response to Board Staff Interrogatory 4(a).

b) Yes, THESL is currently delivering programs jointly with Enbridge in the low income sector. There are also ongoing discussions with Enbridge to explore if there are potential synergies between CDM and DSM that would make the program delivery more effective.

c) The intent would be to launch all of the programs within three months of receiving approval. The Board-Approved programs will be launched following the OPA's province-wide programs so that the programs will be clearly distinct.