Draft Report

Measures and Assumptions For Demand Side Management (DSM) Planning

Appendix C: Substantiation Sheets

Presented to

Ontario Energy Board

Ontario Energy Board
2300 Yonge Street,
27th Floor
Toronto, Ontario M4P 1E4

February 6, 2009

Navigant Consulting Inc.
1 Adelaide Street East, Suite 2601
Toronto, ON M5C 2V9
416.927.1641
www.navigantconsulting.com

TABLE OF CONTENTS

GLOSSARY AND DEFINITION OF TERMS

Measure Name

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Description of energy efficient technology
Base Equipment and Technologies Description
Description of base technology.

Decision Type	Target Market(s)	End Use
Description of the decision type (e.g. New, Retrofit, Removal)	Description of the target market(s) for the measure (e.g. Residential / Small Commercial, New homes / Existing Homes, Single-Family / Multi-Family)	Description of the end use of the measure (e.g., space heating, water heating)

Codes, Standards, and Regulations

Description of any applicable codes, standards, and / or regulations that governing the performance (e.g, energy consumption) of the equipment.

Resource Savings Table (10 year Effective Useful Life [EUL] illustrated)

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	Annual natural gas savings for lifetime of measure	Annual electricity savings for life of measure (if applicable)	Annual water savings for life of measure (if applicable)	Annual equipment and operations and maintenance cost of energy efficient measure	Annual equipment and operations and maintenance cost of baseline measure
2					
…					
9					
10					
TOTALS	**Total natural gas savings**	**Total electricity savings**	**Total water savings**	**Total equipment and O&M cost**	**Total equipment and O&M cost**

Resource Savings Assumptions

Annual Natural Gas Savings	m^3
Basis for determination of natural gas savings.	
Annual Electricity Savings	**kWh**
Basis for determination of electricity savings.	
Annual Water Savings	**L**
Basis for determination of water savings.	

Other Input Assumptions

Effective Useful Life (EUL)	Years
Description and rationale of how many years the savings for the energy efficient measure are expected to last.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$**
Description and rationale of difference in the equipment cost and any operation and maintenance cost associated for the energy efficient measure and the baseline measure.	
Customer Payback Period (Natural Gas Only)	**Years**
Rationale used to determine the length of time required to recover the cost of the energy efficient measure based on the natural gas savings only.	
Market Penetration or Market Share	**% or level**
High level description and rationale used to determine the current penetration level of the energy efficient measure in the target market area or the current market share of the energy efficient measure in the target market area. When available, the current market penetration or market share percentage is provided, else, an estimated “low”, “medium” or “high” scale is used, where “low” is below 5%, “medium” is between 5 and 50%, and “high” is greater than 50%.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Source of database reported by other jurisdiction	Annual gas savings reported by other jurisdiction	Effective useful life reported by other jurisdiction	Incremental cost by reported by jurisdiction	Market penetration/share reported in other jurisdiction

Comments

Description of any input assumptions or values used by the other jurisdictions to determine their savings.

RESIDENTIAL SPACE HEATING

Air Sealing

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Air infiltration control; caulking, weather stripping of doors and windows, etc. (6 ACH_{50})
Base Equipment and Technologies Description
Existing infiltration controls (8 ACH_{50})[1]

Decision Type	Target Market(s)	End Use
Retrofit	Existing Residential (Pre-1980s)	Space heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires:

- Windows that separate heated space from unheated space are designed to limit the rate of air infiltration to no more than 0.77 L/s for each metre of sash crack when tested at pressure differential of 75 Pa.
- Sliding glass door assemblies that separate heated space from unheated space are designed to limit the rate of air infiltration to no more than 2.5 L/s for each square metre of door area when tested at a pressure differential of 75 Pa.
- Swinging doors that separate heated space from unheated space are designed to limit the rate of air infiltration to no more than 6.35 L/s for each square metre of door area when tested at a pressure differential of 75 Pa.
- Caulking material to reduce air infiltration is: non-hardening, compatible with the substrate to which it is applied.
- Any location where there is a possibility of air leakage into heated spaces in a building through exterior walls will be caulked, gasketed or sealed.

[1] Base and efficient equipment air change rates are estimates of the average scenario for a home built in the 1950s to 1980s. Determined from communication with a local contractor specializing in the sale and installation of air infiltration control measures.

[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Table

Year (EUL=)	Electricity and Other Resource Savings: Natural Gas (m^3)	Electricity (kWh)	Water (L)	Equipment & O&M Costs of Conservation Measure ($)	Equipment & O&M Costs of Base Measure ($)
1	231	101	0	1,000	0
2	231	101	0	0	0
3	231	101	0	0	0
4	231	101	0	0	0
5	231	101	0	0	0
6	231	101	0	0	0
7	231	101	0	0	0
8	231	101	0	0	0
9	231	101	0	0	0
10	231	101	0	0	0
11	231	101	0	0	0
12	231	101	0	0	0
13	231	101	0	0	0
14	231	101	0	0	0
15	231	101	0	0	0
TOTALS	**3,465**	**1,515**	**0**	**1,000**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	231 m^3

Assumptions and inputs:

- Navigant Consulting used HOT2000[3] to model energy savings resulting from the energy efficient upgrade. The following input assumptions where based on a candidate house for a typical pre-1980 home[4].

---

[3] NRCan, http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/software_tools/hot2000.html

[4] Candidate home characteristics are based on previous weatherization study completed by Marbek in 2008 for Union Gas and Navigant Consulting input assumptions.

House Characteristics using HOT2000	
Location	Toronto, ON
Storeys	2
Above Grade Wall Insulation	R-Value = 8
Below Grade Wall Insulation	R-Value = 1
Attic Insulation	R-Value = 10
Foundation Floor Insulation	R-Value = 5
Air Leakage (ACH)	8.0
Window Type	Double pane with standard glazing, Aluminum
Number of Windows	8
Ceiling Area (ft^2)	829
Main Level Wall Area (ft^2)	944
Living Space Area (ft^2)	1,658
Basement Wall Area (ft^2)	827
Basement Floor Area (ft^2)	829
Base Loads Use	Defaults
Furnace Efficiency (AFUE)	80
Furnace Capacity (Btu/hr)	75,000
Fans Mode	Auto
A/C Efficiency (SEER)	10
A/C Capacity (Btu/hr)	13000[†]

† The current version of HOT2000 has limitation on A/C capacities under specified conditions. 13000 Btu/hr is the maximum value it allows.

- Based on the assumptions above, the following results are obtained:

HOT2000 Simulation Results	Space Heating NG Consumption (m^3)	Space Cooling Consumption (kWh)	Annual Furnace Fan Consumption (kWh)
Base Case	2,965	682	501
Air Sealing Upgrade	2,735	677	461
Savings	229	5	39
Savings%	**7.7%**	**0.7%**	**7.9%**

- Energy savings estimated by the three other jurisdictions listed below (Washington State, Iowa and New Hampshire[5]) are between 6 to 35% over their baseline. The large variation is due to differing input assumptions for both the base case scenario and the energy efficient scenario.
- In terms of the baseline consumption, Navigant Consulting estimates that a typical pre-1980's home consumes approximately 25% more natural gas then a typical baseline home used by Enbridge[6] (2,436 m3), approximately 3,000 m^3.
- Applying the 7.7% savings calculated in the table above to the average annual consumption of natural gas cited directly above yields:
- Natural gas savings = 7.7% x 3,000 = 231 m^3

Annual Electricity Savings — 101 kWh

Annual electricity savings are derived from two sources:

1. Space cooling consumption
2. Furnace fan consumption

[5] Opinion Dynamics Corporation, *The New Hampshire Electric Utilities' Low-income Retrofit Program – Impact Evaluation*, January 2006 http://www.cee1.org/eval/db_pdf/556.pdf

[6] Enbridge Gas Customer Profiling Yearly Average End Use, November 23, 2004

Space cooling consumption:

- Assuming that baseline house is equipped with a SEER 10, 2.5 ton[7] A/C unit and is used 500 hours per year[8], this implies that:

  Base A/C electricity use = 500 (cooling hours)*[30,000 (Btu/hr)/(10 (SEER)* 1,000)] = 1,500 kWh
- Applying the 0.7% savings calculated in the table in the previous section to the average annual consumption of electricity cited directly above yields:

  Electricity savings (A/C) = 0.7 %*1,500 kWh = 10.5 kWh

Furnace fan consumption:

- Annual furnace fan consumption for a typical Toronto home with a non-continuous mid-efficiency furnace = 1,150 kWh[9]
- Applying the 7.9% savings calculated in the table in the previous section to the annual furnace fan electricity consumption cited directly above yields:

  Electricity savings (furnace fan) = 7.9%*1,150 = 90.85 kWh.

Total Electricity Savings

- Total electricity savings are the sum of furnace fan savings and air conditioner savings:

  Total electricity savings = 10.5 + 90.85 = 101.4 kWh

Annual Water Savings	**0 L**
N/A.	

Other Input Assumptions

Effective Useful Life (EUL)	**15 Years**
Based on a survey of the EUL used in other jurisdictions (Vermont[10] – 20 years, Washington State[11] – 10 years, Iowa[12] – 15 years and Oregon[13] – 15 years) Navigant Consulting estimates a EUL of 15 years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$1,000**
Incremental cost determined from communication with local contractor[14].	
Customer Payback Period (Natural Gas Only)[15]	**8.3 Years**
Using a 5-year average commodity cost (avoided cost)[16] of $0.38 / m^3 and an average residential distribution cost[17] of $0.14 / m^3, the payback period for natural gas savings is determined to be 8.3 years, based on the following:	

[7] Implying input of 30,000 Btu/hr, Energy Star Savings Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls

[8] Number of full-load cooling hours provided by http://energyexperts.org/ac%5Fcalc/ and based on the assumption that Ontario's climate is sufficiently similar to that of the north-eastern U.S.

[9] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

[10] Efficiency Vermont, *Technical Reference User Manual (TRM)*, February 2006

[11] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

[12] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

[13] Ecotope Inc. *Natural Gas Efficiency and Conservation Measure Assessment for Residential and Commercial Sectors* Prepared for Energy Trust of Oregon. August, 2003.

[14] Incremental cost is an increasing function of the magnitude change in air tightness and a decreasing function of the base ACH_{50} – improving a house's air tightness from 8 to 5 ACH_{50} will be **more** than 50% more expensive than improving it from 8 to 6 ACH_{50}, and improving a house's air tightness from 10 ACH_{50} to 8 ACH_{50} will cost much less than improving a house's air tightness from 8 ACH_{50} to 6 ACH_{50}.

[15] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[16] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[17] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $1000/ (231 m^3/year * $0.52 / m^3) = 8.3 years

Market Penetration[18]	Medium
Based on the observation of high penetration in one jurisdiction (Washington State[19] – 60%), of medium penetration in another (Iowa[20] – 25%) and on communication with a local contractor, Navigant Consulting estimates the penetration in Ontario to be medium.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[21]	193	15	363	25%
Comments Furnace central heating of a single family existing home. Annual electricity savings for central A/C: 257.5 kWh. Measure saves 10% of 1,935 m^3 required for space heating.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy, 2007[22]	102	10	650	60%
Comments No indication of base or efficient air tightness. Measure saves 6% of 1,707 m^3 required for space heating.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Energy Trust of Oregon, 2003[23]	106	15	250	N/A
Comments Changing from a base of 10 ACH_{50} to 8 ACH_{50}. No indication given of percentage savings or base natural gas consumption for space heating.				

[18] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,
[19] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[20] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[21] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[22] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[23] Ecotope Inc. *Natural Gas Efficiency and Conservation Measure Assessment for Residential and Commercial Sectors* Prepared for Energy Trust of Oregon. August, 2003.
http://www.cee1.org/eval/db_pdf/544.pdf

Basement Wall Insulation (R-12)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Basement wall insulation R-12
Base Equipment and Technologies Description
Basement wall insulation R-1

Decision Type	Target Market(s)	End Use
Retrofit	Existing Residential (Pre-1980)	Space Heating

Codes, Standards, and Regulations

The minimum R value required by Ontario Building Code[1] for foundation wall is R-12.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($/ft²)	($)
1	237	87	0	2	0
2	237	87	0	0	0
3	237	87	0	0	0
4	237	87	0	0	0
5	237	87	0	0	0
6	237	87	0	0	0
7	237	87	0	0	0
8	237	87	0	0	0
9	237	87	0	0	0
10	237	87	0	0	0
11	237	87	0	0	0
12	237	87	0	0	0
13	237	87	0	0	0
14	237	87	0	0	0
15	237	87	0	0	0
16	237	87	0	0	0
17	237	87	0	0	0
18	237	87	0	0	0
19	237	87	0	0	0
20	237	87	0	0	0
21	237	87	0	0	0
22	237	87	0	0	0
23	237	87	0	0	0
24	237	87	0	0	0
25	237	87	0	0	0
TOTALS	**5,925**	**2,175**	**0**	**2**	**0**

1 Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	237 m^3

- Navigant Consulting used HOT2000[2] to model energy savings resulting from the energy efficient upgrade. The following input assumptions where based on a candidate house for a typical pre-1980 home[3].

House Characteristics using HOT2000	
Location	Toronto, ON
Storeys	2
Above Grade Wall Insulation	R-Value = 8
Below Grade Wall Insulation	R-Value = 1
Attic Insulation	R-Value = 10
Foundation Floor Insulation	R-Value = 5
Air Leakage (ACH)	8.0
Window Type	Double pane with standard glazing, Aluminum
Number of Windows	8
Ceiling Area (ft^2)	829
Main Level Wall Area (ft^2)	944
Living Space Area (ft^2)	1,658
Basement Wall Area (ft^2)	827
Basement Floor Area (ft^2)	829
Base Loads Use	Defaults
Furnace Efficiency (AFUE)	80
Furnace Capacity (Btu/hr)	75,000
Fans Mode	Auto
A/C Efficiency (SEER)	10
A/C Capacity (Btu/hr)	13000†

† The current version of HOT2000 has limitation on A/C capacities under specified conditions. 13000 Btu/hr is the maximum value it allows.

- Based on the above assumptions, the following results are obtained:

HOT2000 Simulation Results	Space Heating NG Consumption (m^3)	Space Cooling Consumption (kWh)	Annual Furnace Fan Consumption (kWh)
Base Case	2,965	682	501
Basement Wall Upgrade	2,729	682	463
Savings	235	0	38
Savings%	**7.9%**	**0.0%**	**7.6%**

- Annual natural gas savings for space heating is 7.9%.
- In terms of the baseline consumption, Navigant Consulting estimates that a typical pre-1980's home consumes approximately 25% more natural gas then a typical baseline home used by Enbridge[4] (2,436 m^3), approximately 3,000 m^3.
- Applying the 7.9% savings calculated in the table above to the average annual consumption of natural gas cited directly above yields:

$$\text{Natural Gas Savings} = 3{,}000\ m^3 \times 7.9\% = 237\ m^3$$

[2] NRCan, http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/software_tools/hot2000.html

Annual Electricity Savings	87 kWh

Annual electricity savings are derived from two sources:

1. Space cooling consumption
2. Furnace fan consumption

Space cooling consumption:

- Assuming that baseline house is equipped with a SEER 10, 2.5 ton[5] A/C unit and is used 500 hours per year[6], this implies that:

  Base A/C electricity use = 500 (cooling hours)*[30,000 (Btu/hr)/(10 (SEER)* 1,000)] = 1,500 kWh

- Applying the 0% savings calculated in the table in the previous section to the average annual consumption of electricity cited directly above yields:

  Electricity savings (A/C) = 0% x 1,500 kWh/year = 0 kWh.

Furnace fan consumption:

- Annual furnace fan consumption for a typical Toronto home with a non-continuous mid-efficiency furnace = 1,150 kWh[7]
- Applying the 7.6% savings calculated in the table in the previous section to the annual furnace fan electricity consumption cited directly above yields:

  Electricity savings (furnace fan) = 7.6% x 1150 kWh = 87.4 kWh

Total Electricity Savings:

- Total electricity savings are the sum of furnace fan savings and air conditioner savings:

  Total electricity savings = 0 kWh + 87.4 kWh = 87.4 kWh ≈ 87 kWh

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	25 Years

The EUL is reported to be 25 years by the Iowa Utilities Board[8]. Navigant Consulting estimates an EUL of 25 years.

Base & Incremental Conservation Measure Equipment and O&M Costs	$2 / ft^2

Based on communication with various local vendors, the incremental cost of wall insulation from R-1 to R-12 is approximately $2 per ft^2, which includes only the insulation material and labour but not the costs of wall removal and reconstruction required for installation. For the candidate home, the incremental cost is estimated to be $1,654 ($2.00 x 827 ft^2 = $1,645).

Customer Payback Period (Natural Gas Only)[9]	13.4 Years

Using an 5-year average commodity cost (avoided cost)[10] of $0.38 / m^3 and an average residential distribution cost[11] of $0.14 / m^3, the payback period for natural gas savings is determined to be 13.4 years, based on the following:

---

[3] Candidate home characteristics are based on previous weatherization study completed by Marbek in 2008 for Union Gas and Navigant Consulting input assumptions.

[4] Enbridge Gas Customer Profiling Yearly Average End Use, November 23, 2004

[5] Implying input of 30,000 Btu/hr, Energy Star Savings Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls

[6] Number of full-load cooling hours provided by http://energyexperts.org/ac%5Fcalc/ and based on the assumption that Ontario's climate is sufficiently similar to that of the north-eastern U.S.

[7] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

[8] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

[9] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $2 /ft^2 x 827 ft^2 / (237 m^3/year * $0.52 / m^3) = 13.4 years	
Market Penetration[12]	**High**
Based on penetration rates of other jurisdictions (63% in Iowa State) and communication with local contractors, Navigant Consulting estimates the penetration in Ontario to be high.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[13]	122.5	25	1,933	63%
Comments Assuming baseline R-value of basement wall insulation is 8 and upgrade R-value of basement wall insulation is 13. Estimated 6.4% savings are based on 696 therms, which would translate to 44.5 therms (122.5 m^3).				

[10] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[11] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[12] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,
[13] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Ceiling Insulation (R-40)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Ceiling insulation R-40
Base Equipment and Technologies Description
Ceiling insulation R-10

Decision Type	Target Market(s)	End Use
Retrofit	Existing Residential (Pre-1980s)	Space Heating

Codes, Standards, and Regulations

The minimum R value required by Ontario Building Code[1] for ceiling below attic or roof space is 40.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($\$/ft^2$)	($)
1	348	214	0	0.7	0
2	348	214	0	0	0
3	348	214	0	0	0
4	348	214	0	0	0
5	348	214	0	0	0
6	348	214	0	0	0
7	348	214	0	0	0
8	348	214	0	0	0
9	348	214	0	0	0
10	348	214	0	0	0
11	348	214	0	0	0
12	348	214	0	0	0
13	348	214	0	0	0
14	348	214	0	0	0
15	348	214	0	0	0
16	348	214	0	0	0
17	348	214	0	0	0
18	348	214	0	0	0
19	348	214	0	0	0
20	348	214	0	0	0
TOTALS	**6,960**	**4,280**	**0**	**0.7**	**0**

[1] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	348 m^3

- Navigant Consulting used HOT2000[2] to model energy savings resulting from the energy efficient upgrade. The following input assumptions where based on a candidate house for a typical pre-1980 home[3].

House Characteristics using HOT2000	
Location	Toronto, ON
Storeys	2
Above Grade Wall Insulation	R-Value = 8
Below Grade Wall Insulation	R-Value = 1
Attic Insulation	R-Value = 10
Foundation Floor Insulation	R-Value = 5
Air Leakage (ACH)	8.0
Window Type	Double pane with standard glazing, Aluminum
Number of Windows	8
Ceiling Area (ft^2)	829
Main Level Wall Area (ft^2)	944
Living Space Area (ft^2)	1,658
Basement Wall Area (ft^2)	827
Basement Floor Area (ft^2)	829
Base Loads Use	Defaults
Furnace Efficiency (AFUE)	80
Furnace Capacity (Btu/hr)	75,000
Fans Mode	Auto
A/C Efficiency (SEER)	10
A/C Capacity (Btu/hr)	13000†

† The current version of HOT2000 has limitation on A/C capacities under specified conditions. 13000 Btu/hr is the maximum value it allows.

- Based on the above assumptions, the following results are obtained:

HOT2000 Simulation Results	Space Heating NG Consumption (m^3)	Space Cooling Consumption (kWh)	Annual Furnace Fan Consumption (kWh)
Base Case	2,965	682	501
Ceiling Upgrade	2,622	648	440
Savings	343	34	61
Savings%	**11.6%**	**5.0%**	**12.1%**

- Annual natural gas savings for space heating is 11.6%.
- Energy savings estimated by the three other jurisdictions listed below (Washington State, Iowa and New Hampshire) estimate savings are between 5 to 25% over their baseline. The large variation is due to differing input assumptions for both the base case and the energy efficient scenario.
- In terms of the baseline consumption, Navigant Consulting estimates that a typical pre-1980's home consumes approximately 25% more natural gas then a typical baseline home used by Enbridge[4] (2,436 m^3), approximately 3,000 m^3.
- Applying the 11.6% savings calculated in the table above to the average annual consumption of natural gas cited directly above yields:

$$\text{Natural Gas Savings} = 3{,}000\ m^3 \times 11.6\% = 348\ m^3$$

[2] NRCan, http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/software_tools/hot2000.html

Annual Electricity Savings	214 kWh

Annual electricity savings are derived from two sources:

1. Space cooling consumption
2. Furnace fan consumption

Space cooling consumption:

- Assuming that baseline house is equipped with a SEER 10, 2.5 ton[5] A/C unit and is used 500 hours per year[6], this implies that:

  Base A/C electricity use = 500 (cooling hours)*[30,000 (Btu/hr)/(10 (SEER)* 1,000)] = 1,500 kWh

- Applying the 5% savings calculated in the table in the previous section to the average annual consumption of electricity cited directly above yields:

  Electricity savings (A/C) = 5% x 1,500 kWh/year = 75 kWh.

Furnace fan consumption:

- Annual furnace fan consumption for a typical Toronto home with a non-continuous mid-efficiency furnace = 1,150 kWh[7]
- Applying the 12.1% savings calculated in the table in the previous section to the annual furnace fan electricity consumption cited directly above yields:

  Electricity savings (furnace fan) = 12.1% x 1150 kWh = 139.2 kWh

Total Electricity Savings:

- Total electricity savings are the sum of furnace fan savings and air conditioner savings:

  Total electricity savings = 139.2 kWh + 75 kWh = 214.2 kWh ≈ 214 kWh

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	20 Years

The EUL is reported to be 25 years by the Iowa Utilities Board[8] and 30 years by Puget Sound Energy[9]. The OPA reports the EUL as 20 years. Navigant Consulting is assuming 20 years.

Base & Incremental Conservation Measure Equipment and O&M Costs	$0.7 / ft^2

Based on communication with various local vendors, the incremental cost of ceiling insulation from R-10 to R-40 is approximately 70 cents per ft^2. For the candidate home, the incremental cost is estimated to be $580 ($0.70 x 829 ft^2 = $580).

Customer Payback Period (Natural Gas Only)[10]	3.2 Years

Using a 5-year average commodity cost (avoided cost)[11] of $0.38 / m^3 and an average residential

[3] Candidate home characteristics are based on previous weatherization study completed by Marbek in 2008 for Union Gas and Navigant Consulting input assumptions.
[4] Enbridge Gas Customer Profiling Yearly Average End Use, November 23, 2004
[5] Implying input of 30,000 Btu/hr, Energy Star Savings Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls
[6] Number of full-load cooling hours provided by http://energyexperts.org/ac%5Fcalc/ and based on the assumption that Ontario's climate is sufficiently similar to that of the north-eastern U.S.
[7] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[8] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[9] Quantec, Puget Sound Energy Demand-Side Management Resource Assessment
[10] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

distribution cost[12] of \$0.14 / m³, the payback period for natural gas savings is determined to be 3.2 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= $\$0.7/ft^2 \times 829\ ft^2 / (348\ m^3/year * \$0.52 / m^3)$
= 3.2 years

Market Penetration[13]	Medium
Based on the penetration rates in other jurisdictions (25% in Iowa State and 20% in Washington State) and communication with local contractors, Navigant Consulting estimates the penetration in Ontario to be medium.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost (\$)	Penetration/Market Share
State of Iowa Utilities Board[14]	88	25	287	25%
Comments Assuming baseline R-value of ceiling insulation is 19 and upgrade R-value of ceiling insulation is 49. Estimated 4.6% savings are based on 696 therms, which would translate to 32 therms (88 m^3).				
Source	**Annual Natural Gas Savings (m^3)**	**Effective Useful Life (Years)**	**Incremental Cost (\$)**	**Penetration/Market Share**
Puget Sound Energy[15]	556.3	30	720	20%
Comments Assuming baseline R-value of ceiling insulation is 11 and upgrade R-value of ceiling insulation is 38. Estimated 9% savings are based on 6,181 m^3, which would translate to 556.3 m^3.				
Source	**Annual Natural Gas Savings (m^3)**	**Effective Useful Life (Years)**	**Incremental Cost (\$)**	**Penetration/Market Share**
New Hampshire Electric Utilities[16]	223	N/A	N/A	N/A
Comments New Hampshire Electric Utilities Estimates 25% natural gas savings on ceiling insulation.				

[11] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[12] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[13] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[14] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[15] Quantec, Puget Sound Energy Demand-Side Management Resource Assessment
[16] ODC, The New Hampshire Electric Utilities' Low-income Retrofit Program Impact Evaluation, Jan 16, 2006

Enhanced Furnace (Electronically Commutated Motor) – Existing Residential

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Gas furnace equipped with an electronically commutated motor (ECM)
Base Equipment and Technologies Description
Gas Furnace with a permanent split capacitor (PSC) Motor

Decision Type	Target Market(s)	End Use
Retrofit	Residential Existing Homes	Space Heating

Codes, Standards, and Regulations

- Under Ontario's building code, all gas furnaces installed in new residential constructions must meet a minimum condensing efficiency level effective January 1, 2007.[1]
- Presently, there is no minimum energy performance standard restricting the electricity consumption of furnace fan blowers.
- NRCan proposes to increase the minimum performance level, the Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces with an input rate not exceeding 65.92 kW (225,000 Btu/h) to 90% for December 31, 2009[2].

[1] Ministry of Energy, "Heating and Cooling your Home: A Conservation Guide", Reproduced with the permission of Natural Resource Canada, 2004. http://www.energy.gov.on.ca/english/pdf/conservation/heating_and_cooling_your_home.pdf
[2] Office of Energy Efficiency, Canada's Energy Efficiency Regulations, Proposed Regulations Bulletin, March 2007. http://www.oee.nrcan.gc.ca/regulations/bulletin/gas-furnace-mar2007.cfm?Text=N&PrintView=N

Resource Savings Table (for 2 different cases)

Continuous Fan Usage

Year (EUL=)	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure[3]
	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	-183	1,387	0	960	0
2	-183	1,387	0	0	0
3	-183	1,387	0	0	0
4	-183	1,387	0	0	0
5	-183	1,387	0	0	0
6	-183	1,387	0	0	0
7	-183	1,387	0	0	0
8	-183	1,387	0	0	0
9	-183	1,387	0	0	0
10	-183	1,387	0	0	0
11	-183	1,387	0	0	0
12	-183	1,387	0	0	0
13	-183	1,387	0	0	0
14	-183	1,387	0	0	0
15	-183	1,387	0	0	0
TOTALS	**-2,745**	**20,805**	**0**	**960**	**0**

[3] US DOE Energy Star Furnace Calculator, "Assumptions" tab.
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls

Resource Savings Assumptions

Annual Natural Gas Savings	-183 m^3

Continuous fan use and non-continuous fan use is estimated to be 26% and 74%, respectively, based on Ontario customer survey results[4].

A study conducted by the Canadian Center for Housing Technologies determined that the annual gas use of a typical existing home with a continuous ECM actually *increases* by 180 m^3 for high efficiency furnaces (AFUE 92) and 202 m^3 for mid-efficiency furnaces (AFUE 82)[5]. The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency based on recent survey results for residential furnaces[6], resulting in an average increase of 183 m^3.

The CCHT study gives a baseline gas use as 2,769 m^3 for high efficiency furnaces and 3,107m^3 for mid-efficiency furnaces[7]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical home with a PSC motor is expected to use 2,810 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 2,993 m^3 of natural gas (2,810 + 183), or an increase of 6.5% over the baseline.

Annual Electricity Savings	1,387 kWh

Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions Lists[8], the electricity savings for an existing home using an ECM are estimated to be 1,387 kWh/year for continuous furnace fan usage. This represents a saving of 72% over a conventional PSC motor.

These results are based on the same CCHT study, which determined that annual electricity savings for an existing home using a gas furnace with a continuous ECM for heating only are 1,535 kWh for high efficiency furnaces (AFUE 92) and 1,545 kWh for mid-efficiency furnaces (AFUE 82)[9]. Since it is unlikely that the furnace fan is running continuously during the shoulder season, the OPA assumes that during the shoulder season, the same electricity savings from a non-continuous ECM are applicable.

Annual Water Savings	0 L

N/A

[4] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[5] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[6] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[7] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[8] Ontario Power Authority, 2009 OPA Measures and Assumptions List (Mass Market), November 2008.
[9] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

Non-Continuous Fan Usage

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure[10]
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	-26.4	324	0	960	0
2	-26.4	324	0	0	0
3	-26.4	324	0	0	0
4	-26.4	324	0	0	0
5	-26.4	324	0	0	0
6	-26.4	324	0	0	0
7	-26.4	324	0	0	0
8	-26.4	324	0	0	0
9	-26.4	324	0	0	0
10	-26.4	324	0	0	0
11	-26.4	324	0	0	0
12	-26.4	324	0	0	0
13	-26.4	324	0	0	0
14	-26.4	324	0	0	0
15	-26.4	324	0	0	0
TOTALS	**-396**	**4,860**	**0**	**960**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	-26.4 m^3

Continuous fan use and non-continuous fan use is estimated to be 26% and 74%, respectively, based on customer survey results[11].

A study conducted by the Canadian Center for Housing Technologies determined that a the annual gas use of a typical existing home with a non-continuous ECM actually *increases* by 26 m^3 for high efficiency furnaces (AFUE 92) and 29 m^3 for mid-efficiency furnaces (AFUE 82)[12]. The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency based on recent survey results for residential furnaces[13], resulting in an average increase of 26.4 m^3.

The CCHT study gives a baseline gas use as 2,953 m^3 for high efficiency furnaces and 3,313 m^3 for mid-efficiency furnaces[14]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical home with a PSC motor is expected to use 2,996 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 3,022 m^3 of natural gas (2,996 + 26), or an increase of 0.9% over the baseline.

[10] US DOE Energy Star Furnace Calculator, "Assumptions" tab. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls
[11] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[12] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[13] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[14] Ibid.

Annual Electricity Savings	324 kWh
Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions List[15], the electricity savings for a new home using an ECM are estimated to be 324 kWh/year for non-continuous furnace fan usage. This represents a saving of 40% over a conventional PSC motor. These results are based on the same CCHT study, which determined that annual electricity savings for a new home using a gas furnace with an ECM for heating only are 324 kWh for both high efficiency furnaces (AFUE 92) mid-efficiency furnaces (AFUE 82)[16].	
Annual Water Savings	**0 L**
N/A	

[15] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.
[16] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

Other Input Assumptions

Effective Useful Life (EUL)	15 Years
An OPA commissioned study by Seeline Group Inc. suggests a useful life of 15 years. Furthermore, a June 2007 study by GDS Associates, Inc.[17] for New England State Program Working Group (SPWG) also suggest 15 years. Finally, the Iowa Utilities Board[18] also uses 15 years as an effective useful life for an ECM.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$960**
Based on the average of a survey of prices from HVAC contractors in Ontario[19], the incremental cost is estimated to be $960. Incremental costs were confirmed through communication with additional HVAC contractors.	
Customer Payback Period (Natural Gas and Electricity)	**Continuous = 22 years Non-Continuous = 51 years**
Since natural gas usage increases with an ECM, Navigant Consulting has used both natural gas and electricity savings to calculate the customer payback period. *For Natural Gas Usage:* Combining a 5-year average commodity cost (avoided cost)[20] of $0.38 / m^3 and an average residential distribution cost[21] of $0.14 / m^3, the total cost of natural gas for residential customers is determined to be $0.52. *For Electricity Savings:* An average commodity and distribution cost of $0.10 / kWh is assumed for residential customers. The payback period incorporating both natural gas usage and electricity savings is determined to be 22 years for continuous usage and 51 years for non-continuous furnace fan usage, based on the following: Payback Period = Incremental cost / [(natural gas savings x natural gas cost) + (electricity savings x electricity cost)] *Continuous Fan Usage:* = $960 / [(-183 m^3/year * $0.52 / m^3) + (1,387 kWh/year * $0.10 / kWh)] = 22 years *Non-Continuous Fan Usage:* = $960 / [(-26.4 m^3/year * $0.52 / m^3) + (324 kWh/year * $0.10 / kWh)] = 51 years	
Market Share[22]	**Low**
Although the benefits of electronically commutated motors are increasingly being promoted by the	

[17] GDS Associates Inc, Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG) For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007.
[18] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[19] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[20] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[21] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[22] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,

industry, the overall market share still remains low in the residential retrofit market, as seen in another jurisdiction (Iowa reports a 5% market penetration for residential homes[23]). Therefore, Navigant Consulting estimates the market share in Ontario to be low.

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
2009 OPA Measures and Assumptions List[24]	$-80.1m^3$ (continuous) $22.6m^3$ (non-continuous)	15	$960	N/A
Comments Assumptions made in the OPA Measures and Assumptions List are the same assumptions that are made in the above tables.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
Iowa State Utility Board[25]	n/a	15	$76	5%
Comments Only electricity savings reported (75% over base equipment). Base equipment is a standard motor on a gas fired furnace. Baseline consumption is reported on an annual basis (e.g. 723 kWh for a single family).				

[23] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[24] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.
[25] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Enhanced Furnace (Electronically Commutated Motor) – New Construction

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Gas furnace equipped with an electronically commutated motor (ECM)

Base Equipment and Technologies Description
Gas Furnace with a permanent split capacitor (PSC) Motor

Decision Type	Target Market(s)	End Use
New	Residential New Home	Space Heating

Codes, Standards, and Regulations

- Under Ontario's building code, all gas furnaces installed in new residential constructions must meet a minimum condensing efficiency level effective January 1, 2007.[1]
- Presently, there is no minimum energy performance standard restricting the electricity consumption of furnace fan blowers.
- NRCan proposes to increase the minimum performance level, the Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces with an input rate not exceeding 65.92 kW (225,000 Btu/h) to 90% for December 31, 2009[2].

[1] Ministry of Energy, "Heating and Cooling your Home: A Conservation Guide", Reproduced with the permission of Natural Resource Canada, 2004. http://www.energy.gov.on.ca/english/pdf/conservation/heating_and_cooling_your_home.pdf

[2] Office of Energy Efficiency, Canada's Energy Efficiency Regulations, Proposed Regulations Bulletin, March 2007. http://www.oee.nrcan.gc.ca/regulations/bulletin/gas-furnace-mar2007.cfm?Text=N&PrintView=N

Resource Savings Table (for 2 different cases)

Continuous Fan Usage

Year (EUL=)	Electricity and Other Resource Savings Natural Gas (m^3)	Electricity (kWh)	Water (L)	Equipment & O&M Costs of Conservation Measure ($)	Equipment & O&M Costs of Base Measure[3] ($)
1	-166	1403	0	960	0
2	-166	1403	0	0	0
3	-166	1403	0	0	0
4	-166	1403	0	0	0
5	-166	1403	0	0	0
6	-166	1403	0	0	0
7	-166	1403	0	0	0
8	-166	1403	0	0	0
9	-166	1403	0	0	0
10	-166	1403	0	0	0
11	-166	1403	0	0	0
12	-166	1403	0	0	0
13	-166	1403	0	0	0
14	-166	1403	0	0	0
15	-166	1403	0	0	0
TOTALS	**-2,745**	**20,805**	**0**	**960**	**0**

[3] US DOE Energy Star Furnace Calculator, “Assumptions” tab.
http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls

Resource Savings Assumptions

Annual Natural Gas Savings	-166 m^3

Continuous fan use and non-continuous fan use is estimated to be 26% and 74%, respectively, based on Ontario customer survey results[4].

A study conducted by the Canadian Center for Housing Technologies determined that a the annual gas use of a typical new home with a continuous ECM actually *increases* by 164m^3 for high efficiency furnaces (AFUE 92) and 184m^3 for mid-efficiency furnaces (AFUE 82)[5]. The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency based on recent survey results for residential furnaces[6], resulting in an average increase of 166.4m^3.

The CCHT study gives a baseline gas use as 1,744 m^3 for high efficiency furnaces and 1,957 m^3 for mid-efficiency furnaces[7]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical furnace with a PSC motor is expected to use 1,770 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 1,936 m^3 of natural gas (1,770 + 166), or an increase of 9.4 % over the baseline.

Annual Electricity Savings	1,403 kWh

Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions Lists[8], the electricity savings for a new home using an ECM are estimated to be 1,403 kWh/year for continuous furnace fan usage. This represents a savings of 78% over a conventional PSC motor.

These results are based on the same CCHT study, which determined that annual electricity savings for a new home using a gas furnace with an ECM for heating only are 1,569 kWh for high efficiency furnaces (AFUE 92) and 1,571 kWh for mid-efficiency furnaces (AFUE 82)[9]. Since it is unlikely that the furnace fan is running continuously during the shoulder season, the OPA assumes that during the shoulder season, the same electricity savings from a non-continuous ECM are applicable.

Annual Water Savings	0 L

N/A

[4] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[5] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[6] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[7] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[8] Ontario Power Authority, 2009 OPA Measures and Assumptions List (Mass Market), November 2008.
[9] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

Non-Continuous Fan Usage

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure[10]
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	-26.4	207	0	960	0
2	-26.4	207	0	0	0
3	-26.4	207	0	0	0
4	-26.4	207	0	0	0
5	-26.4	207	0	0	0
6	-26.4	207	0	0	0
7	-26.4	207	0	0	0
8	-26.4	207	0	0	0
9	-26.4	207	0	0	0
10	-26.4	207	0	0	0
11	-26.4	207	0	0	0
12	-26.4	207	0	0	0
13	-26.4	207	0	0	0
14	-26.4	207	0	0	0
15	-26.4	207	0	0	0
TOTALS	**-396**	**3,105**	**0**	**960**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	-26.4 m^3

Continuous fan use and non-continuous fan use is estimated to be 26% and 74%, respectively, based on customer survey results[11].

A study conducted by the Canadian Center for Housing Technologies determined that a the annual gas use of a typical existing home with a non-continuous ECM actually *increases* by 26 m^3 for high efficiency furnaces (AFUE 92) and 29 m^3 for mid-efficiency furnaces (AFUE 82)[12]. The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency based on recent survey results for residential furnaces[13], resulting in an average increase of 26.4 m^3.

The CCHT study gives a baseline gas use as 2,953 m^3 for high efficiency furnaces and 3,313 m^3 for mid-efficiency furnaces[14]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical home with a PSC motor is expected to use 2,996 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 3,022 m^3 of natural gas (2,996 + 26), or an increase of 0.9% over the baseline.

[10] US DOE Energy Star Furnace Calculator, "Assumptions" tab. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls
[11] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[12] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[13] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[14] Ibid.

Annual Electricity Savings	207 kWh
Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions List[15], electricity savings for a new home using an ECM are estimated to be 207 kWh/year for non-continuous furnace fan usage. This represents a savings of 40% over a traditional PSC motor. These results are based on the same CCHT study, which determined that annual electricity savings for a new home using a gas furnace with an ECM for heating only are 207 kWh for both high efficiency furnaces (AFUE 92) mid-efficiency furnaces (AFUE 82)[16]	
Annual Water Savings	**0 L**
N/A	

[15] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.
[16] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

Other Input Assumptions

Effective Useful Life (EUL)	15 Years
An OPA commissioned study by Seeline Group Inc. suggests a useful life of 15 years. Furthermore, a June 2007 study by GDS Associates, Inc.[17] for New England State Program Working Group (SPWG) also suggest 15 years. Finally, the Iowa Utilities Board[18] also uses 15 years as an effective useful life for an ECM.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$960**
Based on the average of a survey of prices from HVAC contractors in Ontario[19], the incremental cost is estimated to be $960. Incremental costs were confirmed through communication with additional HVAC contractors.	
Customer Payback Period (Natural Gas and Electricity)	**Continuous = 18 years** **Non-Continuous = 137 years**
Since natural gas usage increases with an ECM, Navigant Consulting has used both natural gas and electricity savings to calculate the customer payback period. *For Natural Gas Usage:* Combining a 5-year average commodity cost (avoided cost)[20] of $0.38 / m^3 and an average residential distribution cost[21] of $0.14 / m^3, the total cost of natural gas for residential customers is determined to be $0.52. *For Electricity Savings:* An average commodity and distribution cost of $0.10 / kWh is assumed for residential customers. The payback period incorporating both natural gas usage and electricity savings is determined to be 18 years for continuous usage and 137 years for non-continuous furnace fan usage, based on the following: Payback Period = Incremental cost / [(natural gas savings x natural gas cost) + (electricity savings x electricity cost)] *Continuous Fan Usage:* = $960 / [(-166 m^3/year * $0.52 / m^3) + (1,403 kWh/year * $0.10 / kWh)] = 18 years *Non-Continuous Fan Usage:* = $960 / [(-26.4 m^3/year * $0.52 / m^3) + (207 kWh/year * $0.10 / kWh)] = 137 years	
Market Share[22]	**Low**
Although the benefits of electronically commutated motors are increasingly being promoted by the	

[17] GDS Associates Inc, Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG) For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007.

[18] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131

[19] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.

[20] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[21] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[22] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

industry, the overall market share still remains low in the residential retrofit market, as seen in another jurisdiction (Iowa reports a 5% market penetration for residential homes[23]). Therefore, Navigant Consulting estimates the share in Ontario to be low.

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
2009 OPA Measures and Assumptions List[24]	-66.8m^3 (continuos usage) 30.6m^3 (non-continuos)	15	$960	N/A
Comments Assumptions made in the OPA Measures and Assumptions List are the same assumptions that are made in the above tables.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
Iowa State Utility Board[25]	n/a	15	$76	5%
Comments Only electric savings reported (75% over base equipment). Base equipment is a standard motor on a gas fired furnace. Baseline consumption is reported on an annual basis (e.g. 723 kWh for a single family).				

[23] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[24] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.
[25] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Energy Star Windows (Low-E)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Energy Star Low-E Windows, argon filled (U=0.26 or R=3.8)
Base Equipment and Technologies Description
Double pane with standard glazing (U=0.49 or R = R=2.0)

Decision Type	Target Market(s)	End Use
Retrofit	Exiting Residential	Space heating

Codes, Standards, and Regulations

Minimum ENERGY STAR® requirements are based on either a U-value or Energy Rating (ER) for each of the four Canadian zones[1].

Zone	Maximum U-values and Minimum R-Values			Minimum Energy Rating (ER) Values (Maximum U-value 2.00 W/m^2•K)				
	U-value (W/m^2•K)	U-value (Btu/h•ft.^{2}•°F)	R-Value (ft.^{2}•h•°F/Btu)		Most Windows and All Doors (includes fixed casement style windows)		Picture Windows Only	
					1998	2004*	1998	2004*
A	2	0.35	2.9	or	-16	17	-6	27
B	1.8	0.32	3.2	or	-12	21	-2	31
C	1.6	0.28	3.6	or	-8	25	2	35
D	1.4	0.25	4	or	-5	29	5	39

[1] NRCan, Office of Energy Efficiency, http://www.oee.nrcan.gc.ca/energystar/english/consumers/ratings.cfm?text=N&printview=N

Resource Savings Table

Year (EUL=)	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
	Natural Gas	Electricity	Water		
	(m^3)	(kWh)	(L)	($/window)	($)
1	121	206	0	150	0
2	121	206	0	0	0
3	121	206	0	0	0
4	121	206	0	0	0
5	121	206	0	0	0
6	121	206	0	0	0
7	121	206	0	0	0
8	121	206	0	0	0
9	121	206	0	0	0
10	121	206	0	0	0
11	121	206	0	0	0
12	121	206	0	0	0
13	121	206	0	0	0
14	121	206	0	0	0
15	121	206	0	0	0
16	121	206	0	0	0
17	121	206	0	0	0
18	121	206	0	0	0
19	121	206	0	0	0
20	121	206	0	0	0
TOTALS	**2,420**	**4,020**	**0**	$150	0

Resource Savings Assumptions

Annual Natural Gas Savings	121 m^3

Natural gas savings based on REFREN 5.0 modeling using the following assumptions:

- Existing frame 2,000 ft^2
- 2-storey residential home, with a gas furnace, central air conditioner
- 300 ft^2 in windows (15% floor area)
- Toronto, ON weather
- Baseline windows assumed wood/vinyl double pane, clear (air filled) windows (U=0.49)
- Energy efficient windows assumes wood/vinyl double pane, low-E, argon filled windows (U=0.26)[2]

Based on the above assumptions, the following results were obtained:

- Baseline heating consumption = 141.3 MMBtu (3,884 m^3) of natural gas
- Energy efficient heating consumption = 134.2 MMBtu (3,689 m^3) of natural gas
- Savings = 3,884 m^3 – 3,689 m^3 = 195 m^3 or 5.0%

Applying the percent savings to Enbridge's baseline natural gas consumption for mid-efficiency furnaces[3] (2,436 m^3):

- Natural Gas Savings = 2,436 m^3 * 5.0% = 121 m^3

Annual Electricity Savings	206 kWh

Electric saving from space cooling reduction is based on the same assumptions as above:

- Baseline cooling consumption = 590 kWh
- Energy efficient cooling consumption = 342 kWh
- Savings = 590 kWh – 384 kWh = 206 kWh or 35%

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	20 Years

The EUL is reported to be 25 years by The New England State Program Working Group (SPWG)[4], the Iowa Utilities Board[5] and Efficiency Vermont[6]. NYSERDA[7] and the OPA[8] report an EUL of 20 years. Navigant is assuming 20 years.

Base & Incremental Conservation Measure Equipment and O&M Costs	$150/window

Based on communication with various local vendors, the incremental cost of purchasing a new low-e, argon windows over the traditional regular double pane, is approximately $100-200 per window, or an average of $150 per window. For the modeled candidate home, 300 ft^2 of windows is estimated to be approximately 12 windows, which translates to a total incremental cost of $1,800.

Customer Payback Period (Natural Gas Only)[9]	28 Years

[2] Based on communication with various local window vendors, majority of customers are choosing low-e argon filled windows, with R-value approximately 4.
[3] Enbridge Gas Customer Profiling Yearly Average End Use, November 23, 2004
[4] GDS Associates, Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures prepared for The New England State Program Working Group (SPWG), June 2007
[5] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[6] Vermont Residential Master Technical Reference Manual No.2005-37
[7] NYSERDA, New York Energy $mart Programs, Deemed Savings Database, August 2008
[8] Ontario Power Authority. 2009 OPA Measures and Assumptions List. November 2008.

Using an 5-year average commodity cost (avoided cost)[10] of $0.38 / m^3 and an average residential distribution cost[11] of $0.14 / m^3, the payback period for natural gas savings is determined to be 48 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $1,800 / (121 m^3/year * $0.52 / m^3) = 28 years	
Market Share[12]	**High**
According to NRCan, in 2003, almost 70% of Ontario residents who replaced their windows opted for either low-e or gas filled windows. Furthermore, based on communications with local contractors and distributors, the majority of customers are replacing their windows with low-e, gas filled windows. Therefore, Navigant Consulting estimates the market share in Ontario to be high.	

[9] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[10] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[11] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[12] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Questar Gas[13]	6.23 DTh (22.7 m^3)	35	$201	N/A
Comments Details regarding baseline and new technology are not listed.				

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[14]	3.8	25	3,868 US$	75%
Comments Assuming baseline technology of existing windows (U=0.51, SHGC = 0.67) is being replaced with state code windows (U= 0.35, SHGC= 0.32). Savings reported as 0.2% of baseline consumption of 696 therms, which would translate to 1.39 therms, or 3.8 m^3.				

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
2009 OPA Measures and Assumptions List[15]	319	25	$500/window	N/A
Comments Assuming baseline technology of eight (8) existing windows (single pane with storm windows) being replaced by double pane, low-e argon, wood frame windows. Per window savings also reported as 39.8 m^3.				

[13] Nexant, DSM Market Characterization Report, prepared for Questar Gas, August 2006
[14] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[15] Ontario Power Authority. 2009 OPA Measures and Assumptions List. November 2008.

Heat Reflective Panels

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
A saw tooth panel made of clear PVC with a reflective surface placed behind a gas radiator reducing heat lost to poorly insulated exterior walls.
Base Equipment and Technologies Description
Existing housing with gas radiant heat with no reflecting panels.

Decision Type	Target Market(s)	End Use
New	Existing single family residential homes (pre-1980)	Space Heating

Codes, Standards, and Regulations

No code or standard exists for heat reflective panels.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas	Electricity	Water		
	(m^3)	(kWh)	(L)	($)	($)
1	143	0	0	229	0
2	143	0	0	0	0
3	143	0	0	0	0
4	143	0	0	0	0
5	143	0	0	0	0
6	143	0	0	0	0
7	143	0	0	0	0
8	143	0	0	0	0
9	143	0	0	0	0
10	143	0	0	0	0
11	143	0	0	0	0
12	143	0	0	0	0
13	143	0	0	0	0
14	143	0	0	0	0
15	143	0	0	0	0
16	143	0	0	0	0
17	143	0	0	0	0
18	143	0	0	0	0
TOTALS	**2,574**	**0**	**0**	**229**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	143 m^3

A 2006 Enbridge Gas Distribution Load Research Study[1] reports an average boiler consumption of 3,493 m^3 for single family homes. A 2008 heat reflective panel pilot study conducted by Enbridge determined an annual gas savings of 4.1% in a single family environment[2].

Applying this savings to the average annual gas consumption results in an annual gas savings of 143 m^3 (3,493 m^3 x 4.1%).

Annual Electricity Savings	0 kWh

No electricity savings result from heat reflective panels.

Annual Water Savings	0 L

No water savings result from heat reflective panels.

Other Input Assumptions

Effective Useful Life (EUL)	18 Years

Reflective panels are assumed to have the same effective useful life as a furnace. The US DOE reports an 18 year measure life for gas furnaces, according to a Lawrence Berkeley National Laboratory study[3]. Furthermore, ACEEE[4] and State of Iowa[5] both estimate an effective useful life of furnaces to be 18 years. Puget Sound Energy[6] and New England State Program Working Group (SPWG)[7] also suggest 18 years for high efficiency furnaces.

Base & Incremental Conservation Measure Equipment and O&M Costs	$229

The manufacturer of heat reflective panels, Novitherm, provides the average price for reflectors in a single family home (typically installed by the homeowner)[8].

Customer Payback Period (Natural Gas Only)	3.1 Years

Using an 5-year average commodity cost (avoided cost)[9] of \$0.38 / m^3 and an average residential distribution cost[10] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 3.1 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= \$229/ (143 m^3/year * \$0.52 / m^3)
= 3.1 years

[1] Enbridge Gas Distribution. Residential Boiler Consumption Research: Summary.
[2] Ibid.
[3] US DOE Energy Star Program. Lifecycle Cost Estimate for an Energy Star Qualified Residential Furnace. Assumptions Tab. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls
[4] Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers. ACEEE, September 2004.
[5] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[6] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
[7] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG), For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007
[8] Novitherm Heat Reflectors, Residential - Reduce Heating Costs www.novitherm.com
[9] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[10] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration[11]	**Low**
Given the relative novelty of this technology, Navigant Consulting estimates the penetration in Ontario to be low.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
N/A	N/A	N/A	N/A	N/A
Comments N/A				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/ Market Share**
N/A	N/A	N/A	N/A	N/A
Comments N/A				

[11] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,

High Efficiency (Condensing) Furnace - Residential

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

High-efficiency condensing furnace with regular PSC motor – AFUE 90, 92 and 96

Base Equipment and Technologies Description

Mid-efficiency furnace AFUE 80[1]

Decision Type	Target Market(s)	End Use
New, Retrofit	Residential	Space Heating

Codes, Standards, and Regulations

- Under Ontario's building code, all gas furnaces installed in new residential construction must meet a minimum condensing efficiency level effective January 1, 2007.[2]
- NRCan proposes to increase the minimum performance level, the Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces with an input rate not exceeding 65.92 kW (225,000 Btu/h) to 90% for December 31, 2009.[3]

[1] The federal baseline is AFUE 78, but very few are sold below 80. *Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers*. ACEEE, September 2004, Page 9.

[2] Ministry of Energy, "Heating and Cooling your Home: A Conservation Guide." Reproduced with the permission of Natural Resource Canada, 2004. http://www.energy.gov.on.ca/english/pdf/conservation/heating_and_cooling_your_home.pdf

[3] Office of Energy Efficiency, Canada's Energy Efficiency Regulations, Proposed Regulations Bulletin, March 2007. http://www.oee.nrcan.gc.ca/regulations/bulletin/gas-furnace-mar2007.cfm?Text=N&PrintView=N

Resource Savings Table (for 3 different cases)

AFUE 90

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	268	0	0	2,900	2,233
2	268	0	0	0	0
3	268	0	0	0	0
4	268	0	0	0	0
5	268	0	0	0	0
6	268	0	0	0	0
7	268	0	0	0	0
8	268	0	0	0	0
9	268	0	0	0	0
10	268	0	0	0	0
11	268	0	0	0	0
12	268	0	0	0	0
13	268	0	0	0	0
14	268	0	0	0	0
15	268	0	0	0	0
16	268	0	0	0	0
17	268	0	0	0	0
18	268	0	0	0	0
TOTALS	**4,824**	**0**	**0**	**2,900**	**2,233**

Resource Savings Assumptions

Annual Natural Gas Savings	268 m^3

- Gas savings associated with upgrading from a mid-efficiency furnace to a high efficiency furnace are based on the following formula:
- Annual Savings = 1 – Base Technology AFUE / Efficient Equipment AFUE
    - = 1 – 80/90
    - = 11.1%
- The US DOE reports an 11.7% gas savings for an AFUE 90 furnace (based on an AFUE 80 baseline).[4]
- Natural gas savings are based on Enbridge research[5] indicating that the average consumption for a mid-efficiency furnace is 2,436m^3.
- Using the calculated percent savings (11.1%) multiplied by the base energy consumption (2,436 m^3) the annual gas savings are estimated to be 268 m^3.

Annual Electricity Savings	0 kWh
Electricity savings resulting from high efficiency furnaces are assumed to be negligible.	

Annual Water Savings	0 L
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	18 Years
ACEEE[6] and State of Iowa[7] both estimate an effective useful life of 18 years. Puget Sound Energy[8] and New England State Program Working Group (SPWG)[9] also suggest 18 years for high efficiency furnaces.	

Base & Incremental Conservation Measure Equipment and O&M Costs	$667
Average equipment costs were determined based on communication with several Ontario HVAC contractors. The average baseline equipment cost (AFUE 80) was determined to be $2,233 and the average cost of a 90 AFUE condensing gas furnace was determined to be $2,900, resulting in an incremental cost of $667. In comparison, the US DOE[10] reports an AFUE 80 furnace at $2,526 and an AFUE 90 condensing gas furnace at $3,170, giving an incremental cost of $644.	

Customer Payback Period (Natural Gas Only)	4.8 Years
Using an 5-year average commodity cost (avoided cost)[11] of $0.38 / m^3 and an average residential	

---

[4] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls

[5] Based on information provided by Enbridge Gas, based on Decision for the Enbridge 2006 DSM Plan (EB2005-0001).

[6] Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers. ACEEE, September 2004.

[7] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131

[8] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

[9] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG), For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007

[10] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls

distribution cost[12] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 4.8 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= \$667/ (268 m^3/year * \$0.52 / m^3)
= 4.8 years

Market Share[13]	**Medium**

According to NRCan, the market penetration of gas fired high efficiency furnaces (AFUE 90+) in single family homes is approximately 27% in Ontario[14]. Based on communications with local contractors and distributors, due to recent conservation efforts (e.g., rebates) to promote high efficiency furnaces, customers are increasingly upgrading to high-efficient furnaces over mid-efficiency furnaces. Therefore, Navigant Consulting estimates the market share in Ontario to be medium.

AFUE 92

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	(\$)	(\$)
1	317	0	0	3,300	2,233
2	317	0	0	0	0
3	317	0	0	0	0
4	317	0	0	0	0
5	317	0	0	0	0
6	317	0	0	0	0
7	317	0	0	0	0
8	317	0	0	0	0
9	317	0	0	0	0
10	317	0	0	0	0
11	317	0	0	0	0
12	317	0	0	0	0
13	317	0	0	0	0
14	317	0	0	0	0
15	317	0	0	0	0
16	317	0	0	0	0
17	317	0	0	0	0
18	317	0	0	0	0
TOTALS	**5,706**	**0**	**0**	**3611**	**2,233**

[11] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[12] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[13] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[14] NRCan, Office of Energy Efficiency, Comprehensive Energy Use Database: Table 22: Single detached heating system stock by heating system type, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_on.cfm, updated September 2008.

Resource Savings Assumptions

Annual Natural Gas Savings	317 m^3

- Gas savings associated with upgrading from a mid-efficiency furnace to a high efficiency furnace are based on the following formula:

- Annual Savings = 1 – Base Technology AFUE / Efficient Equipment AFUE
    - = 1 – 80/92
    - = 13.0%

- The US DOE reports a 12.9% gas savings for an AFUE 92 furnace (based on an AFUE 80 baseline).[15]

- Natural gas savings are based on Enbridge research[16] indicating that the average consumption for a mid-efficiency furnace is 2,436 m^3.

- Using the calculated percent savings (13.0%) multiplied by the base energy consumption (2,436 m^3) the annual gas savings are estimated to be 317 m^3.

Annual Electricity Savings	0 kWh
Electricity savings resulting from high efficiency furnaces are negligible.	
Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	18 Years
ACEEE[17] and State of Iowa[18] both estimate an effective useful life of 18 years. Puget Sound Energy[19] and New England State Program Working Group (SPWG)[20] also suggest 18 years for high efficiency furnaces.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$1,067**
Average equipment costs were determined based on communication with several Ontario HVAC contractors. The average baseline equipment cost (AFUE 80) was determined to be $2,233 and the average cost of a 92 AFUE condensing gas furnace was determined to be $3,300, resulting in an incremental cost of $1,067. In comparison, the US DOE[21] reports an AFUE 80 furnace at $2,526 and an AFUE 92 condensing gas furnace at $3,611, giving an incremental cost of $1,067.	
Payback Period	**6.5 Years**
Using an 5-year average commodity cost (avoided cost)[22] of $0.38 / m^3 and an average residential	

[15] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls
[16] Based on information provided by Enbridge Gas, based on Decision for the Enbridge 2006 DSM Plan (EB2005-0001).
[17] Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers. ACEEE, September 2004.
[18] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[19] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
[20] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG), For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM),June 2007
[21] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls

distribution cost[23] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 6.5 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= \$1,067/ (317 m^3/year * \$0.52 / m^3)
= 6.5 years

Market Share[24]	Medium

According to NRCan, the market penetration of gas fired high efficiency furnaces (AFUE 90+) in single family homes is approximately 27% in Ontario[25]. Based on communications with local contractors and distributors, due to recent conservation efforts (e.g., rebates) to promote high efficiency furnaces, customers are increasingly upgrading to high-efficient furnaces over mid-efficiency furnaces. Therefore, Navigant Consulting estimates the share in Ontario to be medium.

AFUE 96

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	407	0	0	4,667	2,233
2	407	0	0	0	0
3	407	0	0	0	0
4	407	0	0	0	0
5	407	0	0	0	0
6	407	0	0	0	0
7	407	0	0	0	0
8	407	0	0	0	0
9	407	0	0	0	0
10	407	0	0	0	0
11	407	0	0	0	0
12	407	0	0	0	0
13	407	0	0	0	0
14	407	0	0	0	0
15	407	0	0	0	0
16	407	0	0	0	0
17	407	0	0	0	0
18	407	0	0	0	0
TOTALS	**7,326**	**0**	**0**	**4,667**	**2,233**

[22] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[23] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[24] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[25] NRCan, Office of Energy Efficiency, Comprehensive Energy Use Database: Table 22: Single detached heating system stock by heating system type, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_on.cfm, updated September 2008.

Resource Savings Assumptions

Annual Natural Gas Savings	407 m^3

- Gas savings associated with upgrading from a mid-efficiency furnace to a high efficiency furnace are based on the following formula:

- Annual Savings = 1 – Base Technology AFUE / Efficient Equipment AFUE
  = 1 – 80/96
  = 16.7%

- The US DOE reports a 16.1% gas savings for an AFUE 96 furnace (based on an AFUE 80 baseline).[26]

- Natural gas savings are based on Enbridge research[27] indicating that the average consumption for a mid-efficiency furnace is 2,436 m^3.

- Using the calculated percent savings (16.7%) multiplied by the base energy consumption (2,436 m^3) the annual gas savings are estimated to be 407 m^3.

Annual Electricity Savings	0 kWh
Electricity savings resulting from high efficiency furnaces are negligible.	
Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	18 Years
ACEEE[28] and State of Iowa[29] both estimate an effective useful life of 18 years. Puget Sound Energy[30] and New England State Program Working Group (SPWG)[31] also suggest 18 years for high efficiency furnaces.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$2,433**
Average equipment cost were determined based on communication with several Ontario HVAC contractors. The average baseline equipment cost (AFUE 80) was determined to be $2,233 and the average cost of a 96 AFUE condensing gas furnace was determined to be $4,667, resulting in an incremental cost of $2,433. In comparison, the US DOE[32] reports an AFUE 80 furnace at $2,526 and an AFUE 96 condensing gas furnace at $4,560, giving an incremental cost of $2,433.	
Payback Period	**11.5 Years**
Using an 5-year average commodity cost (avoided cost)[33] of $0.38 / m^3 and an average residential	

[26] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls
[27] Based on information provided by Enbridge Gas, based on Decision for the Enbridge 2006 DSM Plan (EB2005-0001).
[28] Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers. ACEEE, September 2004.
[29] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[30] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
[31] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG), For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007
[32] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls

distribution cost[34] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 11.5 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$2,433 / (407 m^3/year * \$0.52 / m^3) = 11.5 years

Market Share[35]	Medium
According to NRCan, the market share of gas fired high efficiency furnaces (AFUE 90+) in single family homes is approximately 27% in Ontario[36]. Based on communications with local contractors and distributors, due to recent conservation efforts (e.g., rebates) to promote high efficiency furnaces, customers are increasingly upgrading to high-efficient furnaces over mid-efficiency furnaces. Therefore, Navigant Consulting estimates the penetration in Ontario to be medium.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
State of Iowa Utilities Board[37]	AFUE 90: 13.3% or 259 m^3	18	US\$175	N/A
	AFUE 93: 16.0% or 312 m^3		US\$210	
	AFUE 96: 18.8% or 366 m^3		US\$305	
Comments The State of Iowa reports a baseline gas furnace as AFUE 78 (state code) using 701 therms/year or 1947.2 m^3/year.				
Puget Sound Energy[38]	AFUE 90: 13% or 222 m^3	18	US\$600	N/A
	AFUE 96: 19% or 324 m^3		US\$950	
Comments Puget Sound reports their savings based on a baseline gas furnace of AFUE 78 using 614 therms/year or 1,707 m^3/year.				

[33] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[34] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[35] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[36] NRCan, Office of Energy Efficiency, Comprehensive Energy Use Database: Table 22: Single detached heating system stock by heating system type, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_on.cfm, updated September 2008.
[37] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[38] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Programmable Thermostat - Residential

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Programmable thermostat.
Base Equipment and Technologies Description
Standard thermostat.

Decision Type	Target Market(s)	End Use
Retrofit	Residential existing homes	Space Heating

Codes, Standards, and Regulations

- For a programmable thermostat to receive Energy Star® qualification, it must meet specific criteria such as having at least two different programming periods (for weekday and weekend programming), at least four possible temperature settings and allow for temporary overriding by the user.
- In Canada, applicable CSA standards can be found in CSA C828-99- CAN/CSA Performance Requirements for Thermostats used with Individual Room Electric Space Heating Devices.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	146	182	0	25	0
2	146	182	0	0	0
3	146	182	0	0	0
4	146	182	0	0	0
5	146	182	0	0	0
6	146	182	0	0	0
7	146	182	0	0	0
8	146	182	0	0	0
9	146	182	0	0	0
10	146	182	0	0	0
11	146	182	0	0	0
12	146	182	0	0	0
13	146	182	0	0	0
14	146	182	0	0	0
15	146	182	0	0	0
TOTALS	**2,190**	**2,730**	**0**	**25**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	146 m^3

- Two utility studies[1] are used to determine savings resulting from residential programmable thermostats on natural gas consumptions.

  - In the ***GasNetworks*** study[2], 4,061 mail-in surveys and bills were analyzed. Results were normalized for temperature and the energy impacts were determined through a multivariate regression analysis. The study found that programmable thermostat saved 6 % of total household annual natural gas use. GasNetworks is proposing 75 ccf (212 m^3) natural gas savings based on a Non-Programmable Thermostat annual consumption of 1,253 ccf (3,548 m^3) natural gas.
  - In the ***Enbridge Billing Analysis***[3], 911 customers' natural gas consumption was analyzed in 2005. Enbridge determined an average savings of 159 m^3 for a house using 2,878 m^3 of natural gas.

- Canadian Centre for Housing Technology (CCHT) also conducted a study in 2005 on programmable thermostat natural gas savings[4]. The study was done in two identical research homes located in Ottawa to allow direct comparison of changes in operating conditions in a home. It reports a 6.5% predicted savings for 18°C night setback.
- Based on these three studies, Navigant Consulting is assuming an average saving at 6% for natural gas consumptions.

Studies	Baseline Gas Consumption (m^3)	Gas Savings (m^3)	Gas Savings%
GasNetworks (2007)	3,548	212	6.0%
Enbridge (2005)	2,878	159	5.5%
CCHT (2005)	-	-	6.5%
NCI Average			6.0%

- The baseline natural gas consumption for Enbridge[5] is 2,436 m^3 for mid-efficiency furnaces,
- Therefore, NCI estimates for natural gas savings = 2,436 m^3 x 6% = 146 m^3

Annual Electricity Savings	182 kWh

- A side-by-side housing study conducted by the Canadian Centre for Housing Technology[6] determined seasonal energy savings for a residential unit from a programmable thermostat as follows:

CAC:**

Temp Set Back	*Total Summer Furnace and CAC Electricity Consumption (kWh)*	*Seasonal Savings (%)*
None (22C)	3,099	0
25 C daytime set back	2,767	11
24 C daytime set back	2,376	23

** 12 SEER , 2 ton capacity CAC, 362 cooling degree days (18C)

[1] "Resource Savings Values in Selected Residential DSM Prescriptive Programs", Summit Blue Consulting, June 2008.
[2] RLW Analytics, Validating the impact of programmable thermostats: final report. Prepared for GasNetworks by RLW Analytics. Middletown, CT, January 2007.
[3] "Resource Savings Values in Selected Residential DSM Prescriptive Programs", Summit Blue Consulting, June 2008.
[4] The Effects of Thermostat Setting on Seasonal Energy Consumption at the CCHT Research Facility, Manning, Swinton, Szadkowski, Gusdorf, Ruest, February 14, 2005, http://irc.nrc-cnrc.gc.ca/pubs/rr/rr191/rr191.pdf
[5] Enbridge Gas Customer Profiling Yearly Average End Use, November 23, 2004; based on Summit Blue Report, Navigant Consulting will use baseline consumption data provided by Enbridge for analysis.
[6] Canadian Center for Housing Technologies, The Effects of Thermostat Set-back and Set-up on Seasonal Energy Consumption, Surface Temperatures and Recovery Times at the CCHT Twin House Facility, March 2007 http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc48361/nrcc48361.pdf

- A BC Hydro study[7] reports savings between 10% and 15% for 4°C set back during night and unoccupied periods, Energy Star Calculator[8] reports 3% saving per degree for heating season (8.25% for full set back). Using the CCHT study results from a full daytime and night-time set back of 4 degrees:
  - Approximate savings is expected for the winter season = 2,314 – 2,270 = 44 kWh/year

- Navigant Consulting is assuming a base CAC usage of 1,257 kWh/year based on the OPA's assumption using CAC rated at 8.7 SEER and 24,000 Btu/hr unit[9]. Using the CCHT study results, setting the thermostat 3 degrees higher would save 11%:
  - Based on CAC usage of 1,257 kWh/year, electricity savings = 1,257 x 11% = 138 kWh/year

- Therefore, assuming an average home has both space cooking using CAC and force air heating, the total electricity savings = 138 kWh/year + 44 kWh/year = 182 kWh/year.

Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	**15 Years**
Navigant Consulting is estimating 15 years as the effective useful life based on the average lifetime of programmable thermostat from Energy Star ® website.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 25**
Average incremental cost of programmable thermostats determined to be $25 based on average cost of non-programmable and programmable thermostats from Home Depot and Canadian Tire website in 2008.	
Customer Payback Period (Natural Gas Only)[10]	**0.3 Years**
Using an 5-year average commodity cost (avoided cost)[11] of $0.38 / m^3 and an average residential distribution cost[12] of $0.14 / m^3, the payback period for natural gas savings is determined to be 0.3 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $25/ (146 m^3/year * $0.52 / m^3) = 0.3 years	

[7] Marbek Resource Consultants, The Sheltair Group Inc , BC Hydro BC Hydro Conservation Potential Review 2002, Residential Sector Report (Base Year: Fiscal 2000/01) (Revision 1) Submitted to: BC Hydro, June 2003
[8] US EPA (EPA Energy Star® Simple Savings Calculator – Programmable Thermostat), http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorProgrammableThermostat.xls
[9] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, referenced from: Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI), 2006 Cool Savings Rebate Program, Prepared for the Ontario Power Authority, April 2007.
[10] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[11] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[12] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration	65%
Due to the number of conservation programs in Ontario currently offering programmable thermostats and based on previous research conducted for the OPA[13], Navigant Consulting estimates the penetration of programmable thermostats amongst single family residents in Ontario to be 65%.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[14]	276	15	$25	46% (single family)
Comments Measure provides savings of 11.5% over 2,399 m3 required for space heating with base equipment.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Ontario Power Authority[15]	182	15	$140	N/A
Comments Based on gas savings from Canadian Centre for Housing Technology study for an 80% AFUE gas furnace using standard PCS motor and furnace size of 67,500 BTU/hr, using 4761 heating degree hours.				

[13] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

[14] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

[15] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008

Wall Insulation (R-19)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Main floor wall insulation R-19
Base Equipment and Technologies Description
Main floor wall insulation R-8

Decision Type	Target Market(s)	End Use
Retrofit	Existing Residential (Pre-1980)	Space Heating

Codes, Standards, and Regulations

The minimum R value required by Ontario Building Code[1] for walls other than the foundation wall is 19.

[1] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Table

Year (EUL=)	Electricity and Other Resource Savings: Natural Gas (m^3)	Electricity (kWh)	Water (L)	Equipment & O&M Costs of Conservation Measure ($/ft^2)	Equipment & O&M Costs of Base Measure ($)
1	405	194	0	2.5	0
2	405	194	0	0	0
3	405	194	0	0	0
4	405	194	0	0	0
5	405	194	0	0	0
6	405	194	0	0	0
7	405	194	0	0	0
8	405	194	0	0	0
9	405	194	0	0	0
10	405	194	0	0	0
11	405	194	0	0	0
12	405	194	0	0	0
13	405	194	0	0	0
14	405	194	0	0	0
15	405	194	0	0	0
16	405	194	0	0	0
17	405	194	0	0	0
18	405	194	0	0	0
19	405	194	0	0	0
20	405	194	0	0	0
21	405	194	0	0	0
22	405	194	0	0	0
23	405	194	0	0	0
24	405	194	0	0	0
25	405	194	0	0	0
26	405	194	0	0	0
27	405	194	0	0	0
28	405	194	0	0	0
29	405	194	0	0	0
30	405	194	0	0	0
TOTALS	**12,150**	**5,820**	**0**	**2.5**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	405 m^3

- Navigant Consulting used HOT2000[2] to model energy savings resulting from the energy efficient upgrade. The following input assumptions were based on a candidate house for a typical pre-1980 home[3].

[2] NRCan, http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/software_tools/hot2000.html
[3] Candidate home characteristics are based on previous weatherization study completed by Marbek in 2008 for Union Gas and Navigant Consulting input assumptions.

House Characteristics using HOT2000	
Location	Toronto, ON
Storeys	2
Above Grade Wall Insulation	R-Value = 8
Below Grade Wall Insulation	R-Value = 1
Attic Insulation	R-Value = 10
Foundation Floor Insulation	R-Value = 5
Air Leakage (ACH)	8.0
Window Type	Double pane with standard glazing, Aluminum
Number of Windows	8
Ceiling Area (ft^2)	829
Main Level Wall Area (ft^2)	944
Living Space Area (ft^2)	1,658
Basement Wall Area (ft^2)	827
Basement Floor Area (ft^2)	829
Base Loads Use	Defaults
Furnace Efficiency (AFUE)	80
Furnace Capacity (Btu/hr)	75,000
Fans Mode	Auto
A/C Efficiency (SEER)	10
A/C Capacity (Btu/hr)	13000†

† The current version of HOT2000 has limitation on A/C capacities under specified conditions. 13000 Btu/hr is the maximum value it allows.

- Based on the above assumptions, the following results are obtained:

HOT2000 Simulation Results	Space Heating NG Consumption (m^3)	Space Cooling Consumption (kWh)	Annual Furnace Fan Consumption (kWh)
Base Case	2,965	682	501
Main Floor Wall Upgrade	2,563	664	434
Savings	402	19	66
Savings%	**13.5%**	**2.8%**	**13.2%**

- Annual natural gas savings for space heating is 13.5%.
- Energy savings estimated by the three other jurisdictions listed below (Washington State, Iowa and New Hampshire) are between 10 to 15% over their baseline. The variation is due to differing input assumptions for both the base case and the energy efficient scenarios.
- In terms of the baseline consumption, Navigant Consulting estimates that a typical pre-1980's home consumes approximately 25% more natural gas then a typical baseline home used by Enbridge[4] (2,436 m^3), approximately 3,000 m^3.
- Applying the 13.5% percent savings calculated in the table above to the average annual consumption of natural gas cited directly above yields:

$$\text{Natural Gas Savings} = 3{,}000 \text{ m}^3 \times 13.5\ \% = 405 \text{ m}^3$$

Annual Electricity Savings	194 kWh

Annual electricity savings are derived from two sources:

1. Space cooling consumption
2. Furnace fan consumption

[4] Enbridge Gas Customer Profiling Yearly Average End Use, November 23, 2004

Space cooling consumption:

- Assuming that baseline house is equipped with a SEER 10, 2.5 ton[5] A/C unit and is used 500 hours per year[6], this implies that:

  Base A/C electricity use = 500 (cooling hours)*[30,000 (Btu/hr)/(10 (SEER)* 1,000)] = 1,500 kWh
- Applying the 2.8% savings calculated in the table in the previous section to the average annual consumption of electricity cited directly above yields:

  Electricity savings (A/C) = 2.8% x 1,500 kWh/year = 42 kWh.

Furnace fan consumption:

- Annual furnace fan consumption for a typical Toronto home with a non-continuous mid-efficiency furnace = 1,150 kWh[7]
- Applying the 13.2% savings calculated in the table in the previous section to the annual furnace fan electricity consumption cited directly above yields:

  Electricity savings (furnace fan)= 13.2% x 1150 kWh = 151.8 kWh

Total Electricity Savings:

- Total electricity savings are the sum of furnace fan savings and air conditioner savings:

  Total electricity savings = 151.8 kWh + 42 kWh = 193.8 kWh ≈ 194 kWh

Annual Water Savings	**0 L**

N/A

[5] Implying input of 30,000 Btu/hr, Energy Star Savings Calculator, http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_CAC.xls

[6] Number of full-load cooling hours provided by http://energyexperts.org/ac%5Fcalc/ and based on the assumption that Ontario's climate is sufficiently similar to that of the north-eastern U.S.

[7] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

Other Input Assumptions

Effective Useful Life (EUL)	30 Years
The EUL is reported to be 25 years by the Iowa Utilities Board[8] and 30 years by Puget Sound Energy[9]. The OPA reports the EUL to be 30 years, so Navigant Consulting estimates an EUL of 30 years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$2.5 / ft^2**
Based on communication with various local vendors, the incremental cost of wall insulation from R=8 to R=19 is approximately $2.5 per ft^2, which includes only the insulation material and labour but not the costs of wall removal and reconstruction required for installation. For the candidate home, the incremental cost is estimated to be $2,360 ($2.50 x 944 ft^2 / floor = $2,360).	
Customer Payback Period (Natural Gas Only)[10]	**11.2 Years**
Using a 5-year average commodity cost (avoided cost)[11] of $0.38 / m^3 and an average residential distribution cost[12] of $0.14 / m^3, the payback period for natural gas savings is determined to be 11.2 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $2.5/ft^2 x 944 ft^2 / (405 m^3/year * $0.52 / m^3) = 11.2 years	
Market Penetration[13]	**High**
Based on penetration rates of other jurisdictions (63% in Iowa State and 85% in Washington State) and communication with local contractors, Navigant Consulting estimates the penetration in Ontario is high.	

[8] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[9] Quantec, Puget Sound Energy Demand-Side Management Resource Assessment
[10] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[11] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[12] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[13] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[14]	211.7	25	1,933	63%
Comments Assuming baseline R-value of wall insulation is 8 and upgrade R-value of wall insulation is 11. Estimated 11.1% savings are based on 696 therms, which would translate to 77.3 therms (211.7 m^3).				
Source	**Annual Natural Gas Savings (m^3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Puget Sound Energy[15]	618	30	1,064	85%
Comments Assuming baseline R-value of wall insulation is 0 and upgrade R-value of wall insulation is 13. Estimated 10% savings are based on 6,181 m^3, which would translate to 618 m^3.				
Source	**Annual Natural Gas Savings (m^3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
New Hampshire Electric Utilities[16]	625	N/A	N/A	N/A
Comments New Hampshire Electric Utilities Estimates 15% natural gas savings on wall insulation.				

[14] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[15] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
[16] ODC, The New Hampshire Electric Utilities' Low-income Retrofit Program Impact Evaluation, Jan 16, 2006

RESIDENTIAL WATER HEATING

Faucet Aerator (Residential Bathroom)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Faucet Aerator (Bathroom) (1.5 GPM)
Base Equipment and Technologies Description
Average existing stock (2.2 GPM)[1]

Decision Type	Target Market(s)	End Use
Retrofit	Residential (existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires bathroom and kitchen faucets to have a maximum flow of 2.2 GPM (8.35 L/min).

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	10	0	2,004	2	0
2	10	0	2,004	0	0
3	10	0	2,004	0	0
4	10	0	2,004	0	0
5	10	0	2,004	0	0
6	10	0	2,004	0	0
7	10	0	2,004	0	0
8	10	0	2,004	0	0
9	10	0	2,004	0	0
10	10	0	2,004	0	0
TOTALS	**100**	**0**	**20,040**	**2**	**0**

[1] From on-site audit data. Resource Management Strategies, Inc. *Regional Municipality of York Water Efficiency Master Plan Update,* 2007. Cited in: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.
[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	10 m^3

Assumptions and inputs:

- Average faucet water temperature: 32 °C (90 °F)[3]
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W = Water savings (gallons)
8.33 = Energy content of water (Btu/gallon/°F)
T_{out} = Faucet water temperature (°F)
T_{in} = Water inlet temperature (°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 22% over base case:

$$Percent\ Savings = \frac{(G_{base} - G_{new})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 34 m^3
G_{base} = Annual natural gas use with base equipment, 43 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	2,004 L

Assumptions and inputs:

- Average household size: 3.1 persons[6]
- Baseline faucet use (all faucets) per capita per day: 53 litres (14 gallons)[7]
- Bathroom faucet use as a percentage of total faucet use: 15%[8]
- Point estimate of quantity of water that goes straight down the drain: 70%[9]

---

[3] Average of findings in two studies. Mayer, P. W. et al, *Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in East Bay Municipal Utility District Service Area,* 2003 and Skeel, T. and Hill, S. *Evaluation of Savings from Seattle's "Home Water Saver" Apartment/Condominium Program*, 1994. Both cited in: Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] Summit Blue (2008).

[7] Ibid.

[8] DeOreo, W. and P. Mayer, *The End Uses of Hot Water in Snigle Family Homes from Flow Trace Analysis*, 1999 cited in Summit Blue (2008).

[9] Summit Blue (2008).

Annual water savings calculated as follows:

$$Savings = Fu * Ppl * 365 * Ba * \left((1 - Dr) - \left(1 - \frac{Fl_{base} - Fl_{eff}}{Fl_{base}} \right) * Dr \right)$$

Where:

Fu = Faucet use per capita (gallons)
Ppl = Number of people per household
365 = Days per year
Dr = Percentage of water that goes straight down the drain
Ba = Individual bathroom faucet use as a percentage of total faucet use
Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)

Water savings was determined to be 22% over base case:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water use with efficient equipment: 6,993 litres (1,847 gallons)
W_{base}= Annual water use with base equipment: 8,997 litres (2,376 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	**10 Years**
The U.S. DOE assumes a 10 year life for faucet aerators[10].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**2 $**
Average equipment cost based on communication with local hardware stores.	
Customer Payback Period (Natural Gas Only)[11]	**0.4 Years**

Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average residential distribution cost[13] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.4 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= \$2/ (10 m^3/year * \$0.52 / m^3)
= 0.4 years

[10] U.S. Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Lavatory Faucets* http://www1.eere.energy.gov/femp/procurement/eep_faucets.html

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration	90%
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of faucet aerators (bathroom and kitchen) across all sectors to be 90%[14].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[15]	8	5	N/A	45%
Comments For a switch from a 2.5 GPM to a 1.8 GPM aerator. Measure saves 1% of 759 m^3 required for water heating.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[16]	32	9	20 US$	90%
Comments For a switch from a 3.0 GPM to a 1.5 GPM aerator. In neither study is any distinction made between kitchen and bathroom faucet use. Measure saves 6.2% of 514 m^3 required for water heating.				

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Faucet Aerator (Residential Kitchen)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Faucet Aerator (kitchen) (1.5 GPM)

Base Equipment and Technologies Description

Average existing stock (2.5 GPM)[1]

Decision Type	Target Market(s)	End Use
Retrofit	Residential (existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires bathroom and kitchen faucets to have a maximum flow of 2.2 GPM (8.35 L/min).

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	38	0	7,797	2	0
2	38	0	7,797	0	0
3	38	0	7,797	0	0
4	38	0	7,797	0	0
5	38	0	7,797	0	0
6	38	0	7,797	0	0
7	38	0	7,797	0	0
8	38	0	7,797	0	0
9	38	0	7,797	0	0
10	38	0	7,797	0	0
TOTALS	**380**	**0**	**77,970**	**2**	**0**

[1] From on-site audit data. Resource Management Strategies, Inc. *Regional Municipality of York Water Efficiency Master Plan Update,* 2007. Cited in: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.
[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	38 m^3

Assumptions and inputs:

- Average faucet water temperature: 32 °C (90 °F)[3]
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W = Water savings (gallons)
8.33 = Energy content of water (Btu/gallon/°F)
T_{out} = Faucet water temperature (°F)
T_{in} = Water inlet temperature (°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 20% over base case:

$$Percent\ Savings = \frac{(G_{base} - G_{new})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 151 m^3
G_{base} = Annual natural gas use with base equipment, 188 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	7,797 L

Assumptions and inputs:

- Average household size: 3.1 persons[6]
- Baseline faucet use (all faucets) per capita per day: 53 litres (14 gallons)[7]
- Kitchen faucet use as a percentage of total faucet use: 65%[8]
- Point estimate of quantity of water that goes straight down the drain: 50%[9]

---

[3] Average of findings in two studies. Mayer, P. W. et al, *Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in East Bay Municipal Utility District Service Area,* 2003 and Skeel, T. and Hill, S. *Evaluation of Savings from Seattle's "Home Water Saver" Apartment/Condominium Program*, 1994. Both cited in: Summit Blue (2008).
[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf
[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13
[6] Summit Blue (2008).
[7] Ibid.
[8] DeOreo, W. and P. Mayer, *The End Uses of Hot Water in Snigle Family Homes from Flow Trace Analysis*, 1999 cited in Summit Blue (2008).
[9] Summit Blue (2008).

Annual water savings calculated as follows:

$$Savings = Fu * Ppl * 365 * Ki * \left((1 - Dr) - \left(1 - \frac{Fl_{base} - Fl_{eff}}{Fl_{base}} \right) * Dr \right)$$

Where:

Fu = Faucet use per capita (gallons)
Ppl = Number of people per household
365 = Days per year
Dr = Percentage of water that goes straight down the drain
Ki = Kitchen faucet use as a percentage of total faucet use
Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)

Water savings was determined to be 20% over base case:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water use with efficient equipment: 38,986 litres (10,297 gallons)
W_{base}= Annual water use with base equipment: 31,188 litres (8,237 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
The U.S. DOE assumes a 10 year life for faucet aerators[10].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**2 $**
Average equipment cost based on communication with local hardware stores.	
Customer Payback Period (Natural Gas Only)[11]	**0.1 Years**
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average residential distribution cost[13] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.1 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$2/ (38 m^3/year * \$0.52 / m^3) = 0.1 years	

[10] U.S. Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Lavatory Faucets* http://www1.eere.energy.gov/femp/procurement/eep_faucets.html

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration	90%
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of faucet aerators (bathroom and kitchen) across all sectors to be 90%[14].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[15]	8	5	N/A	45%
Comments For a switch from a 2.5 GPM to a 1.8 GPM aerator. Measure saves 1% of 759 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[16]	32	9	20 US$	90%
Comments For a switch from a 3.0 GPM to a 1.5 GPM aerator. In neither study is any distinction made between kitchen and bathroom faucet use. Measure saves 6.2% of 514 m^3 required for water heating.				

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008
[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.5 Gpm, Residential, UG ESK)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow Showerhead (1.5 GPM) – distributed to participants under Union Gas' ESK program.

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1].

Decision Type	Target Market(s)	End Use
Retrofit	Residential (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min).

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	33	0	6,334	6	0
2	33	0	6,334	0	0
3	33	0	6,334	0	0
4	33	0	6,334	0	0
5	33	0	6,334	0	0
6	33	0	6,334	0	0
7	33	0	6,334	0	0
8	33	0	6,334	0	0
9	33	0	6,334	0	0
10	33	0	6,334	0	0
TOTALS	**330**	**0**	**63,340**	**6**	**0**

[1] Shower-heads distributed under Union Gas's ESK program are installed by homeowners rather than Union contractors. No observation is made of the base equipment's GPM. It is therefore assumed to be the full-on flow rate corresponding to the as-used flow from York Region monitoring study calculated using the equation cited below.
Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007. Cited by: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.

[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	33 m^3

Assumptions and inputs:

- Average shower temperature with base equipment: 40 °C (104 °F)
- Average shower temperature with efficient equipment: 41 °C (106 °F) [3]
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (°F)
$T_{out,new}$ = Shower temperature with efficient equipment (°F)
T_{in} = Water inlet temperature (°F)
8.33 = Energy content of water (Btu/gallon/°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 12% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 249 m^3
G_{base} = Annual natural gas use with base equipment, 282 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	6,334 L

Assumptions and inputs:

- As-used flow rate with base equipment: 1.89 GPM[6]
- Average household size: 3.1 persons[7]

---

[3] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).
[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf
[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13
[6] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008). Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.
[7] Summit Blue (2008).

- Showers per capita per day: 0.75[8]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[9]
- Average showering time per capita per day with base equipment: 7.32 minutes
- Average showering time per capita per day with new technology: 7.5 minutes[10]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household
Sh = Showers per capita per day
365 = Days per year
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes)
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used

Water savings were determined to be 14% over base technology:

$$Percent\ Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment, 38,138 litres (10,073 gallons)
W_{base}= Annual water consumed by showers with base equipment: 44,472 litres (11,746 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**6$**
Incremental cost based on a survey of online retailers[11].	
Customer Payback Period (Natural Gas Only)[12]	**0.4 Years**
Using a 5-year average commodity cost (avoided cost)[13] of \$0.38 / m^3 and an average residential distribution cost[14] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.4 years,	

[8] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007
[9] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)
[10] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)
[11] Whedon Products 1.5 GPM Ultra Saver Showerhead. http://www.antonline.com/p_USB3C-GP_398829.htm
[12] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $6/ (33 m^3/year * $0.52 / m^3) = 0.4 years

Market Penetration	65%
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[15].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[16]	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[17]	71	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 13.9% of 514 m^3 required for water heating.				

[13] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[14] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[15] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

[16] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html

[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.25 Gpm, Residential, Enbridge TAPS)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Low-flow Showerhead (1.25 Gpm) – Installed by Enbridge-designated contractors.

Base Equipment and Technologies Description
Average existing stock within one of three ranges. Range mid-points used as point estimates: • Scenario **A** – 2.0 GPM • Scenario **B –** 2.25 GPM • Scenario **C** – 3.0 GPM When new showerheads are installed contractors use a bag-test to determine base equipment flow-rate.

Decision Type	Target Market(s)	End Use
Retrofit	Residential (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[1] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	13	0
2	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
3	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
4	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
5	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
6	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
7	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
8	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
9	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
10	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
TOTALS	**A:** 490 **B:** 620 **C:** 1,020	**0**	**A:** 88,170 **B:** 108,860 **C:** 171,680	**13**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	A: 49 m^3 B: 62 m^3 C: 102 m^3

Assumptions and inputs:

- Average shower temperature with base equipment: 40 °C (104 °F)[2]
- Average shower temperature with efficient equipment: 41 °C (106 °F)
- Average water inlet temperature: 7.22 °C (45 °F)[3]
- Average water heater energy factor: 0.57[4]

---

[1] Ontario Regulations 350/06, 2006 Building Code

[2] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).

[3] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (^{o}F)
$T_{out,new}$ = Shower temperature with efficient equipment (^{o}F)
T_{in} = Water inlet temperature (^{o}F)
8.33 = Energy content of water (Btu/gallon/^{o}F)
EF = Water heater energy factor.
10^{-6} = Factor to convert Btu to MMBtu.
27.8 = Factor to convert MMBtu to m^3.

Scenario **A:** Gas savings were determined to be 18% over base equipment:
Scenario **B:** Gas savings were determined to be 23% over base equipment:
Scenario **C:** Gas savings were determined to be 35% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment,
Scenario **A:** 218 m^3
Scenario **B:** 222 m^3
Scenario **C:** 235 m^3
G_{base} = Annual natural gas use with base equipment,
Scenario **A:** 267 m^3
Scenario **B:** 284 m^3
Scenario **C:** 336 m^3

Annual Electricity Savings	**0 kWh**

N/A

Annual Water Savings	**A: 8,817 L** **B: 10,886 L** **C: 17,168 L**

Assumptions and inputs:

- As-used flow rate with base equipment[5]:
  Scenario **A:** 1.78 GPM
  Scenario **B:** 1.91 GPM
  Scenario **C:** 2.32 GPM

[4] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[5] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008).
Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.

- Average household size: 3.1 persons[6]
- Showers per capita per day: 0.75[7]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[8]
- Average showering time per capita per day with base equipment:
  Scenario **A:** 7.37 minutes
  Scenario **B:** 7.31 minutes
  Scenario **C:** 7.13 minutes
- Average showering time per capita per day with new technology: 7.61 minutes[9]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household.
Sh = Showers per capita per day.
365 = Days per year.
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes).
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used.

Scenario **A:** Water savings were determined to be 21% over base equipment
Scenario **B:** Water savings were determined to be 24% over base equipment
Scenario **C:** Water savings were determined to be 32% over base equipment

$$Percent\,Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment,
Scenario **A:** 33,349 litres (8,808 gallons)
Scneario **B:** 34,002 litres (8,980 gallons)
Scenario **C:** 35,986 litres (9,504 gallons)
W_{base}= Annual water consumed by showers with base equipment:
Scenario **A:** 42,166 litres (11,137 gallons)
Scenario **B:** 44,888 litres (11,856 gallons)
Scenario **C:** 53,154 litres (14,039 gallons)

[6] Summit Blue (2008).
[7] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007
[8] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)
[9] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**13$**
Incremental cost based on a survey of online retailers[10].	
Customer Payback Period (Natural Gas Only)[11]	**A: 0.5 Years** **B: 0.4 Years** **C: 0.3 Years**
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average residential distribution cost[13] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.5 years for Scenario A, 0.4 years for Scenario B and 0.25 years for Scenario C, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) Scenario A = \$13/ (49 m^3/year * \$0.52 / m^3) = 0.5 years Scenario B = \$13/ (62 m^3/year * \$0.52 / m^3) = 0.4 years Scenario C = \$13/ (102 m^3/year * \$0.52 / m^3) = 0.3 years	
Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[14].	

[10] Earth Massage Showerhead 1.25 GPM http://cgi.ebay.com/Earth-Massage-Showerhead-Water-Saver-1-25-gpm-flow_W0QQitemZ130256063752QQihZ003QQcategoryZ71282QQcmdZViewItemQQ_trksidZp1742.m153.l1262

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[15]	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[16]	71	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 13.9% of 514 m^3 required for water heating.				

[15] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html

[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.25 Gpm, Residential, UG ESK)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow Showerhead (1.25 Gpm) – distributed to participants under Union Gas' ESK program.

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1].

Decision Type	Target Market(s)	End Use
Retrofit	Residential (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	60	0	10,570	13	0
2	60	0	10,570	0	0
3	60	0	10,570	0	0
4	60	0	10,570	0	0
5	60	0	10,570	0	0
6	60	0	10,570	0	0
7	60	0	10,570	0	0
8	60	0	10,570	0	0
9	60	0	10,570	0	0
10	60	0	10,570	0	0
TOTALS	**600**	**0**	**105,700**	**13**	**0**

1 Shower-heads distributed under Union Gas's ESK program are installed by homeowners rather than Union contractors. No observation is made of the base equipment's GPM. It is therefore assumed to be the full-on flow rate corresponding to the as-used flow from York Region monitoring study calculated using the equation cited below.
Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007. Cited by: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.

2 Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	60 m^3

Assumptions and inputs:

- Average shower temperature with base equipment: 40 °C (104 °F)
- Average shower temperature with efficient equipment: 41 °C (106 °F) [3]
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (°F)
$T_{out,new}$ = Shower temperature with efficient equipment (°F)
T_{in} = Water inlet temperature (°F)
8.33 = Energy content of water (Btu/gallon/°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 21% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 221 m^3
G_{base} = Annual natural gas use with base equipment, 282 m^3

Annual Electricity Savings	0 kWh
N/A	

Annual Water Savings	10,570 L

Assumptions and inputs:

- As-used flow rate with base equipment: 1.89 GPM[6]
- Average household size: 3.1 persons[7]

---

[3] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008). Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.

[7] Summit Blue (2008).

- Showers per capita per day: 0.75[8]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[9]
- Average showering time per capita per day with base equipment: 7.32 minutes
- Average showering time per capita per day with new technology: 7.61 minutes[10]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household
Sh = Showers per capita per day
365 = Days per year
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes)
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used

Water savings were determined to be 24% over base equipment:

$$Percent\ Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment, 33,902 litres (8,954 gallons)
W_{base}= Annual water consumed by showers with base equipment: 44,472 litres (11,746 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**13$**
Incremental cost based on a survey of online retailers[11].	
Customer Payback Period (Natural Gas Only)[12]	**0.4 Years**
Using a 5-year average commodity cost (avoided cost)[13] of \$0.38 / m³ and an average residential distribution cost[14] of \$0.14 / m³, the payback period for natural gas savings is determined to be 0.4 years,	

[8] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007
[9] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)
[10] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)
[11] Earth Massage Showerhead 1.25 GPM http://cgi.ebay.com/Earth-Massage-Showerhead-Water-Saver-1-25-gpm-flow_W0QQitemZ130256063752QQihZ003QQcategoryZ71282QQcmdZViewItemQQ_trksidZp1742.m153.l1262
[12] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $13/ (60 m^3/year * $0.52 / m^3) = 0.4 years

Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[15].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[16]	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[17]	71	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 13.9% of 514 m^3 required for water heating.				

[13] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[14] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[15] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

[16] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html

[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Pipe Wrap (R-4)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Insulated hot water pipe for conventional gas storage tank-type hot water heater (R-4).

Base Equipment and Technologies Description

Conventional gas storage tank-type hot water heater without pipe wrap (R-1).

Decision Type	Target Market(s)	End Use
Retrofit	Residential (Existing)	Water heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	25	0	0	2	0
2	25	0	0	0	0
3	25	0	0	0	0
4	25	0	0	0	0
5	25	0	0	0	0
6	25	0	0	0	0
7	25	0	0	0	0
8	25	0	0	0	0
9	25	0	0	0	0
10	25	0	0	0	0
TOTALS	**250**	**0**	**0**	**2**	

Resource Savings Assumptions

Annual Natural Gas Savings	25 m^3

Assumptions and inputs:

- Gas savings calculated using method set out in 2006 Massachusetts study[1] except where noted.
- Average water heater energy factor: 0.57[2]
- Average household size: 3.1 persons[3]
- Assumed diameter of pipe to be wrapped: 0.75 inches
- Length of pipe to be wrapped: 6 feet.
- Surface area of pipe to be wrapped: 1.18 square feet.
- Ambient temperature around pipes: 16 ^oC (60 ^oF) [4]
- Average water heater set point temperature: 54 ^oC (130 ^oF)[5]
- Hot water temperature in outlet pipe: 52 ^oC (125 ^oF)[6]

Annual gas savings calculated as follows:

$$Savings = \left(\frac{1}{R_{base}} - \frac{1}{R_{eff}} \right) * Sa * \left(T_{pipe} - T_{amb} \right) * 24 * 365 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

R_{base} = R-value of base equipment
R_{eff} = R-value of efficient equipment
Sa = Surface area of outlet pipe (ft^2)
T_{pipe} = Temperature of water in outlet pipe (^oF)
T_{amb} = Ambient temperature around pipe (^oF)
24 = Hours per day
365 = Days per year
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 75% over base measure

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff} \right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 8 m^3
G_{base} = Annual natural gas use with base equipment, 33 m^3

---

[1] RLW Analytics, *Final Market Potential Report Of Massachusetts Owner Occupied 1-4 Unit Dwellings*, July 2006 http://www.cee1.org/eval/db_pdf/575.pdf
[2] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13
[3] Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.
[4] RLW Analytics (2006). Given geographic proximity, Massachusetts temperatures used unchanged for Ontario.
[5] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4
[6] From source: "It is common to find a 5 - 10 F temperature drop from the water heater to the furthest fixtures in the house." Chinnery, G. *Policy recommendations for the HERS Community to consider regarding HERS scoring credit due to enhanced effective energy factors of water heaters resulting from volumetric hot water savings due to conservation devices/strategies,* EPA Energy Star for Homes, Sept 2006 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Volumetric_Hot_Water_Savings_Guidelines.pdf

Annual Electricity Savings	0 kWh
N/A	
Annual Water Savings	**0 L**
Navigant has assumed that adopting the measure would not affect the quantity of water consumed.	

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Based on the estimated measure lifetimes used in four other jurisdictions (Iowa - 15 years, Puget Sound Energy - 10 years, Efficiency Vermont – 10 years, and NYSERDA[7] – 10 years) Navigant recommends using an EUL of 10 years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**2 $**
Average equipment cost (for six feet of pipe wrap) based on communication with local hardware stores.	
Customer Payback Period (Natural Gas Only)[8]	**0.2 Years**
Using an 5-year average commodity cost (avoided cost)[9] of \$0.38 / m^3 and an average residential distribution cost[10] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.2 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$2/ (25 m^3/year * \$0.52 / m^3) = 0.2 years	
Market Penetration	**47%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of this measure to be 47%[11].	

[7] NYSERDA, New York Energy Smart Programs, *Deemed Savings Database*

[8] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[9] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[10] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[11] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[12]	21	15	113 US$	52%
Comments For addition of R-4 insulation to previously un-insulated pipes. Measure saves 4% of 514 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Puget Sound Energy, 2007[13]	8	10	8 US$	38%
Comments For addition of R-4 insulation to previously un-insulated pipes. Measure saves 1% of 759 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Midwest Energy Efficiency Alliance, 2003[14]	36	N/A	N/A	10.4%
Comments No indication given of percentage savings or base natural gas consumption for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Efficiency Vermont, 2006[15]	N/A	10	15 US$	N/A
Comments Only electricity savings reported (33 kWh) for an electric hot water system. Insulation upgrade not specified. No indication given of percentage savings or base natural gas consumption for water heating.				

[12] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[13] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[14] Midwest Energy Efficiency Alliance, *Illinois Residential Market Analysis, Final Report*, May 12, 2003. http://www.cee1.org/eval/db_pdf/390.pdf
[15] Efficiency Vermont, *Technical Reference User Manual (TRM)*, February 2006

Solar Pool Heaters

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Swimming pools heated by solar heating systems
Base Equipment and Technologies Description
Swimming polls heated by conventional gas-fired heating systems (50% seasonal efficiency)

Decision Type	Target Market(s)	End Use
New/Replacement	Residential (New/Existing)	Water Heating

Codes, Standards, and Regulations

- Although currently there are no codes that define minimum values for the solar collector thermal efficiency, the following two standards define the thermal performance testing procedures applying to a single isolated collector: 1) CAN/CSA-F378-87 (R2004)[1], 2) Florida Solar Energy Centre (FSEC) standard test, FSEC-GP-5-80[2].

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	493	-57	0	3,450	2,000
2	493	-57	0	0	0
3	493	-57	0	0	0
4	493	-57	0	0	0
5	493	-57	0	0	0
6	493	-57	0	0	0
7	493	-57	0	0	0
8	493	-57	0	0	0
9	493	-57	0	0	0
10	493	-57	0	0	0
11	493	-57	0	0	0
12	493	-57	0	0	0
13	493	-57	0	0	0
14	493	-57	0	0	0
15	493	-57	0	0	0
16	493	-57	0	0	0
17	493	-57	0	0	0
18	493	-57	0	0	0
19	493	-57	0	0	0
20	493	-57	0	0	0
TOTALS	**9,860**	**-1,140**	**0**	**3,450**	**2,000**

[1] CAN/CSA Solar Collector Standard, http://www.csa-intl.org/onlinestore/GetCatalogItemDetails.asp?mat=2000426&Parent=173
[2] FSEC Solar Collector Standard, http://www.fsec.ucf.edu/en/industry/testing/STcollectors/standards/FSEC-GP-5-80.html

Resource Savings Assumptions

Annual Natural Gas Savings	493 m^3

- Navigant Consulting used RETScreen® software[3] to model the energy savings resulting from a solar pool heater for a typical residential swimming pool in Ontario. The following system characteristics are assumed for both London and Sudbury, representing typical Southern and Northern Ontario climate zones:

Variable Names	Value	Source
Collector type	Unglazed	NCI
Gross area of one collector	4.37 m^2	NCI
Aperture area of one collector	4.37 m^2	NCI
Fr (tau alpha) coefficient (1)	82%	NCI
Fr UL coefficient (2)	15.76 $(W/m^2)/^oC$	NCI
Number of collectors	5	NCI
Heat exchanger/antifreeze protection	Yes	NCI
Heat exchanger effectiveness	80%	NCI
Pipe diameter	38 mm	NCI
Pumping power per collector area	3 W/m^2	NCI
Piping and solar tank losses	0.01%	NCI
Losses due to snow and/or dirt	0.03%	NCI
Horz. dist. from mech. room to collector	5 m	NCI
# of floors from mech. room to collector	2	NCI

Notes[4]:

(1) Fr (tau alpha) coefficient is a dimensionless parameter used to characterise the collector's optical efficiency.

(2) Fr UL coefficient is a parameter used to characterize the collector's thermal losses [$(W/m^2)/^oC$]

- The RETScreen® software takes into account the local weather data, annual solar radiation, annual average temperature, annual average wind speed, desired load temperature and other system characteristics specific for both the London and Sudbury area.
- The following table summarizes the output of the model and the weighted average natural gas savings is calculated by assigning 70% to London and 30% to Sudbury based on the customer population service territory used by Union Gas:

Annual Natural Gas Savings	Renewable Energy Delivered (GJ)	Natural Gas Displaced (m^3)	Weight	Weighted Average (m^3)
Northern Ontario (Sudbury)	16.4	442	30%	493
Southern Ontario (London)	19.1	515	70%	

- Since the solar power replaces the need for natural gas, it is assumed that the percentage of natural gas savings is 100%.

Annual Electricity Savings	- 57 kWh

- The electricity required for pumping the water through the collector system is calculated to be 0.057 MWh/year (57 kWh) based on the assumptions presented above, i.e., pumping power per collector area of 3 W/m^2 and piping and solar tank losses of 0.01%. This amount of electricity is considered incremental in comparison to a conventional natural gas heater.
- Using the same weighted average for both London and Sudbury, the incremental electricity is summarized below:

[3] NRCan, RETScreen ® http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/eng/software_tools/retscreen.html

[4] NRCan, RETScreen ® Software Online User Manual, 2005

Annual Electricity Consumption	Renewable Energy Delivered (MWh)	Weight	Weighted Average (kWh)
Northern Ontario (Sudbury)	0.05	30%	57
Southern Ontario (London)	0.06	70%	

Annual Water Savings	0 L
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	20 Years

According to NRCan, solar pool heating systems are durable and last approximately 20 years[5]. Florida Solar Energy Centre estimates an effective useful life of 15 years[6] considering the longer swimming heating season in Florida. Therefore, Navigant Consulting estimates an EUL of 20 years for a solar pool heating system in Ontario.

Base & Incremental Conservation Measure Equipment and O&M Costs	$1,450

The cost of a solar pool heater is dependent on the size of the swimming pool. Based on communication with local contractors[7], the average installed cost is $69 per m^2. Given a medium-sized pool of 50 m^2, the installed cost is determined to be $3,450. The average cost for a conventional residential pool gas-fired heating system is $2,000[8]. Therefore, the incremental cost for solar pool heater is determined to be $1,450.

Customer Payback Period (Natural Gas Only)[9]	5.7 Years

Using a 5-year average commodity cost (avoided cost)[10] of $0.38 / m^3 and an average residential distribution cost[11] of $0.14 / m^3, the payback period for natural gas savings is determined to be 5.7 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= $1,450 / (493 m^3/year x $0.52 / m^3)
= 5.7 years

Market Share[12]	Medium

Based on NRCan report[13] and communication with local contractors, approximately 60% of in-ground pools are heated across Canada, most commonly by natural gas heaters or electric air-source heat pumps. Roughly 10% of heated pools currently use solar heaters. Therefore, Navigant Consulting estimates the market share of solar pool heaters in Ontario to be medium.

5 NRCan, An Introduction to Solar Pool Heating Systems, http://www.energyalternatives.ca/PDF/An%20Introduction%20to%20Solar%20Pool%20Heating%20Systems.pdf
6 FESC, Q&A for Solar Pool Heating, http://www.fsec.ucf.edu/en/consumer/solar_hot_water/pools/q_and_a/index.htm#Long
7 For example, Ottawa Solar Power, http://ottawasolarpower.com/osp2008/poolheatingcost.html
8 NRCan, RETScreen ® Software Online User Manual, 2005
9 Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
10 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
11 Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
12 Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,
13 NRCan, Residential Solar Pool Heating Systems: A Buyer's Guide, 2001.

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Florida Solar Energy Centre (FSEC), 2008[14]	2,332	15	3,500	N/A
Comments Assuming a 470 ft^2 collector located in central Florida and 12 months of swimming season (effectively 210 days of heating), the annual solar energy delivered is 87 MMBtu, which is equivalent to 2,332 m^3 natural gas savings. The effective useful life is estimated to be 15 years according to FSEC[15].				

[14] FSEC, Solar Swimming Pool Heating in Florida, http://www.fsec.ucf.edu/en/consumer/solar_hot_water/pools/sizing.htm
[15] FESC, Q&A for Solar Pool Heating, http://www.fsec.ucf.edu/en/consumer/solar_hot_water/pools/q_and_a/index.htm#Long

Tankless Gas Water Heater - Existing Residential

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Tankless Gas Water Heater (EF = 0.82)

Base Equipment and Technologies Description

Conventional gas 50 gallon storage tank water heater (EF = 0.575)

Decision Type	Target Market(s)	End Use
New	Residential (Existing)	Water heating

Codes, Standards, and Regulations

Ontario's Energy Efficiency Act[1] requires that gas-fired water storage heaters with nominal inputs of 75,000 Btu or less capable of storing between 20 and 100 US gallons have a minimum energy factor of 0.67 - (0.0019*X)
Where X is the capacity (in gallons) of the storage tank.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	137	0	0	$1,500	$750
2	137	0	0	0	0
3	137	0	0	0	0
4	137	0	0	0	0
5	137	0	0	0	0
6	137	0	0	0	0
7	137	0	0	0	0
8	137	0	0	0	0
9	137	0	0	0	0
10	137	0	0	0	0
11	137	0	0	0	0
12	137	0	0	0	0
13	137	0	0	0	0
14	137	0	0	0	0
15	137	0	0	0	0
16	137	0	0	0	0
17	137	0	0	0	0
18	137	0	0	0	0
TOTALS	**2 ,412**	**0**	**0**	$1,500	$750

[1] http://www.energy.gov.on.ca/english/pdf/conservation/2006%20-%20EEA%20Guide%20C%20-%20Water%20Heaters.pdf

Resource Savings Assumptions

Annual Natural Gas Savings	137 m^3

Assumptions and inputs:

- Following a 2006 recommendation to the California Energy Commission that the Alternative Calculation Method (ACM) be amended to recognise the disparity between the nominal Energy Factor of tankless water heaters drawing less than 11 gallons and the actual energy efficiency, savings are calculated using an energy factor degraded by 8.8%[2]
- Adjusted energy factor[3]: 0.77
- Daily average household hot water use: 179 litres (47 gallons)[4]
- Average water inlet temperature: 7.22 C (45 F)[5]
- Average water heater set point temperature: 54 C (130 F)[6]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \left(\frac{1}{EF_{base}} - \frac{1}{EF_{eff}} \right) * 10^{-6} * 27.8$$

Where:

W = Annual hot water use (gallons)
8.33 = Energy content of water (Btu/gallon/^{o}F)
T_{out} = Water heater set point temperature (^{o}F)
T_{in} = Water inlet temperature (^{o}F)
EF_{base} = Energy factor of base equipment
EF_{eff} = Adjusted energy factor of efficient equipment
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to metres cubed

Gas savings 23% over base measure:

$$Percent\ Savings = \frac{(G_{base} - G_{eff})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 454 m^3
G_{base} = Annual natural gas use with base equipment, 594 m^3

Annual Electricity Savings	0 kWh
N/A	

Annual Water Savings	0 L

[2] Davis Energy Group, *Measure Information Template: Tankless Gas Water Heaters*, April 2008 http://www.energy.ca.gov/title24/2008standards/prerulemaking/documents/2006-05-18_workshop/2006-05-11_GAS_WATER.PDF

[3] It should be noted that an alternative study, by Exelon Services for Okaloosa Gas, conducted carefully controlled tests to determine the thermal efficiency of a tankless and a storage tank gas water heater. This study found that the listed energy factor *underestimated* the tankless water heater's true thermal efficiency. This result is not reflected in this substantiation sheet due to the more recent findings cited above, based on a larger sample than the Okaloosa study.
Exelon Services and Okaloosa Gas District, Performance Comparison of Residential Water Heating Systems,December 2002

[4] From sample of 150 Enbridge customers whose gas consumption is monitored by Enbridge. Correspondence with Enbridge.

[5] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[6] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4

Navigant has assumed that adopting the measure would not affect the quantity of water consumed.

Other Input Assumptions

Effective Useful Life (EUL)	18 Years
Navigant Consulting recommends using an EUL of 18 years, the mean of estimated measure lifetimes used two other jurisdictions (Iowa[7], 20 years, and Puget Sound Energy[8], 13 years) and that quoted by an academic paper[9] (20 years).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**750 $**
Cost of tankless water heater determined to be $1,500[10]. Average price for a 50 gallon conventional storage tank water heater $750[11].	
Customer Payback Period (Natural Gas Only)[12]	**10.5 Years**
Using a 5-year average commodity cost (avoided cost)[13] of $0.38 / m^3 and an average residential distribution cost[14] of $0.14 / m^3, the payback period for natural gas savings is determined to be 10.5 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $750/ (137 m^3/year * $0.52 / m^3) = 10.5 years	
Market Penetration[15]	**Low**
Based on the observation of low penetration in two other jurisdictions (Washington State[16] – 10%, Iowa[17] – 1%) and communications with local contractors, Navigant Consulting estimates the penetration in Ontario to be low.	

7 Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

8 Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

9 Aguilar, C., White, D.J., and Ryan, David L. *Domestic Water Heating and Water Heater Energy Consumption in Canada*, April 2005

10 Based on online prices from Home Depot for a Paloma Whole Home 7.4 GPM, www.homedepot.ca

11 Based on average prices from Home Depot, www.homedepot.ca

12 Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

13 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

14 Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

15 Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

16 Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

17 Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy, 2007[18]	152	13	350 US$	10%
Comments Assuming base equipment to be a conventional water tank with an EF=0.64. Measure saves 20% of 759 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[19]	207	20	685 US$	1%
Comments Assuming base equipment to be a conventional water tank with an EF = 0.59. Measure saves 40.2% of 514 m^3 required for water heating.				

[18] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[19] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Tankless Gas Water Heater - New Residential

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Tankless Water Heater (EF = 0.82)

Base Equipment and Technologies Description

Conventional gas 50 gallon storage tank water heater (EF = 0.575)

Decision Type	Target Market(s)	End Use
New	Residential (New)	Water heating

Codes, Standards, and Regulations

Ontario's Energy Efficiency Act[1] requires that gas-fired water storage heaters with nominal inputs of 75,000 Btu or less capable of storing between 20 and 100 US gallons have a minimum energy factor of 0.67 - (0.0019*X), where X is the capacity (in gallons) of the storage tank.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	137	0	0	1,500	750
2	137	0	0	0	0
3	137	0	0	0	0
4	137	0	0	0	0
5	137	0	0	0	0
6	137	0	0	0	0
7	137	0	0	0	0
8	137	0	0	0	0
9	137	0	0	0	0
10	137	0	0	0	0
11	137	0	0	0	0
12	137	0	0	0	0
13	137	0	0	0	0
14	137	0	0	0	0
15	137	0	0	0	0
16	137	0	0	0	0
17	137	0	0	0	0
18	137	0	0	0	0
TOTALS	**2,412**	**0**	**0**	1,500	750

[1] http://www.energy.gov.on.ca/english/pdf/conservation/2006%20-%20EEA%20Guide%20C%20-%20Water%20Heaters.pdf

Resource Savings Assumptions

Annual Natural Gas Savings	137 m^3

Assumptions and inputs:

- Following a 2006 recommendation to the California Energy Commission that the Alternative Calculation Method (ACM) be amended to recognise the disparity between the nominal Energy Factor of tankless water heaters drawing less than 11 gallons and the actual energy efficiency, savings are calculated using an energy factor degraded by 8.8%[2]
- Adjusted energy factor[3]: 0.77
- Daily average household hot water use: 179 litres (47 gallons)[4]
- Average water inlet temperature: 7.22 °C (45 °F)[5]
- Average water heater set point temperature: 54 °C (130 °F)[6]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \left(\frac{1}{EF_{base}} - \frac{1}{EF_{eff}} \right) * 10^{-6} * 27.8$$

Where:

W = Annual hot water use (gallons)
8.33 = Energy content of water (Btu/gallon/°F)
T_{out} = Water heater set point temperature (°F)
T_{in} = Water inlet temperature (°F)
EF_{base} = Energy factor of base equipment
EF_{eff} = Adjusted energy factor of efficient equipment
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 23% over base measure:

$$Percent\ Savings = \frac{(G_{base} - G_{eff})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 454 m^3
G_{base} = Annual natural gas use with base equipment, 594 m^3

Annual Electricity Savings	0 kWh
N/A	

[2] Davis Energy Group, *Measure Information Template: Tankless Gas Water Heaters*, April 2008 http://www.energy.ca.gov/title24/2008standards/prerulemaking/documents/2006-05-18_workshop/2006-05-11_GAS_WATER.PDF

[3] It should be noted that an alternative study, by Exelon Services for Okaloosa Gas, conducted carefully controlled tests to determine the thermal efficiency of a tankless and a storage tank gas water heater. This study found that the listed energy factor *underestimated* the tankless water heater's true thermal efficiency. This result is not reflected in this substantiation sheet due to the more recent findings cited above, based on a larger sample than the Okaloosa study. Exelon Services and Okaloosa Gas District, Performance Comparison of Residential Water Heating Systems,December 2002

[4] From sample of 150 Enbridge customers whose gas consumption is monitored by Enbridge. Correspondence with Enbridge.

[5] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[6] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4

Annual Water Savings	0 L
Navigant has assumed that adopting the measure would not affect the quantity of water consumed.	

Other Input Assumptions

Effective Useful Life (EUL)	18 Years
Navigant Consulting recommends using an EUL of 18 years, the mean of estimated measure lifetimes used two other jurisdictions (Iowa[7], 20 years, and Puget Sound Energy[8], 13 years) and that quoted by an academic paper[9] (20 years).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**750 $**
Cost of tankless water heater determined to be $1,500[10]. Average price for a 50 gallon conventional storage tank water heater $750[11].	
Customer Payback Period (Natural Gas Only)[12]	**10.5 Years**
Using a 5-year average commodity cost (avoided cost)[13] of $0.38 / m^3 and an average residential distribution cost[14] of $0.14 / m^3, the payback period for natural gas savings is determined to be 10.5 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $750/ (137 m^3/year * $0.52 / m^3) = 10.5 years	
Market Penetration[15]	**Low**
Based on the observation of low penetration in two other jurisdictions (Washington State[16] – 10%, Iowa[17] – 1%) and communications with local contractors, Navigant Consulting estimates the penetration in Ontario to be low.	

[7] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[8] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[9] Aguilar, C., White, D.J., and Ryan, David L. *Domestic Water Heating and Water Heater Energy Consumption in Canada*, April 2005,
[10] Based on online price from Home Depot for a Paloma Whole Home 7.4 GPM tankless water heater, www.homedepot.ca
[11] Based on average prices from Home Depot, www.homedepot.ca
[12] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[13] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[14] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[15] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[16] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy, 2007[18]	224	13	450 US$	10%
Comments Assuming base equipment to be a conventional water tank with an EF=0.64. Measure saves 25% of 898 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[19]	199	20	685 US$	1%
Comments Assuming base equipment to be a conventional water tank with an EF = 0.59. Measure saves 40.2% of 495 m^3 required for water heating.				

[18] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[19] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

LOW INCOME SPACE HEATING

Programmable Thermostat (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Programmable thermostat.
Base Equipment and Technologies Description
Standard thermostat.

Decision Type	Target Market(s)	End Use
Retrofit	Low income residential homes	Space Heating

Codes, Standards, and Regulations

- For a programmable thermostat to receive Energy Star® qualification, it must meet specific criteria such as having at least two different programming periods (for weekday and weekend programming), at least four possible temperature settings and allow for temporary overriding by the user.
- In Canada, applicable CSA standards can be found in CSA C828-99- CAN/CSA Performance Requirements for Thermostats used with Individual Room Electric Space Heating Devices.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	146	182	0	25	0
2	146	182	0	0	0
3	146	182	0	0	0
4	146	182	0	0	0
5	146	182	0	0	0
6	146	182	0	0	0
7	146	182	0	0	0
8	146	182	0	0	0
9	146	182	0	0	0
10	146	182	0	0	0
11	146	182	0	0	0
12	146	182	0	0	0
13	146	182	0	0	0
14	146	182	0	0	0
15	146	182	0	0	0
TOTALS	**2,190**	**2,730**	**0**	**25**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	146 m^3

- Lacking any conclusive empirical data to suggest otherwise, Navigant Consulting has applied the same behavioural and base/efficient equipment assumptions to the Low-Income sector as to the Residential sector.
- Two utility studies[1] are used to determine savings resulting from residential programmable thermostats on natural gas consumptions.
  - In the ***GasNetworks*** study[2], 4,061 mail-in surveys and bills were analyzed. Results were normalized for temperature and the energy impacts were determined through a multivariate regression analysis. The study found that programmable thermostat saved 6 % of total household annual natural gas use. GasNetworks is proposing 75 ccf (212 m^3) natural gas savings based on a Non-Programmable Thermostat annual consumption of 1,253 ccf (3,548 m^3) natural gas.
  - In the ***Enbridge Billing Analysis***[3], 911 customers' natural gas consumption was analyzed in 2005. Enbridge determined an average saving of 159 m^3 for a house using 2,878 m^3 of natural gas.
- Canadian Centre for Housing Technology (CCHT) also conducted a study in 2005 on programmable thermostat natural gas savings[4]. The study was done in two identical research homes located in Ottawa to allow direct comparison of changes in operating conditions in a home. It reports a 6.5% predicted savings for 18°C night setback.
- Based on these three studies, Navigant Consulting is assuming an average saving at 6% for natural gas consumptions.

Studies	Baseline Gas Consumption (m^3)	Gas Savings (m^3)	Gas Savings%
GasNetworks (2007)	3,548	212	6.0%
Enbridge (2005)	2,878	159	5.5%
CCHT (2005)	-	-	6.5%
NCI Average			6.0%

- The baseline natural gas consumption for Enbridge[5] is 2,436 m^3 for mid-efficiency furnaces,
- Therefore, NCI estimates for natural gas savings = 2,436 m^3 x 6% = 146 m^3

Annual Electricity Savings	182 kWh

- A side-by-side housing study conducted by the Canadian Centre for Housing Technology[6] determined seasonal energy savings for a residential unit from a programmable thermostat as follows:

CAC:**

Temp Set Back	*Total Summer Furnace and CAC Electricity Consumption (kWh)*	*Seasonal Savings (%)*
None (22C)	3,099	0
25 C daytime set back	2,767	11
24 C daytime set back	2,376	23

[1] "Resource Savings Values in Selected Residential DSM Prescriptive Programs", Summit Blue Consulting, June 2008.
[2] RLW Analytics, Validating the impact of programmable thermostats: final report. Prepared for GasNetworks by RLW Analytics. Middletown, CT, January 2007.
[3] "Resource Savings Values in Selected Residential DSM Prescriptive Programs", Summit Blue Consulting, June 2008.
[4] The Effects of Thermostat Setting on Seasonal Energy Consumption at the CCHT Research Facility, Manning, Swinton, Szadkowski, Gusdorf, Ruest, February 14, 2005, http://irc.nrc-cnrc.gc.ca/pubs/rr/rr191/rr191.pdf
[5] Enbridge Gas Customer Profiling Yearly Average End Use, November 23, 2004; based on Summit Blue Report, Navigant Consulting will use baseline consumption data provided by Enbridge for analysis.
[6] Canadian Center for Housing Technologies, The Effects of Thermostat Set-back and Set-up on Seasonal Energy Consumption, Surface Temperatures and Recovery Times at the CCHT Twin House Facility, March 2007
http://irc.nrc-cnrc.gc.ca/pubs/fulltext/nrcc48361/nrcc48361.pdf

** 12 SEER , 2 ton capacity CAC, 362 cooling degree days (18C)

- A BC Hydro study[7] reports savings between 10% and 15% for 4°C set back during night and unoccupied periods, Energy Star Calculator[8] reports 3% saving per degree for heating season (8.25% for full set back). Using the CCHT study results from a full daytime and night-time set back of 4 degrees:
  - Approximate savings is expected for the winter season = 2,314 – 2,270 = 44 kWh/year

- Navigant Consulting is assuming a base CAC usage of 1,257 kWh/year based on the OPA's assumption using CAC rated at 8.7 SEER and 24,000 Btu/hr unit[9]. Using the CCHT study results, setting the thermostat 3 degrees higher would save 11%:
  - Based on CAC usage of 1,257 kWh/year, electricity savings = 1,257 x 11% = 138 kWh/year

- Therefore, assuming an average home has both space cooking using CAC and force air heating, the total electricity savings = 138 kWh/year + 44 kWh/year = 182 kWh/year.

Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	**15 Years**

Navigant Consulting is estimating 15 years as the effective useful life based on the average lifetime of programmable thermostat from Energy Star ® website.

Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 25**

Average incremental cost of programmable thermostats was determined to be $25 based on average cost of non-programmable and programmable thermostats from Home Depot and Canadian Tire website in 2008.

Customer Payback Period (Natural Gas Only)[10]	**0.3 Years**

Using an 5-year average commodity cost (avoided cost)[11] of \$0.38 / m^3 and an average residential distribution cost[12] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.3 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= \$25/ (146 m^3/year * \$0.52 / m^3)
= 0.3 years

[7] Marbek Resource Consultants, The Sheltair Group Inc , BC Hydro BC Hydro Conservation Potential Review 2002, Residential Sector Report (Base Year: Fiscal 2000/01) (Revision 1) Submitted to: BC Hydro, June 2003
[8] US EPA (EPA Energy Star® Simple Savings Calculator – Programmable Thermostat), http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/CalculatorProgrammableThermostat.xls
[9] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, referenced from: Heating, Refrigeration and Air Conditioning Institute of Canada (HRAI), 2006 Cool Savings Rebate Program, Prepared for the Ontario Power Authority, April 2007.
[10] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[11] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[12] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration	65%
Due to the number of conservation programs in Ontario currently offering programmable thermostats and based on previous research conducted for the OPA[13], Navigant Consulting estimates the penetration of programmable thermostats amongst single family residents in Ontario to be 65%.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[14]	166	15	$25	26% (Low income SF)
Comments Measure provides savings of 11.5% over 1,446 m3 required for space heating with base equipment.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Ontario Power Authority[15]	182	15	$140	N/A
Comments Based on gas savings from Canadian Centre for Housing Technology study for an 80% AFUE gas furnace using standard PCS motor and furnace size of 67,500 BTU/hr, using 4761 heating degree hours.				

[13] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

[14] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

[15] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008

Weatherization (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Weatherization includes: draft proofing (caulking and weather stripping) and increased insulation.
Base Equipment and Technologies Description
No weatherization.

Decision Type	Target Market(s)	End Use
Retrofit	Low-income Residential (Existing)	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	1,134	165	0	2,284	0
2	1,134	165	0	0	0
3	1,134	165	0	0	0
4	1,134	165	0	0	0
5	1,134	165	0	0	0
6	1,134	165	0	0	0
7	1,134	165	0	0	0
8	1,134	165	0	0	0
9	1,134	165	0	0	0
10	1,134	165	0	0	0
11	1,134	165	0	0	0
12	1,134	165	0	0	0
13	1,134	165	0	0	0
14	1,134	165	0	0	0
15	1,134	165	0	0	0
16	1,134	165	0	0	0
17	1,134	165	0	0	0
18	1,134	165	0	0	0
19	1,134	165	0	0	0
20	1,134	165	0	0	0
21	1,134	165	0	0	0
22	1,134	165	0	0	0
23	1,134	165	0	0	0
TOTALS	**26.082**	**3,795**	**0**	**2,284**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	**1,134 m^3**

- According to a low income weatherization research report[1] prepared by Green$aver on behalf of Enbridge Gas, a total of 61 homes were retrofitted in the 2007 Enbridge pilot program. Home audits were conducted.
- Audits were completed on selected homes (inspection of the attic, wall and foundation insulation, windows, heating systems, water heaters and ventilation systems). The air tightness of each home was measured using a Blower Door device.
- Potential retrofit upgrades were modeled and if the total feasible improvements were projected at 15% or more of their current energy use, the home was recommended for retrofit work (including draft proofing[2] and attic and/or wall insulation[3]).
- After completion of the energy retrofit work, a second audit was conducted followed by an inspection verifying that the completed work met the specifications provided, and allowing for full assessment of the project results.
- Based on program data supplied by Enbridge and audited by Green$aver, program savings results are summarized below:

	Baseline NG Consumption (m^3)	Retrofit NG Consumption (m^3)	NG Savings (m^3)
Total	310,168	247,804	62,364
Average	5,639	4,506	1,134

- Baseline estimates of natural gas consumption = 5,639 m^3.
- Natural Gas Savings % = 1,134 m^3 / 5,639 m^3 = 20 %

Annual Electricity Savings	**165 kWh**

- Electricity savings are modelled using HOT2000 after retrofit.
- Assumptions and Inputs:
  - Four occupants per house (2 adults, 2 children), occupied 50% of the time
  - Temperature set-point of 21 °C for the main floor walls and 19 °C for the basement
  - Consumption of 225 litres of DWH per day
  - Electrical consumption (lights and appliances) of 24 kWh per day
  - Weather data file is based on the analysis of periods from 1971 - 2000
  - A/C is not factored into electrical savings
- Based on program data supplied by Enbridge and audited by Green$aver, program savings results are summarized below:

	Baseline Electricity Consumption (kWh)	Retrofit Electricity Consumption (kWh)	Electricity Savings (kWh)
Total	512,822	502,773	10,050
Average	8,407	8,242	165

- Baseline estimates of electricity consumption = 8,407kWh.
- Electricity Savings % = 165 kWh / 8407 kWh = 2 %

Annual Water Savings	**0 L**

N/A

[1] Green$ave, Low Income Weatherization Research Summary, prepared for Enbridge Gas, December 2007.
[2] Draft proofing included: caulking and weather stripping around doors and door frames, around window casing, around headers and baseboards and attic hatches
[3] Insulation included blowing cellulose insulation into wood framed wall cavities and crawlspaces, adding or blowing insulation into attics and crawlspaces and adding insulation to the whole length of basement walls

Other Input Assumptions

Effective Useful Life (EUL)	23 Years
Based on average measure life of installed measures for 61 participant homes in Green$aver study[4]. Measures included attic insulation, wall insulation, door and weather stripping and caulking.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 2,284**
Based on average actual cost (2007) for the 61 program participants in the pilot study[5].	
Customer Payback Period (Natural Gas Only)[6]	**3.9 Years**
Using a 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average residential distribution cost[8] of $0.14 / m^3, the payback period for natural gas savings is determined to be 3.9 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $2,284 / (1,134 m^3/year * $0.52 / m^3) = 3.9 years	
Market Penetration[9]	**Medium**
Based on communication with local contractors, the increased promotions and retrofit programs available to homeowners, Navigant Consulting is estimating the market penetration of weatherization to be medium.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Iowa Sate Low-income Weatherization Program (2003)[10]	767.3	1,031	5,064	N/A
Comments On average, the 1,813 participants in this program saved 1031 kWh of electricity and 276 therms (767.3 m^3) of natural gas.				

[4] Green$aver, Low Income Weatherization Research Summary, prepared for Enbridge Gas, December 2007.
[5] Ibid.
[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] http://www.dcaa.iowa.gov/bureau_weath/pdfs/CY03ExecSummary.pdf

LOW INCOME WATER HEATING

Faucet Aerator (Bathroom) (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Faucet Aerator (Bathroom) (1.5 GPM)

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1]

Decision Type	Target Market(s)	End Use
Retrofit	Low-Income Residential (existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires bathroom and kitchen faucets to have a maximum flow of 2.2 GPM (8.35 L/min).

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	10	0	**2,004**	2	0
2	10	0	**2,004**	0	0
3	10	0	**2,004**	0	0
4	10	0	**2,004**	0	0
5	10	0	**2,004**	0	0
6	10	0	**2,004**	0	0
7	10	0	**2,004**	0	0
8	10	0	**2,004**	0	0
9	10	0	**2,004**	0	0
10	10	0	**2,004**	0	0
TOTALS	**100**	**0**	**20,040**	**2**	**0**

[1] From on-site audit data. Resource Management Strategies, Inc. *Regional Municipality of York Water Efficiency Master Plan Update*, 2007. Cited in: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.

[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	10 m^3

Assumptions and inputs:

- Lacking any conclusive empirical data to suggest otherwise, Navigant Consulting has applied the same behavioural and base/efficient equipment assumptions to the Low-Income sector as to the Residential sector.
- Average faucet water temperature: 32 °C (90 °F)[3]
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W = Water savings (gallons)
8.33 = Energy content of water (Btu/gallon/°F)
T_{out} = Faucet water temperature (°F)
T_{in} = Water inlet temperature (°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 22% over base case:

$$Percent\ Savings = \frac{(G_{base} - G_{new})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 34 m^3
G_{base} = Annual natural gas use with base equipment, 43 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	2,004 L

Assumptions and inputs:

- Average household size: 3.1 persons[6]
- Baseline faucet use (all faucets) per capita per day: 53 litres (14 gallons)[7]
- Bathroom faucet use as a percentage of total faucet use: 15%[8]

---

[3] Average of findings in two studies. Mayer, P. W. et al, *Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in East Bay Municipal Utility District Service Area,* 2003 and Skeel, T. and Hill, S. *Evaluation of Savings from Seattle's "Home Water Saver" Apartment/Condominium Program*, 1994. Both cited in: Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] Summit Blue (2008).

[7] Ibid.

[8] DeOreo, W. and P. Mayer, *The End Uses of Hot Water in Snigle Family Homes from Flow Trace Analysis*, 1999 cited in Summit Blue (2008).

- Point estimate of quantity of water that goes straight down the drain: 70%[9]

Annual water savings calculated as follows:

$$Savings = Fu * Ppl * 365 * Ba * \left((1 - Dr) - \left(1 - \frac{Fl_{base} - Fl_{eff}}{Fl_{base}} \right) * Dr \right)$$

Where:

Fu = Faucet use per capita (gallons)
Ppl = Number of people per household
365 = Days per year
Dr = Percentage of water that goes straight down the drain
Ba = Individual bathroom faucet use as a percentage of total faucet use
Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)

Water savings was determined to be 22% over base case:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water use with efficient equipment: 6,993 litres (1,847 gallons)
W_{base}= Annual water use with base equipment: 8,997 litres (2,376 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
The U.S. DOE assumes a 10 year life for faucet aerators[10].	

Base & Incremental Conservation Measure Equipment and O&M Costs	2 $
Average equipment cost based on communication with local hardware stores.	

Customer Payback Period (Natural Gas Only)[11]	0.4 Years
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m³ and an average residential distribution cost[13] of \$0.14 / m³, the payback period for natural gas savings is determined to be 0.4 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$2/ (10 m³/year * \$0.52 / m³)	

[9] Summit Blue (2008).
[10] U.S. Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Lavatory Faucets* http://www1.eere.energy.gov/femp/procurement/eep_faucets.html
[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

= 0.4 years	
Market Penetration[14]	**90%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of faucet aerators (bathroom and kitchen) across all sectors to be 90%[15].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[16]	8	5	N/A	45%
Comments For a switch from a 2.5 GPM to a 1.8 GPM aerator. Measure saves 1% of 759 m^3 required for water heating.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[17]	36	9	20 US$	90%
Comments For a switch from a 3.0 GPM to a 1.5 GPM aerator for the Low-Income sector. In neither study is any distinction made between kitchen and bathroom faucet use. Measure saves 6.2% of 584 m^3 required for water heating.				

[14] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[15] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008
[16] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Faucet Aerator (Kitchen) (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Faucet Aerator (kitchen) (1.5 GPM)

Base Equipment and Technologies Description

Average existing stock (2.5 GPM)[1]

Decision Type	Target Market(s)	End Use
Retrofit	Low-Income Residential (existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires bathroom and kitchen faucets to have a maximum flow of 2.2 GPM (8.35 L/min).

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	38	0	**7,797**	2	0
2	38	0	**7,797**	0	0
3	38	0	**7,797**	0	0
4	38	0	**7,797**	0	0
5	38	0	**7,797**	0	0
6	38	0	**7,797**	0	0
7	38	0	**7,797**	0	0
8	38	0	**7,797**	0	0
9	38	0	**7,797**	0	0
10	38	0	**7,797**	0	0
TOTALS	**380**	**0**	**77,970**	**2**	**0**

[1] From on-site audit data. Resource Management Strategies, Inc. *Regional Municipality of York Water Efficiency Master Plan Update,* 2007. Cited in: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.
[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	38 m^3

Assumptions and inputs:

- Lacking any conclusive empirical data to suggest otherwise, Navigant Consulting has applied the same behavioural and base/efficient equipment assumptions to the Low-Income sector as to the Residential sector.
- Average faucet water temperature: 32 °C (90 F)[3]
- Average water inlet temperature: 7.22 °C (45 F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W = Water savings (gallons)
8.33 = Energy content of water (Btu/gallon/°F)
T_{out} = Faucet water temperature (°F)
T_{in} = Water inlet temperature (°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 20% over base case:

$$Percent\ Savings = \frac{(G_{base} - G_{new})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 151 m^3
G_{base} = Annual natural gas use with base equipment, 188 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	7,797 L

Assumptions and inputs:

- Average household size: 3.1 persons[6]
- Baseline faucet use (all faucets) per capita per day: 53 litres (14 gallons)[7]
- Kitchen faucet use as a percentage of total faucet use: 65%[8]

---

[3] Average of findings in two studies. Mayer, P. W. et al, *Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in East Bay Municipal Utility District Service Area,* 2003 and Skeel, T. and Hill, S. *Evaluation of Savings from Seattle's "Home Water Saver" Apartment/Condominium Program*, 1994. Both cited in: Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] Summit Blue (2008).

[7] Ibid.

[8] DeOreo, W. and P. Mayer, *The End Uses of Hot Water in Snigle Family Homes from Flow Trace Analysis*, 1999 cited in Summit Blue (2008).

- Point estimate of quantity of water that goes straight down the drain: 50%[9]

Annual water savings calculated as follows:

$$Savings = Fu * Ppl * 365 * Ki * \left((1 - Dr) - \left(1 - \frac{Fl_{base} - Fl_{eff}}{Fl_{base}} \right) * Dr \right)$$

Where:

Fu = Faucet use per capita (gallons)
Ppl = Number of people per household
365 = Days per year
Dr = Percentage of water that goes straight down the drain
Ki = Kitchen faucet use as a percentage of total faucet use
Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)

Water savings was determined to be 20% over base case:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water use with efficient equipment: 38,986 litres (10,297 gallons)
W_{base}= Annual water use with base equipment: 31,188 litres (8,237 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
The U.S. DOE assumes a 10 year life for faucet aerators[10].	

Base & Incremental Conservation Measure Equipment and O&M Costs	2 $
Average equipment cost based on communication with local hardware stores.	

Customer Payback Period (Natural Gas Only)[11]	0.1 Years

Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average residential distribution cost[13] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.1 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)

[9] Summit Blue (2008).
[10] U.S. Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Lavatory Faucets* http://www1.eere.energy.gov/femp/procurement/eep_faucets.html
[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

= $2/ (38 m^3/year * $0.52 / m^3) = 0.1 years

Market Penetration	90%
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of faucet aerators (bathroom and kitchen) across all sectors to be 90%[14].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[15]	8	5	N/A	45%
Comments For a switch from a 2.5 GPM to a 1.8 GPM aerator. Measure saves 1% of 759 m^3 required for water heating.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[16]	36	9	20 US$	90%
Comments For a switch from a 3.0 GPM to a 1.5 GPM aerator for the Low-Income sector. In neither study is any distinction made between kitchen and bathroom faucet use. Measure saves 6.2% of 584 m^3 required for water heating.				

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008
[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.5 Gpm, UG ESK) (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow Showerhead (1.5 Gpm) – distributed to participants under Union Gas' ESK program.

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1].

Decision Type	Target Market(s)	End Use
Retrofit	Low-Income Residential (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	33	0	6,334	6	0
2	33	0	6,334	0	0
3	33	0	6,334	0	0
4	33	0	6,334	0	0
5	33	0	6,334	0	0
6	33	0	6,334	0	0
7	33	0	6,334	0	0
8	33	0	6,334	0	0
9	33	0	6,334	0	0
10	33	0	6,334	0	0
TOTALS	**330**	**0**	**63,340**	**6**	

[1] Shower-heads distributed under Union Gas's ESK program are installed by homeowners rather than Union contractors. No observation is made of the base equipment's GPM. It is therefore assumed to be the full-on flow rate corresponding to the as-used flow from York Region monitoring study calculated using the equation cited below.
Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007. Cited by: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.

[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	33 m^3

Assumptions and inputs:

- Lacking any conclusive empirical data to suggest otherwise, Navigant Consulting has applied the same behavioural and base/efficient equipment assumptions to the Low-Income sector as to the Residential sector.
- Average shower temperature with base equipment: 40 °C (104 °F)[3]
- Average shower temperature with efficient equipment: 41 °C (106 °F)
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (°F)
$T_{out,new}$ = Shower temperature with efficient equipment (°F)
T_{in} = Water inlet temperature (°F)
8.33 = Energy content of water (Btu/gallon/°F)
EF = Water heater energy factor.
10^{-6} = Factor to convert Btu to MMBtu.
27.8 = Factor to convert MMBtu to metres cubed

Gas savings were determined to be 12% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 249 m^3.
G_{base} = Annual natural gas use with base equipment, 282 m^3.

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	6,334 L

Assumptions and inputs:

- As-used flow rate with base equipment: 1.89 GPM[6]

---

[3] Although evidence for this change in behaviour remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008). Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that

- Average household size: 3.1 persons[7]
- Showers per capita per day: 0.75[8]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[9]
- Average showering time per capita per day with base equipment: 7.32 minutes
- Average showering time per capita per day with new technology: 7.5 minutes[10]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household
Sh = Showers per capita per day
365 = Days per year
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes)
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used

Water savings were determined to be 14% over base technology:

$$Percent\ Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment, 38,138 litres (10,073 gallons)
W_{base}= Annual water consumed by showers with base equipment: 44,472 litres (11,746 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	**10 Years**
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**6$**
Incremental cost based on a survey of online retailers[11].	
Customer Payback Period (Natural Gas Only)[12]	**0.4 Years**

participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.

7 Summit Blue (2008).

8 Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007

9 Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)

10 Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)

Using a 5-year average commodity cost (avoided cost)[13] of $0.38 / m^3 and an average residential distribution cost[14] of $0.14 / m^3, the payback period for natural gas savings is determined to be 0.4 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $6/ (33 m^3/year * $0.52 / m^3) = 0.4 years

Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[15].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[16].	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[17]	81	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 13.9% of 584 m^3 required for water heating.				

[11] Whedon Products 1.5 GPM Ultra Saver Showerhead.http://www.antonline.com/p_USB3C-GP_398829.htm
[12] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[13] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[14] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[15] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008
[16] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html
[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.25 Gpm, Enbridge TAPS) (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Low-flow Showerhead (1.25 Gpm) – Installed by Enbridge-designated contractors.
Base Equipment and Technologies Description
Average existing stock within one of three ranges. Range mid-points used as point estimates: • Scenario **A** – 2.0 GPM • Scenario **B –** 2.25 GPM • Scenario **C** – 3.0 GPM When new showerheads are installed contractors use a bag-test to determine base equipment flow-rate.

Decision Type	Target Market(s)	End Use
Retrofit	Low-Income Residential (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[1] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	13	0
2	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
3	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
4	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
5	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
6	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
7	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
8	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
9	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
10	**A:** 49 **B:** 62 **C:** 102	0	**A:** 8,817 **B:** 10,886 **C:** 17,168	0	0
TOTALS	**A:** 490 **B:** 620 **C:** 1,020	0	**A:** 88,170 **B:** 108,860 **C:** 171,680	**13**	**0**

[1] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	A: 49 m^3 B: 62 m^3 C: 102 m^3

Assumptions and inputs:

- Lacking any conclusive empirical data to suggest otherwise, Navigant Consulting has applied the same behavioural and base/efficient equipment assumptions to the Low-Income sector as to the Residential sector.
- Average shower temperature with base equipment: 40 °C (104 °F)[2]
- Average shower temperature with efficient equipment: 41 °C (106 °F)
- Average water inlet temperature: 7.22 °C (45 °F)[3]
- Average water heater energy factor: 0.57[4]

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (°F)
$T_{out,new}$ = Shower temperature with efficient equipment (°F)
T_{in} = Water inlet temperature (°F)
8.33 = Energy content of water (Btu/gallon/°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Scenario **A:** Gas savings were determined to be 18% over base equipment:
Scenario **B:** Gas savings were determined to be 23% over base equipment:
Scenario **C:** Gas savings were determined to be 35% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment,
Scenario **A:** 218 m^3
Scenario **B:** 222 m^3
Scenario **C:** 235 m^3
G_{base} = Annual natural gas use with base equipment,
Scenario **A:** 267 m^3
Scenario **B:** 284 m^3
Scenario **C:** 336 m^3

[2] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).

[3] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

Annual Electricity Savings	0 kWh
N/A	
Annual Water Savings	**A: 8,817 L** **B: 10,886 L** **C: 17,168 L**

Assumptions and inputs:

- As-used flow rate with base equipment[5]:
  - Scenario **A:** 1.78 GPM
  - Scenario **B:** 1.91 GPM
  - Scenario **C:** 2.32 GPM
- Average household size: 3.1 persons[6]
- Showers per capita per day: 0.75[7]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[8]
- Average showering time per capita per day with base equipment:
  - Scenario **A:** 7.37 minutes
  - Scenario **B:** 7.31 minutes
  - Scenario **C:** 7.13 minutes
- Average showering time per capita per day with new technology: 7.61 minutes[9]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household
Sh = Showers per capita per day
365 = Days per year
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes)
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used

Scenario **A:** Water savings were determined to be 21% over base equipment
Scenario **B:** Water savings were determined to be 24% over base equipment
Scenario **C:** Water savings were determined to be 32% over base equipment

---

[4] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[5] As-used flow is calculated as a function of “full-on” or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008). Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.

[6] Summit Blue (2008).

[7] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007

[8] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)

[9] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment,
Scenario **A:** 33,349 litres (8,808 gallons)
Scneario **B:** 34,002 litres (8,980 gallons)
Scenario **C:** 35,986 litres (9,504 gallons)

W_{base}= Annual water consumed by showers with base equipment:
Scenario **A:** 42,166 litres (11,137 gallons)
Scenario **B:** 44,888 litres (11,856 gallons)
Scenario **C:** 53,154 litres (14,039 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	**10 Years**
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**13$**
Incremental cost based on a survey of online retailers[10].	
Customer Payback Period (Natural Gas Only)[11]	**A: 0.5 Years** **B: 0.4 Years** **C: 0.3 Years**
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m³ and an average residential distribution cost[13] of \$0.14 / m³, the payback period for natural gas savings is determined to be 0.51 years for Scenario A, 0.4 years for Scenario B and 0.25 years for Scenario C, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) Scenario A = \$13/ (49 m³/year * \$0.52 / m³) = 0.5 years Scenario B = \$13/ (62 m³/year * \$0.52 / m³) = 0.4 years Scenario C = \$13/ (102 m³/year * \$0.52 / m³) = 0.3 years	
Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[14].	

[10] Earth Massage Showerhead 1.25 GPM http://cgi.ebay.com/Earth-Massage-Showerhead-Water-Saver-1-25-gpm-flow_W0QQitemZ130256063752QQihZ003QQcategoryZ71282QQcmdZViewItemQQ_trksidZp1742.m153.l1262

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[15]	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[16]	81	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 13.9% of 584 m^3 required for water heating.				

[15] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html

[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.25 Gpm, UG ESK) (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow Showerhead (1.25 Gpm) – distributed to participants under Union Gas' ESK program.

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1].

Decision Type	Target Market(s)	End Use
Retrofit	Low-Income Residential (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	60	0	10,570	13	0
2	60	0	10,570	0	0
3	60	0	10,570	0	0
4	60	0	10,570	0	0
5	60	0	10,570	0	0
6	60	0	10,570	0	0
7	60	0	10,570	0	0
8	60	0	10,570	0	0
9	60	0	10,570	0	0
10	60	0	10,570	0	0
TOTALS	**600**	**0**	**105,700**	**13**	

[1] Shower-heads distributed under Union Gas's ESK program are installed by homeowners rather than Union contractors. No observation is made of the base equipment's GPM. It is therefore assumed to be the full-on flow rate corresponding to the as-used flow from York Region monitoring study calculated using the equation cited below.
Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007. Cited by: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.

[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	60 m^3

Assumptions and inputs:

- Lacking any conclusive empirical data to suggest otherwise, Navigant Consulting has applied the same behavioural and base/efficient equipment assumptions to the Low-Income sector as to the Residential sector.
- Average shower temperature with base equipment: 40 °C (104 °F)[3]
- Average shower temperature with efficient equipment: 41 °C (106 °F)
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (°F)
$T_{out,new}$ = Shower temperature with efficient equipment (°F)
T_{in} = Water inlet temperature (°F)
8.33 = Energy content of water (Btu/gallon/°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 21% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 221 m^3
G_{base} = Annual natural gas use with base equipment, 282 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	10,570 L

Assumptions and inputs:

- As-used flow rate with base equipment: 1.89 GPM[6]

[3] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).
[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf
[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13
[6] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008). Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that

- Average household size: 3.1 persons[7]
- Showers per capita per day: 0.75[8]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[9]
- Average showering time per capita per day with base equipment: 7.32 minutes
- Average showering time per capita per day with new technology: 7.61 minutes[10]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household
Sh = Showers per capita per day
365 = Days per year
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes)
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used

Water savings were determined to be 24% over base equipment:

$$Percent\ Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment, 33,902 litres (8,954 gallons)
W_{base}= Annual water consumed by showers with base equipment: 44,472 litres (11,746 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	**10 Years**
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**13$**
Incremental cost based on a survey of online retailers[11].	
Customer Payback Period (Natural Gas Only)[12]	**0.4 Years**

participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.

[7] Summit Blue (2008).

[8] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007

[9] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)

[10] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)

[11] Earth Massage Showerhead 1.25 GPM
http://cgi.ebay.com/Earth-Massage-Showerhead-Water-Saver-1-25-gpm-flow_W0QQitemZ130256063752QQihZ003QQcategoryZ71282QQcmdZViewItemQQ_trksidZp1742.m153.l1262

Using a 5-year average commodity cost (avoided cost)[13] of $0.38 / m^3 and an average residential distribution cost[14] of $0.14 / m^3, the payback period for natural gas savings is determined to be 0.42 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $13/ (60 m^3/year * $0.52 / m^3) = 0.42 years

Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[15].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[16].	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[17]	81	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead for the Low-Income sector. Measure saves 13.9% of 584 m^3 required for water heating.				

[12] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[13] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[14] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[15] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008
[16] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html
[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Pipe Wrap – R4 (LIA)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Insulated hot water pipe for conventional gas storage tank-type hot water heater (R-4).

Base Equipment and Technologies Description

Conventional gas storage tank-type hot water heater without pipe wrap (R-1).

Decision Type	Target Market(s)	End Use
Retrofit	Low-Income Residential (Existing)	Water heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	25	0	0	2	0
2	25	0	0	0	0
3	25	0	0	0	0
4	25	0	0	0	0
5	25	0	0	0	0
6	25	0	0	0	0
7	25	0	0	0	0
8	25	0	0	0	0
9	25	0	0	0	0
10	25	0	0	0	0
TOTALS	**250**	**0**	**0**	**2**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	25 m^3

Assumptions and inputs:

- Lacking any conclusive empirical data to suggest otherwise, Navigant Consulting has applied the same behavioural and base/efficient equipment assumptions to the Low-Income sector as to the Residential sector.
- Gas savings calculated using method set out in 2006 Massachusetts study[1] except where noted.
- Average water heater energy factor: 0.57[2]
- Average household size: 3.1 persons[3]
- Assumed diameter of pipe to be wrapped: 0.75 inches
- Length of pipe to be wrapped: 6 feet.
- Surface area of pipe to be wrapped: 1.18 square feet.
- Ambient temperature around pipes: 16 °C (60 °F)[4]
- Average water heater set point temperature: 54 °C (130 °F)[5]
- Hot water temperature in outlet pipe: 52 °C (125 °F)[6]

Annual gas savings calculated as follows:

$$Savings = \left(\frac{1}{R_{base}} - \frac{1}{R_{eff}}\right) * Sa * \left(T_{pipe} - T_{amb}\right) * 24 * 365 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

R_{base} = R-value of base equipment
R_{eff} = R-value of efficient equipment
Sa = Surface area of outlet pipe (ft^2)
T_{pipe} = Temperature of water in outlet pipe (°F)
T_{amb} = Ambient temperature around pipe (°F)
24 = Hours per day
365 = Days per year
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 75% over base measure

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 8 m^3
G_{base} = Annual natural gas use with base equipment, 33 m^3

---

[1] RLW Analytics, *Final Market Potential Report Of Massachusetts Owner Occupied 1-4 Unit Dwellings*, July 2006 http://www.cee1.org/eval/db_pdf/575.pdf
[2] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13
[3] Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.
[4] RLW Analytics (2006). Given geographic proximity, Massachusetts temperatures used unchanged for Ontario.
[5] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4

Annual Electricity Savings	0 kWh
N/A	
Annual Water Savings	**0 L**
Navigant has assumed that adopting the measure would not affect the quantity of water consumed.	

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Based on the estimated measure lifetimes used in four other jurisdictions (Iowa - 15 years, Puget Sound Energy - 10 years, Efficiency Vermont – 10 years, and NYSERDA[7] – 10 years) Navigant recommends using an EUL of 10 years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**2 $**
Average equipment cost (for six feet of pipe wrap) based on communication with local hardware stores.	
Customer Payback Period (Natural Gas Only)[8]	**0.2 Years**
Using an 5-year average commodity cost (avoided cost)[9] of \$0.38 / m^3 and an average residential distribution cost[10] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.2 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$2/ (25 m^3/year * \$0.52 / m^3) = 0.2 years	
Market Penetration	**47%**
Based on previous research conducted for the OPA, Navigant Consulting estimates the market penetration of this measure to be 47%[11].	

[6] From source: "It is common to find a 5 - 10 F temperature drop from the water heater to the furthest fixtures in the house." Chinnery, G. *Policy recommendations for the HERS Community to consider regarding HERS scoring credit due to enhanced effective energy factors of water heaters resulting from volumetric hot water savings due to conservation devices/strategies,* EPA Energy Star for Homes, Sept 2006 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Volumetric_Hot_Water_Savings_Guidelines.pdf

[7] NYSERDA, New York Energy Smart Programs, *Deemed Savings Database*

[8] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[9] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[10] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[11] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[12]	23	15	115 US$	41%
Comments For addition of R-4 insulation to previously un-insulated pipes in the Low-Income sector. Measure saves 4% of 584 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Puget Sound Energy, 2007[13]	8	10	8 US$	38%
Comments For addition of R-4 insulation to previously un-insulated pipes. Measure saves 1% of 759 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Midwest Energy Efficiency Alliance, 2003[14]	36	N/A	N/A	10.4%
Comments No indication given of percentage savings or base natural gas consumption for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Efficiency Vermont, 2006[15]	N/A	10	15 US$	N/A
Comments Only electricity savings reported (33 kWh) for an electric hot water system. Insulation upgrade not specified. No indication given of percentage savings or base natural gas consumption for water heating.				

[12] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[13] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[14] Midwest Energy Efficiency Alliance, *Illinois Residential Market Analysis, Final Report*, May 12, 2003. http://www.cee1.org/eval/db_pdf/390.pdf
[15] Efficiency Vermont, *Technical Reference User Manual (TRM)*, February 2006

COMMERCIAL COOKING

Energy Star Commercial Fryer

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Energy Star commercial fryer (50% cooking efficiency[1])
Base Equipment and Technologies Description
Standard commercial fryer (35% cooking efficiency)

Decision Type	Target Market(s)	End Use
New/Replacement	New/Existing Commercial buildings (Restaurant)	Cooking

Codes, Standards, and Regulations

In order to be a certified Energy Star deep fryer, the fryer must have a minimum cooking efficiency of 50%, and a maximum idle energy rate of 9,000 Btu/hr[2].
NRCan's Office of Energy Efficiency does not regulate commercial fryers.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/Btu/hour)	Electricity (kWh)	Water (L)	($/kBtu/hour)	($)
1	1,099	0	0	$5,750	$2,500
2	1,099	0	0	0	0
3	1,099	0	0	0	0
4	1,099	0	0	0	0
5	1,099	0	0	0	0
6	1,099	0	0	0	0
7	1,099	0	0	0	0
8	1,099	0	0	0	0
9	1,099	0	0	0	0
10	1,099	0	0	0	0
11	1,099	0	0	0	0
12	1,099	0	0	0	0
TOTALS	**13,188**	**0**	**0**	**$5,750**	**$2,500**

[1] Cooking energy efficiency is defined as the quantity of energy input to the food products expressed as a percentage of the quantity of energy input to the appliance.
[2] Energy Star, *Commercial Fryers*, http://www.energystar.gov/index.cfm?c=fryers.pr_fryers

Resource Savings Assumptions

Annual Natural Gas Savings	1,099 m^3

Assumptions and inputs used by Energy Star to calculate savings[3]:

- The Energy Star savings calculator for this measure assumes the fryer is used for 16 hours a day. The Flex Your Power (FYP) website states that commercial fryers are typically used for 8 to 12 hours a day[4]. In calculating gas savings, Navigant Consulting has used the mid-point of the range given by FYP, 10 hours.
- The fryer is used 365 days per year to cook 150 pounds of food per day and is pre-heated once per day.
- Both efficient and base equipment must be pre-heated for 15 minutes before daily use.
- Base equipment has an idle energy rate of 14,000 Btu/hr and is on average idle for 7.25 hours per day.
- Efficient equipment has an idle energy rate of 9,000 Btu/hr and is on average idle for 7.4 hours per day.
- Natural gas use is calculated as the total gas required for cooking energy, idle energy and pre-heat energy. Based on the assumptions above the Energy Star savings calculator provides the following values for base and efficient equipment.

Gas use (base) = Cooking energy (2,479 m^3/year) + Idle energy (1,030 m^3/year) + Pre-heat energy (162 m^3/year)
= 3,671 m^3/year

Gas use (efficient) = Cooking energy (1,735 m^3/year) + Idle energy (680 m^3/year) + Pre-heat energy (157 m^3/year)
= 2,572 m^3/year

Gas savings were determined to be 1,099 m^3 or 30% over the base equipment.

Annual Electricity Savings	0 kWh
N/A	

Annual Water Savings	0 L
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	12 Years

The Minnesota Department of Commerce[5] and Puget Sound Energy[6] both estimate the EUL of this measure to be 15 years. The Consortium for Energy Efficiency[7] and the State of Iowa Utilities Board[8] both estimate the EUL of this measure to be 8 years. Given the range of estimates, and given Energy Star's estimate of an EUL of 12 years for this measure, Navigant Consulting also estimates the EUL of this measure to be 12 years.

Base & Incremental Conservation Measure Equipment and O&M Costs	$3,250

[3] Energy Star Savings Calculator for commercial gas fryers. Unless otherwise noted all assumptions and inputs that follow are drawn from this source. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Commercial_Gas_Fryers.xls
[4] FYP is California's energy efficiency marketing program with funding approved by the California Public Utilities Commission http://www.fypower.org/inst/tools/products_results.html?id=100171
[5] Minnesota Department of Commerce, *Minnesota Deemed Savings Database*, Docket No. E,999/CIP-08-272 https://www.edockets.state.mn.us/EFiling/ShowFile.do?DocNumber=4991781
[6] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[7] Erickson, K. et al, *Cooking Up a New Approach for Program Design II: A Recipe for Success*, Consortium for Energy Efficiency, 2008 http://www.cee1.org/com/com-kit/files/CookingUpaNewApproachII.pdf
[8] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

The incremental cost for an Energy Star fryer purchased from Garland Canada[9] is $5,000. The Consortium for Energy Efficiency reports an incremental cost[10] of $1,240, the Energy Star savings calculator reports and incremental cost of $4,700 and the Minnesota Department of Commerce reports an incremental cost of $2,125. Navigant Consulting estimates the incremental cost to be the mean of the four prices reported for other jurisdictions, or approximately $3,250.

Customer Payback Period (Natural Gas Only)[11]	5.9 Years
Using a 5-year average commodity cost (avoided cost)[12] of $0.38 / m^3 and an average commercial distribution cost[13] of $0.12 / m^3, the payback period for natural gas savings is determined to be 5.9 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $3,250 / (1,099 m^3/year * $0.5 / m^3) = 5.9 years	

Market Penetration[14]	Medium
Based on the observation of medium penetration in two other jurisdictions (Washington State[15] – 15%, Iowa[16] – 35%) and communication with a local distributor, Navigant Consulting estimates the penetration in Ontario to be medium.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[17]	0.3 per ft^2 (restaurant)	8	$2,300	35%
Comments Energy Star fryer with 50% cooking efficiency replacing base equipment with 35% cooking efficiency. Measure saves 6.2% of 4.8 m^3 (1.73 therms) of gas per ft^2 required for cooking.				

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[18]	0.103 per ft^2 (restaurant)	15	$0.79 per ft^2	15%
Comments Efficient equipment is a "power burner" fryer. No indication of base or efficient equipment cooking efficiencies is provided. Measure saves 4% of 2.6 m^3 (0.93 therms) of gas per ft^2 required for cooking.				

[9] Energy Star fryer: FPH-55, $7,500, Base equipment: GF14, $2,500 http://www.enodisusa.com/docs/uploaded/eno/ca/price_lists/Frymaster%20PL%202008.pdf

[10] Where incremental cost was reported in U.S. dollars it has been converted to Canadian dollars using the exchange rate from February 2, 2009, or 1.24 Canadian dollars to the U.S. dollar.

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[14] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,

[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

[17] Ibid.

[18] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Minnesota Department of Commerce[19]	1,004	15	$1,714	N/A

Comments

The deemed savings database reports a standard fryer (122,000 BTUH) using 291.28 MMBtu/year and energy efficient fryer as using 255.16 MMBtu/year, equating to 36.12 MMBtu/year, or 1,004 m^3.

[19] Minnesota Department of Commerce, *Minnesota Deemed Savings Database*, Docket No. E,999/CIP-08-272 https://www.edockets.state.mn.us/EFiling/ShowFile.do?DocNumber=4991781

High Efficiency Commercial Griddle

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
High efficiency commercial griddle (40% cooking efficiency with heavy load[1])
Base Equipment and Technologies Description
Standard commercial griddle (32% cooking efficiency)

Decision Type	Target Market(s)	End Use
Retrofit/New	New/Existing Commercial buildings (Restaurant)	Cooking

Codes, Standards, and Regulations

An Energy Star specification for commercial griddles is due to be launched in April 2009[2].
NRCan's Office of Energy Efficiency does not regulate commercial griddles.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/Btu/hour)	Electricity (kWh)	Water (L)	($/kBtu/hour)	($)
1	503	0	0	$8,570	$7,000
2	503	0	0		
3	503	0	0		
4	503	0	0		
5	503	0	0		
6	503	0	0		
7	503	0	0		
8	503	0	0		
9	503	0	0		
10	503	0	0		
11	503	0	0		
12	503	0	0		
TOTALS	**6,036**	**0**	**0**	**$8,570**	**$7,000**

[1] Cooking energy efficiency is defined as the quantity of energy input to the food products expressed as a percentage of the quantity of energy input to the appliance.
[2] EPA update on Draft 1 Development , Nov 19, 2008, http://www.energystar.gov/ia/partners/prod_development/new_specs/downloads/comm_griddles/Griddle_Draft1_Status_Update.pdf

Resource Savings Assumptions

Annual Natural Gas Savings	503 m^3

Assumptions and inputs used by Pacific Gas and Electric's (PG&E) Food Service Technology Center (FSTC) to calculate savings[3]:

- The FSTC calculator's default assumption is that the griddle is used 12 hours a day. Energy Star[4] and the Federal Energy Management Program (FEMP)[5] both also assume that 12 hours of operation per day. An FSTC report on a specific model of griddle, however, found that in a production-test kitchen serving two meals per day the griddle was in operation an average of eight hours per day[6]. To account for restaurants operating with extended hours or serving three (griddle-prepared) meals per day, Navigant Consulting has assumed 10 hours (the average of both reported values) of operation per day.
- The FSTC calculator assumes a production capacity of 25 lbs/hour for the base griddle and 44 lbs/hour for the high efficiency griddle. Navigant Consulting has therefore modified the base production capacity to match that of the high efficiency griddle to more accurately compare gas use.
- The base equipment is assumed to have an idle energy rate of 18,000 Btu/hr and a pre-heat energy rate of 20,000 Btu/hr (FSTC and Energy Star default assumption).
- The efficient equipment is assumed to adhere to FEMP guidelines and have an idle energy rate of 16,000 Btu/hr and a pre-heat energy rate of 15,000 Btu/hr.

Natural gas use with base equipment, given assumptions and inputs detailed above: 3,061 m^3 (1,101 therms).

Natural gas use with efficient equipment, given assumptions and inputs detailed above: 2,558 m^3 (920 therms).

Annual gas savings were determined to be 503 m^3 or approximately 16% over the base equipment.

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	0 L

N/A

[3] Gas Griddle Life-Cycle Cost Calculator, default assumptions are used except where otherwise noted. http://www.foodservicetechnologycenter.com/saveenergy/tools/calculators/ggridcalc.php
Note that the savings calculated for the two default (base and high efficiency) cases are identical to those presented in the Energy Star Commercial Food Service – Energy and Water Performance Upgrades available in the Commercial Best Practices section of the Energy Star web-site, http://www.energystar.gov/ia/products/commercial_food_service/CFS_Full_Service.xls

[4] Energy Star Commercial Food Service – Energy and Water Performance Upgrades available in the Commercial Best Practices section of the Energy Star web-site, http://www.energystar.gov/ia/products/commercial_food_service/CFS_Full_Service.xls

[5] U.S. DOE, FEMP, *FEMP designated product: Griddles* http://www1.eere.energy.gov/femp/procurement/eep_gas_griddles.html#buyertips

[6] Cadotte, B. and D. Zabrowski, *Toastmaster Accu-Miser Model AM36SS Electric Griddle: In-Kitchen Appliance Performance Report*, Food Service Technology Center, January 1999. http://www.fishnick.com/publications/appliancereports/griddles/Toastmaster_AM36SS_Griddle_in_kitchen.pdf

Other Input Assumptions

Effective Useful Life (EUL)	12 Years
The Minnesota Department of Commerce[7] estimates the EUL of this measure to be 15 years. The State of Iowa Utilities Board[8], Energy Star and FEMP all estimate the EUL of this measure to be 12 years. Given that the majority of the agencies recommend using 12 years and given their relative expertise, Navigant Consulting also estimates the EUL of this measure to be 12 years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$1,570**
Energy Star[9] estimates the cost of base equipment to be $2,480 ($US 2,000) and the cost of the efficient equipment to be $3,925 ($US 3,165)[10] for an incremental cost of $1,445. The Garland CG-36R 01 (heavy-load cooking efficiency- 40.7%, production capacity – 46.2 lbs/hour, rated input – 90 kBtu/hour) has a dealer-recommended price of $9,490[11]. The FSTC assessment of a Lang griddle (heavy-load cooking efficiency – 31.7%, production capacity – 43.2 lbs/hour, rated input – 81kBtu/hour) does not specify a model number, however the specifications listed appear to match those of the Lang 236T which has a suggested price of of $7,795 ($US 6,286)[12]. This implies an incremental cost of $1,695. Navigant Consulting estimates the incremental price as the average of these figures, or $1,570	
Customer Payback Period (Natural Gas Only)[13]	**6.2 Years**
Using a 5-year average commodity cost (avoided cost)[14] of $0.38 / m^3 and an average commercial distribution cost[15] of $0.12 / m^3, the payback period for natural gas savings is determined to be 6.2 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $1,570 / (503 m^3/year * $0.5 / m^3) = 6.2 years	
Market Penetration[16]	**Medium**
Based on the observation of medium penetration in another jurisdiction (Iowa[17] – 25%) and on the observation that a large percentage of griddles tested by the FSTC are high efficiency, Navigant Consulting estimates the penetration in Ontario to be medium.	

7 Minnesota Department of Commerce, *Minnesota Deemed Savings Database*, Docket No. E,999/CIP-08-272 https://www.edockets.state.mn.us/EFiling/ShowFile.do?DocNumber=4991781

8 Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

9 Energy Star Commercial Food Service – Energy and Water Performance Upgrades available in the Commercial Best Practices section of the Energy Star web-site, http://www.energystar.gov/ia/products/commercial_food_service/CFS_Full_Service.xls

10 Cowen, D. and D. Zabrowski, *Garland CG-36R Gas Griddle Performance Test*, Food Service Technology Center, 2002. http://www.fishnick.com/publications/appliancereports/griddles/Garland_CG-36R_Griddle.pdf

11 Garland, *Price List Canada, 2008* http://www.enodisusa.com/docs/uploaded/eno/ca/price_lists/Gar%20USRange%20PL%202008.pdf

12 Lang, *2009 Price List*, http://www.langworld.com/Content/PriceLists/PriceListLangComm2009.pdf

13 Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

14 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

15 Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

16 Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

17 Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[18]	0.024 per ft^2 (restaurant)	12	$2,538	25%
Comments High efficiency griddle with 40% cooking efficiency replacing base equipment with 32% cooking efficiency. Measure saves 0.5% of 4.8 m^3 (1.73 therms) of gas per ft^2 required for cooking.				

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Energy Star Commercial Best Practices[19]	170	12	$1,444	N/A
Comments High efficiency griddle with 40% cooking efficiency replacing base equipment with 32% cooking efficiency.				

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
New York Energy $mart – Deemed Savings Database[20]	806	10	$1,240	N/A
Comments High efficiency griddle with 45% cooking efficiency replacing base equipment with 30% cooking efficiency.				

[18] Ibid.
[19] Energy Star Commercial Food Service – Energy and Water Performance Upgrades, http://www.energystar.gov/ia/products/commercial_food_service/CFS_Full_Service.xls
[20] NYSERDA Deemed Savings Database, revision 12, 2008.

COMMERCIAL SPACE HEATING

Air Curtains – Single Door (8’ x 6’)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Air curtains in retail, office and institutional buildings are used to reduce infiltration of cold outside air through doorways. A reduction in air infiltration means a reduction in natural gas heating during heating season and a reduction in air conditioning during the summer season.

Base Equipment and Technologies Description

Retail, office and institutional buildings without air curtains.

Decision Type	Target Market(s)	End Use
Retrofit	Retail, Office and Institutional Buildings	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	2,191	172	0	1,650	0
2	2,191	172	0	0	0
3	2,191	172	0	0	0
4	2,191	172	0	0	0
5	2,191	172	0	0	0
6	2,191	172	0	0	0
7	2,191	172	0	0	0
8	2,191	172	0	0	0
9	2,191	172	0	0	0
10	2,191	172	0	0	0
11	2,191	172	0	0	0
12	2,191	172	0	0	0
13	2,191	172	0	0	0
14	2,191	172	0	0	0
15	2,191	172	0	0	0
TOTALS	**32,865**	**2,580**	**0**	**1,650**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	2,191 m^3

Natural gas savings reflect reduced heating load; less outside cold air passes through doors. Savings are estimated based on the following assumptions:

Variable Names	Symbol	Value	Source
Inside Temperature for heating season	T_{IH}	68 °F	NCI estimate
Inside Temperature for cooling season	T_{IC}	72 °F	NCI estimate
Average outside temperature in heating season	T_{OH}	29.27 °F	NCI estimate
Average outside temperature in cooling season	T_{OC}	77.00 °F	NCI estimate
Hours per day that door is open	HR	1 hour	NCI estimate
Days per week that door is in use	DPW	7 Days	NCI estimate
Door Height	H	8 feet	NCI estimate
Door Width	W	2 x 6 feet	NCI estimate
Total horsepower of air curtain	HP	0.5 hp	NCI estimate
Air curtain cfm at nozzle	Q_0	1005 cfm	NCI estimate
Air curtain nozzle depth	NZ	2.75 inches	NCI estimate
Door coefficient	DC	0.3	NCI estimate
Days per heating season	DPS_H	120 Days	NCI estimate
Days per cooling season	DPS_C	100 Days	NCI estimate
Average wind velocity for heating season	V_{WH}	10.0 mph	NCI estimate
Average wind velocity for cooling season	V_{WC}	8.3 mph	NCI estimate
Energy Efficiency Ratio for A/C Unit	EER	12 Btu/Watt-hour	NCI estimate

<u>During Heating Season</u>

Doorway Calculations Without Air Curtain for Heating Season:

- Air entering doorway due to wind[1], $Q_W = V_{WH} \times H \times W \times 88$ fpm/mph = 12,672 cfm
- Air entering doorway due to inside/outside temperature difference, QTD = $[68.094+0.4256(T_i - T_{0H})] \times H \times W \times \sqrt{H(T_i - T_{0H})} / (T_i + 460)$ = 3,110 cfm
- Total air entering doorway, $Q_T = Q_W + Q_{TD}$ = 15,782 cfm
- Heat lost at doorway without air curtain $\mathbf{q_D} = 1.1 \times Q_T \times (T_i - T_{0H})$ = 672,357 Btu/hr

Doorway Calculations With Air Curtain for Heating Season:

- Total air flow rate at the door, $Q_E = 0.4704\ Q_0 (\sqrt{H/NZ}) - Q_0$ = 1,788 cfm
- Heat lost at doorway using air curtain, $\mathbf{q_{AC}} = 1.1 \times Q_E \times (T_i - T_{0H})$ = 76,183 Btu/hr

Heat Loss Prevented Per Year Using Air Curtain for Heating Season:

- **$q_S = (q_D - q_{AC}) \times HR \times DPS_H \times (DPW/7)$ = 77.50 MMBtu = 2,191 m^3 natural gas.**

- Baseline estimates of natural gas consumption: heat lost at doorway without air curtains = $q_D \times HR \times DPS_H \times (DPW/7)$ = 87.41 MMBtu = 2470 m^3.
- Natural Gas Savings % = 88.7%

Annual Electricity Savings	172 kWh

- Electricity savings are a result of the following factors:
  - Reduced AC load
  - Increased electricity use to operate air curtain.
- Based on the Enbridge 2007 DSM program Air Door projects for various small commercial sites,

[1] ASHRAE Handbook 2001 Fundamentals Ch.26

electricity savings were calculated using Agviro Air Door Calculator. Based on their reported results, the average savings is determined to be 172 kWh.	
Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	**15 Years**
This EUL was developed in conjunction with equipment manufacturers by Union Gas. It is also confirmed by SEED Program Guidelines[2].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 1,650**
This O&M cost was developed with conjunction with equipment manufacturers by Union Gas.	
Customer Payback Period (Natural Gas Only)[3]	**1.5 Years**
Using a 5-year average commodity cost (avoided cost)[4] of $0.38 / m^3 and an average commercial distribution cost[5] of $0.12 / m^3, the payback period for natural gas savings is determined to be 1.5 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $1,650/ (2,191 m^3/year * $0.5 / m^3) = 1.5 years	
Market Penetration[6]	**Medium**
Based on communication with local contractors, Navigant Consulting estimates a medium market penetration in Ontario.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Berner Energy Calculator[7].	2,092	N/A	2,000	N/A
Comments This is a typical application during winter months. Based on the same assumptions stated above in the Annual Electricity Savings table, the saved annual natural gas is 74 MMBtu, which is equivalent to 2,092 m^3.				

[2] Cost Effectiveness Analysis, SEED Program Guidelines. http://www.oregon.gov/ENERGY/CONS/SEED/docs/AppendixJ.pdf
[3] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[4] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[5] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[6] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,
[7] Berner Calculator, http://www.berner.com/sales/energy.php5

Air Curtains – Double Door (2 x 8' x 6')

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Air curtains in retail, office and institutional buildings are used to reduce infiltration of cold outside air through doorways. A reduction in air infiltration means a reduction in natural gas heating during heating season and a reduction in air conditioning during the summer season.
Base Equipment and Technologies Description
Retail, office and institutional buildings without air curtains.

Decision Type	Target Market(s)	End Use
Retrofit	Retail, Office and Institutional Buildings	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	4,661	1,023	0	2,500	0
2	4,661	1,023	0	0	0
3	4,661	1,023	0	0	0
4	4,661	1,023	0	0	0
5	4,661	1,023	0	0	0
6	4,661	1,023	0	0	0
7	4,661	1,023	0	0	0
8	4,661	1,023	0	0	0
9	4,661	1,023	0	0	0
10	4,661	1,023	0	0	0
11	4,661	1,023	0	0	0
12	4,661	1,023	0	0	0
13	4,661	1,023	0	0	0
14	4,661	1,023	0	0	0
15	4,661	1,023	0	0	0
TOTALS	**69,914**	**15,345**	**0**	**2,500**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	4,661 m^3

Natural gas savings reflect reduced heating load; less outside cold air passes through. Savings are estimated based on the following assumptions:

Variable Names	Symbol	Value	Source
Inside Temperature for heating season	T_{IH}	68 °F	NCI estimate
Inside Temperature for cooling season	T_{IC}	72 °F	NCI estimate
Average outside temperature in heating season	T_{OH}	29.27 °F	NCI estimate
Average outside temperature in cooling season	T_{OC}	77.00 °F	NCI estimate
Hours per day that door is open	HR	1 hour	NCI estimate
Days per week that door is in use	DPW	7 Days	NCI estimate
Door Height	H	8 ’	NCI estimate
Door Width	W	2 x 6 ’	NCI estimate
Total horsepower of air curtain	HP	0.5 hp	NCI estimate
Air curtain cfm at nozzle	Q_0	1005 cfm	NCI estimate
Air curtain nozzle depth	NZ	2.75 “	NCI estimate
Door coefficient	DC	0.3	NCI estimate
Days per heating season	DPS_H	120 Days	NCI estimate
Days per cooling season	DPS_C	100 Days	NCI estimate
Average wind velocity for heating season	V_{WH}	10.0 mph	NCI estimate
Average wind velocity for cooling season	V_{WC}	8.3 mph	NCI estimate
Energy Efficiency Ratio for A/C Unit	EER	12 Btu/Watt-hour	NCI estimate

<u>During Heating Season</u>

Doorway Calculations Without Air Curtain for Heating Season:

- Air entering doorway due to wind[1], $Q_W = V_{WH}$ x H x W x 88 fpm/mph = 25,344 cfm
- Air entering doorway due to inside/outside temperature difference, QTD = [68.094+0.4256($T_{IH} - T_{0H}$)] x H x W x √H($T_{IH} - T_{0H}$)/ (T_{IH} + 460) = 6,220 cfm
- Total air entering doorway, $Q_T = Q_W + Q_{TD}$ = 31,564 cfm
- Heat lost at doorway without air curtain $\mathbf{q_D}$ = 1.1 x Q_T x ($T_{IH} - T_{0H}$) = 1,344,713 Btu/hr

Doorway Calculations With Air Curtain for Heating Season:

- Total air flow rate at the door, $Q_E = 0.4704\ Q_0\ (\sqrt{H/NZ}) - Q_0$ = 1,788 cfm
- Heat lost at doorway using air curtain, $\mathbf{q_{AC}}$ = 1.1 x Q_E x ($T_{IH} - T_{0H}$) = 76,183 Btu/hr

Heat Loss Prevented Per Year Using Air Curtain for Heating Season:

- **$q_S = (q_D - q_{AC})$ x HR x DPS_H x (DPW/7) = 164.91 MMBtu = 4,661 m^3 natural gas.**

- Baseline estimates of natural gas consumption: heat lost at doorway without air curtains = q_D x HR x DPS_H x (DPW/7) = 174.81 MMBtu = 4,941 m^3.
- Natural Gas Savings % = 4,661m^3 / 4,941m^3 = 94.3%

Annual Electricity Savings	1,023 kWh

- Electricity savings are a result of the following factors:
  - Reduced AC load
  - Increased electricity use to operate air curtain.
- Based on the Enbridge 2007 DSM program Air Door projects at various small commercial sites,

[1] ASHRAE Handbook 2001 Fundamentals Ch.26

electricity savings were calculated using Agviro air door calculator. The average result is estimated to be 1,023 kWh.	
Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	**15 Years**
This EUL was developed in conjunction with equipment manufacturers by Union Gas. It is also confirmed by SEED Program Guidelines[2].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 2,500**
This O&M cost was developed in conjunction with equipment manufacturers by Union Gas.	
Customer Payback Period (Natural Gas Only)[3]	**1.1 Years**
Using a 5-year average commodity cost (avoided cost)[4] of \$0.38 / m^3 and an average commercial distribution cost[5] of \$0.12 / m^3, the payback period for natural gas savings is determined to be 1.1 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$2500/ (4,661 m^3/year * \$0.5 / m^3) = 1.1 years	
Market Penetration[6]	**Medium**
Based on communication with local contractors, Navigant Consulting estimates a medium market penetration in Ontario.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Berner Energy Calculator[7]	4,946	N/A	2,500	N/A
Comments Based on the same assumptions used above, for a typical application during the winter season, the annual natural gas savings are determined to be 175 MMBtu, or 4,946 m^3.				

[2] Cost Effectiveness Analysis, SEED Program Guidelines. http://www.oregon.gov/ENERGY/CONS/SEED/docs/AppendixJ.pdf
[3] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[4] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[5] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[6] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,
[7] Berner Calculator, http://www.berner.com/sales/energy.php5

Condensing Boilers (m^3/Btu/hour)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Condensing boiler with 88% estimated seasonal efficiency

Base Equipment and Technologies Description

Non-condensing boiler with 76% estimated seasonal efficiency

Decision Type	Target Market(s)	End Use
Retrofit	Existing Commercial buildings	Space Heating

Codes, Standards, and Regulations

- ASHRAE Standard 155P: test and calculation procedures result in an application-specific seasonal efficiency of commercial space heating boiler systems.
- ASHRAE Standard 90.1-2004: minimum boiler efficiencies for buildings except low-rise residential buildings.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/Btu/hour)	Electricity (kWh)	Water (L)	($/kBtu/hour)	($)
1	0.01	0	0	12	0
2	0.01	0	0	0	0
3	0.01	0	0	0	0
4	0.01	0	0	0	0
5	0.01	0	0	0	0
6	0.01	0	0	0	0
7	0.01	0	0	0	0
8	0.01	0	0	0	0
9	0.01	0	0	0	0
10	0.01	0	0	0	0
11	0.01	0	0	0	0
12	0.01	0	0	0	0
13	0.01	0	0	0	0
14	0.01	0	0	0	0
15	0.01	0	0	0	0
16	0.01	0	0	0	0
17	0.01	0	0	0	0
18	0.01	0	0	0	0
19	0.01	0	0	0	0
20	0.01	0	0	0	0
21	0.01	0	0	0	0
22	0.01	0	0	0	0
23	0.01	0	0	0	0
24	0.01	0	0	0	0
25	0.01	0	0	0	0
TOTALS	**0.25**	**0**	**0**	**12**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	0.0104 m^3/Btu/hr

- The natural gas savings are based on the reduction in space heating gas consumption from using a condensing boiler instead of a non-condensing boiler.
- For condensing and non-condensing boilers, Fuel Consumption = Design Heat Loss (Btu/year) / Boiler efficiency / Natural Gas Low Heating Value[1] (Btu/m3)
- Estimated seasonal efficiency is 76% for non-condensing boilers and 88% for condensing boilers[2].
- Design Heat Loss is calculated using degree days analysis (full year) for London, ON and Sudbury, ON. The single saving number is weighted average of Union Gas South (London, 70%) and Union Gas North (Sudbury, 30%) based on the customer population of Union Gas service territories.

Example: a 300,000 Btu/hr condensing boiler located in London or Sudbury

Assuming the following specifications for a condensing boiler located in London, ON

Variables	Values
Boiler Input (Btu/hr)	300,000
Oversizing	1.2
Boiler Operating Factor	90%

- Heat Loss = (Boiler Input x Boiler Operating Factor) / Oversizing = 225,000 Btu/hr
- In general, Natural Gas Low Heating Value = 35,310 Btu/m^3
- Historically, London experiences 42 hours/year at -5^{o}F. Design Heat Loss per Year at this temperature = 225,000 Btu/hr x 42 hours = 9,450,000 Btu
- For conventional boilers (76% efficiency), natural gas consumption at -5^{o}F = 9,450,000 Btu / 76% / Natural Gas Low Heating Value = 352 m^3/year.
- For condensing boilers (88% efficiency), natural gas consumption at -5^{o}F = 9,450,000 Btu / 76% / Natural Gas Low Heating Value = 304 m^3/year.
- Design Heat Losses at different temperatures (t) are extrapolated based on assumed linear relationship with 225,000 Btu/hr (@-5^{o}F) using 225,000 Btu/hr x (65-t)/[65-(-5)]
- The following tables are constructed to calculate the natural gas consumptions at all temperatures for a whole year.

[1] Natural gas lower heating value – the lower heating value (also known as net calorific value, net CV, or LHV) of a fuel is defined as the amount of heat released by combusting a specified quantity (initially at 25 °C or another reference state) and returning the temperature of the combustion products to 150 °C, given as 35,310 Btu/m^3.

[2] Seasonal efficiencies are estimates based on "Boiler System Efficiency", Thomas H. Durkin, ASHRAE Journal, July 2006

Temperature Intervals		London	Design Heat Loss		Fuel Consumption	
					Conventional Boiler	Condensing Boiler
Temp (*F)	Range	Hours	Btu/hr	Btu/year	m^3/yr	m^3/yr
-20	-15	4				
-15	-10	8				
-10	-5	17				
-5	0	42	225,000	9,450,000	352	304
0	5	87	208,929	18,176,786	677	585
5	10	152	192,857	29,314,286	1,092	943
10	15	281	176,786	49,676,786	1,851	1,599
15	20	337	160,714	54,160,714	2,018	1,743
20	25	435	144,643	62,919,643	2,345	2,025
25	30	584	128,571	75,085,714	2,798	2,416
30	35	948	112,500	106,650,000	3,974	3,432
35	40	735	96,429	70,875,000	2,641	2,281
40	45	634	80,357	50,946,429	1,898	1,640
45	50	622	64,286	39,985,714	1,490	1,287
50	55	643	48,214	31,001,786	1,155	998
55	60		32,143	0	0	0
60	65		16,071	0	0	0
			Total	**598,242,857**	**22,293**	**19,253**

- The operating hours for boilers in London are based on the Union Gas program record.
- Natural Gas savings for condensing boilers in London = 22,293 m^3 – 19,253 m^3 = 3,040 m^3
- The same calculation is repeated for a 300,000 Btu/hr boiler in Sudbury as below:

Temperature Intervals		Sudbury	Design Heat Loss		Fuel Consumption	
					Conventional Boiler	Condensing Boiler
Temp (*F)	Range	Hours	Btu/hr	Btu/year	m^3/yr	m^3/yr
-35	-30	2				
-30	-25	7				
-25	-20	20				
-20	-15	46	225000	10350000	386	333
-15	-10	99	211765	20964705.88	781	675
-10	-5	159	198529	31566176.47	1176	1016
-5	0	221	185,294	40,950,000	1,526	1,318
0	5	272	172,059	46,800,000	1,744	1,506
5	10	345	158,824	54,794,118	2,042	1,763
10	15	380	145,588	55,323,529	2,062	1,780
15	20	437	132,353	57,838,235	2,155	1,861
20	25	502	119,118	59,797,059	2,228	1,924
25	30	658	105,882	69,670,588	2,596	2,242
30	35	748	92,647	69,300,000	2,582	2,230
35	40	584	79,412	46,376,471	1,728	1,493
40	45	537	66,176	35,536,765	1,324	1,144
45	50	605	52,941	32,029,412	1,194	1,031
50	55	665	39,706	26,404,412	984	850
55	60		26,471	0	0	0
60	65		13,235	0	0	0
			Total	**657,701,471**	**24,509**	**21,166**

- Natural Gas savings for condensing boilers in Sudbury = 24,509 m^3 – 21,166 m^3 = 3,342 m^3
- Based on 70% (London) and 30% (Sudbury) mix, the weighted average of natural gas savings = 70% x 3040 + 30% x 3342 = 3,131 m^3.
- Therefore, the natural gas savings = 3,131 m^3

- On a per Btu/hour basis, NG savings = 3,131 m^3 / 300,000 Btu/hour = 0.0104 m^3/Btu/hour.
- Baseline conventional boiler consumption = 70% x 22,293 + 30% x 24,509 = 22,958 m^3.
- Natural Gas Savings % = 3,131 m^3 / 22,958 m^3 = 13.6 %

Annual Electricity Savings	0 kWh
N/A	

Annual Water Savings	0 L
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	25 Years
Condensing boilers have an estimated service life of 25 years[3].	

Base & Incremental Conservation Measure Equipment and O&M Costs	$ 12 / kBtu / hr
A generic incremental cost of $14,000 per million Btu / hr (adjusted for the US/CDN exchange by a factor of 1.10) was used based on information recently published in the ASHRAE Journal[4]. Local Canadian manufactures reported $9,800 for 230,000 Btu/hour condensing boilers[5], which is $43 / kBtu/hour. Baseline cost (conventional boilers) is $31/kBtu/hr. Incremental cost is $12 kBtu/hour.	

Customer Payback Period (Natural Gas Only)[6]	2.3 Years

Using a 5-year average commodity cost (avoided cost)[7] of \$0.38 / m^3 and an average commercial distribution cost[8] of \$0.12 / m^3, the payback period for natural gas savings is determined to be 2.3 years, based on the following:

On a per Btu/hr basis,

Payback Period = Incremental cost / (natural gas savings x natural gas cost)

= \$0.012 / (0.0104 m^3/year * \$0.5 / m^3)

= 2.3 years

Market Share[9]	High
Based on conversations with local contractors and the number of condensing boilers on the market, Navigant Consulting has determined that condensing boilers have a high market share in Ontario.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[10]	0.156 per ft^2	20	$35.80 (Large Office)	N/A
Comments Base equipment has an 80% seasonal efficiency, efficient equipment has an 89% seasonal efficiency.				

---

[3] ASHRAE Applications Handbook – 2003, Chapter 36 – Owning and Operating Costs, Table 3
[4] "Boiler System Efficiency", Thomas H. Durkin, ASHRAE Journal – July 2006
[5] Veissmann Group, http://www.viessmann.ca/en
[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Baseline usage reported on a square footage basis (eg 0.57 therms/sq.ft.for large offices). Estimated 10.2% savings over the baseline. Incremental costs are based on per 1,000 ft^2 basis. Equivalent natural gas savings is 10.2% x 0.57 therms/sq.ft. = 0.058 therms = 0.156 m^3 / ft^2.

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[11]	0.063 per ft^2	20	$0.10 (offices)	N/A

Comments

Base equipment is a standard central boiler with 75% seasonal efficiency and efficient equipment is a condensing boiler with 85% seasonal efficiency. Baseline usage reported on a square footage basis (eg 0.19 therms/sq.ft. for offices). Estimated 12% savings over the baseline. Incremental costs are based on per sqft basis. Equivalent natural gas savings is 12% x 0.19 therms/sq.ft. = 0.0228 therms = 0.063 m^3 / ft^2.

[11] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Demand Control Kitchen Ventilation (DCKV – 5000 CFM)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Kitchen ventilation with DCKV hood exhaust (5000 CFM). Demand ventilation uses temperature and/or smoke sensing to adjust ventilation rates. This saves energy comparing with the traditional 100% on/off kitchen ventilation system.

Base Equipment and Technologies Description

Kitchen ventilation without DCKV.

Decision Type	Target Market(s)	End Use
Retrofit	Existing Commercial (Restaurants)	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	4,801	13,521	0	10,000	0
2	4,801	13,521	0	0	0
3	4,801	13,521	0	0	0
4	4,801	13,521	0	0	0
5	4,801	13,521	0	0	0
6	4,801	13,521	0	0	0
7	4,801	13,521	0	0	0
8	4,801	13,521	0	0	0
9	4,801	13,521	0	0	0
10	4,801	13,521	0	0	0
TOTALS	**48,010**	**135,210**	**0**	**10,000**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	4,801 m^3

- The demand control kitchen ventilation savings were determined using the method described in the Melink Detailed Energy Savings Report[1].
- Assuming the DCKV system is operating 16 hours/day, 7 days/week, 52 weeks/year, at 80% heating efficiency.
- Using design weather data from the Outdoor Airload Calculator[2], baseline net heating loads for an exhaust volume of 5,000 CFM were determined for two locations: London (Union South) and North Bay (Union North): London = 624,111 KBtu; and North Bay = 803,266 KBtu.
- Heating savings for both locations (London and North Bay) were calculated by multiplying the individual baseline heating loads with (*1 – estimated average make-up air RPM factor*), which represents the percent savings when using Demand Control Kitchen Ventilation.
- Weighted average natural gas savings is calculated by assigning 70% to Union Gas South consumption and 30% to Union Gas North consumption based on the customer population of Union Gas service territories.

NG Savings	Weight	Base Case Heating Load (kBTu)	Demand Ventilation Heating Load (kBTu)	Heating Savings (m^3)
Union South (London)	70%	624,111	464,963	4,421
Union North (North Bay)	30%	803,266	598,433	5,690
Weighted Average		**677,858**	**505,004**	**4,801**

- Baseline estimates of natural gas consumption = 677,858 kBtu = 18,829 m^3
- Natural Gas Savings % = 4801 m^3 / 677858 m^3 = 26 %

Annual Electricity Savings	13,521 kWh

- Electricity savings consists two parts: fan motor savings and cooling load savings.
- Main assumption include: Motor capacity is 5 HP at 90% efficiency level, Cooling system COP = 3.
- Total Operating Time per Year (G) = 16 hrs/day x 7 days/week x 52 weeks/year = 5,824 hours
- Baseline fan motor electricity consumption = 0.746 kW/HP x G / 0.9 = 4,827.4 kWh/HP
- DCKV fan motor electricity consumption is calculated as below:

[1] Detailed Energy Savings Report, Melink Corporation, http://www.melinkcorp.com/Intellihood/Energy_Analysis.pdf
[2] This freeware is available at www.archenergy.com/ckv/oac/default.htm.

% Rated RPM	% Run Time	Time HRS/YR	Output KW/HP	System Effic.	Input KW/HP	KWHR/ HP/YR
H	I	J=GxI	K	L	M=K/L	N=JxM
100	5	291.2	0.746	0.9	0.829	241
90	20	1164.8	0.544	0.9	0.604	704
80	25	1456	0.382	0.9	0.424	618
70	25	1456	0.256	0.9	0.284	414
60	15	873.6	0.161	0.9	0.179	156
50	10	582.4	0.093	0.9	0.103	60
40	0	0	0.048	0.9	0.053	0
30	0	0	0.020	0.9	0.022	0
20	0	0	0.015	0.9	0.017	0
10	0	0	0.010	0.90	0.011	0
O Total KWH/HP/YR (Total of Column N)						**2,194** kWh/HP

- The fan motor electricity savings = 5HP x (4,827.4 – 2,194) kWh/HP = 13,167.2 kWh.
- Cooling load savings are calculated using the same method as for heating load savings analysis. Baseline net cooling loads for London and North Bay are obtained using Outdoor Airload Calculator:
  - London = 17,801 kBtu; and
  - North Bay = 5,832 kBtu.
- Multiplying the baseline cooling loads by (*1 – estimated average make-up air RPM factor*), and then assigning 70% weight to London and 30% weight to North Bay, cooling load savings are calculated and shown below:

Cooling Electricity Consumption	Weight	Base Case Cooling (kWh)	DCKV Cooling (kWh)	Cooling Savings (kWh)
Union South (London)	70%	1,739	1,296	443
Union North (North Bay)	30%	570	424	145
Weighted Average		**1,388**	**1,034**	**354**

- Total electricity savings are calculated by combining the two components of electricity usages:

Total Electricity Savings	Weight	Cooling Savings (kWh)	Exhaust Fan Motor Electricity Savings (kWh)	Total Savings (kWh)
Union South (London)	70%	443	13,167	13,611
Union North (North Bay)	30%	145	13,167	13,313
Weighted Average		**354**	**13,167**	**13,521**

- Baseline estimates of electricity consumption = 5HP x 4,827.4 kWh/HP + 1,388 kWh = 25,526 kWh.
- Electricity Savings % = 13,521 kWh / 25,526 kWh = 53 %

Annual Water Savings | 0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
DCKV has an estimated service life of 10 years because the useful life of a CO_2 sensor is expected to be in excess of 10 years. Energy savings related to this measure will persist indefinitely as long as the sensor remains calibrated[3].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 10,000**
Typical costing information was obtained from Melink Canada[4].	
Customer Payback Period (Natural Gas Only)[5]	**4.2 Years**
Using a 5-year average commodity cost (avoided cost)[6] of \$0.38 / m^3 and an average commercial distribution cost[7] of \$0.12 / m^3, the payback period for natural gas savings is determined to be 4.2 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$10,000/ (4,801 m^3/year * \$0.5 / m^3) = 4.2 years	
Market Penetration[8]	**Low**
Based on the penetration rates in another jurisdiction (5% for Puget Sound Energy) and communication with local contractors, Navigant Consulting estimates a low market penetration in Ontario.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[9]	0.0385 per ft^2	15	0.28	5%

Comments

Baseline therm reported on a square footage basis (eg 0.14 therms/sq.ft. for restaurant). Estimated 10% savings for new energy efficient technology is reported as a percent saving over the baseline. Incremental costs are also based on per sqft basis. Equivalent natural gas savings is 10% x 0.14 therms/sq.ft. = 0.014 therms/sq.ft. = 0.0385 m^3 / sq.ft.

---

[3] Pacific Gas and Electric Co, Heschong Mahone Group,, Demand Control Ventilation Measure Description, http://www.energy.ca.gov/title24/2005standards/archive/documents/measures/14/14_2002-03_DEMND_PGE_MAHONE.PDF

[4]Melink Canada, http://melinkcanada.com/

[5] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[6] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[7] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[8] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

[9] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Demand Control Kitchen Ventilation (DCKV – 10000 CFM)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Kitchen ventilation with DCKV hood exhaust (10000 CFM). Demand ventilation uses temperature and/or smoke sensing to adjust ventilation rates. This saves energy comparing with the traditional 100% on/off kitchen ventilation system.
Base Equipment and Technologies Description
Kitchen ventilation without DCKV.

Decision Type	Target Market(s)	End Use
Retrofit	Existing Commercial (Restaurants)	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	11,486	30,901	0	15,000	0
2	11,486	30,901	0	0	0
3	11,486	30,901	0	0	0
4	11,486	30,901	0	0	0
5	11,486	30,901	0	0	0
6	11,486	30,901	0	0	0
7	11,486	30,901	0	0	0
8	11,486	30,901	0	0	0
9	11,486	30,901	0	0	0
10	11,486	30,901	0	0	0
TOTALS	**114,860**	**309,010**	**0**	**15,000**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	11,486 m^3

- The demand control kitchen ventilation savings were determined using the methodology described in the Melink Detailed Energy Savings Report[1].
- Assuming the DCKV system is operating 16 hours/day, 7 days/week, 52 weeks/year, at 80% heating efficiency.
- Using design weather data from the Outdoor Airload Calculator[2], baseline net heating loads for a exhaust volume of 10,000 CFM were determined for London (Union South) and North Bay (Union North). London:1,248,221 KBtu, North Bay: 1,660,531 KBtu
- Heating savings for London and North Bay are calculated by multiplying the individual baseline heating loads with (*1 – estimated average make-up air RPM factor*), which represents the savings% when using Demand Control Kitchen Ventilation.
- Weighted average natural gas savings is calculated by assigning 70% to Union Gas South consumption and 30% to Union Gas North consumption based on the customer population of Union Gas service territories.

NG Savings	Weight	Base Case Heating Load (kBTu)	Demand Ventilation Heating Load (kBTu)	Heating Savings (m^3)
Union South (London)	70%	1,248,221	867,514	10,575
Union North (North Bay)	30%	1,606,531	1,116,539	13,611
Weighted Average		**1,355,714**	**942,221**	**11,486**

- Baseline estimates of natural gas consumption = 1,355,714 kBtu = 37,659 m^3
- Natural Gas Savings % = 11,486 m^3 / 37, 659 m^3 = 31 %

Annual Electricity Savings	30,901 kWh

- Electricity savings consists two parts: fan motor savings and cooling load savings.
- Assuming the motor capacity is 10 HP at 90% efficiency level, cooling system COP = 3.
- Total Operating Time per Year (G) = 16 hrs/day x 7 days/week x 52 weeks/year = 5,824 hours
- Baseline fan motor electricity consumption = 0.746 kW/HP x G / 0.9 = 4,827.4 kWh/HP
- DCKV fan motor electricity consumption is calculated as below:

[1] Detailed Energy Savings Report, Melink Corporation, http://www.melinkcorp.com/Intellihood/Energy_Analysis.pdf
[2] This freeware is available at www.archenergy.com/ckv/oac/default.htm.

% Rated RPM	% Run Time	Time HRS/YR	Output KW/HP	System Effic.	Input KW/HP	KWHR/ HP/YR
H	I	J=GxI	K	L	M=K/L	N=JxM
100	5	291.2	0.746	0.9	0.829	241
90	10	582.4	0.544	0.9	0.604	352
80	20	1164.8	0.382	0.9	0.424	494
70	20	1164.8	0.256	0.9	0.284	331
60	30	1747.2	0.161	0.9	0.179	313
50	15	873.6	0.093	0.9	0.103	90
40	0	0	0.048	0.9	0.053	0
30	0	0	0.020	0.9	0.022	0
20	0	0	0.015	0.9	0.017	0
10	0	0	0.010	0.90	0.011	0
O Total KWH/HP/YR (Total of Column N)						**1,822** kWh/HP

- The fan motor electricity savings = 10HP x (4,827.4 – 1,822) kWh/HP = 30,054 kWh.
- Cooling load savings are calculated using the same method as for heating load savings analysis. Baseline net cooling loads for London and North Bay are obtained using Outdoor Airload Calculator:
  - London = 35,603 kBtu
  - North Bay = 11,663 kBtu.
- Multiplying the baseline cooling loads by (*1 – estimated average make-up air RPM factor*), and then assigning 70% weight to London and 30% weight to North Bay, cooling load savings are calculated.

Cooling Electricity Consumption	Weight	Base Case Cooling (kWh)	DCKV Cooling (kWh)	Cooling Savings (kWh)
Union South (London)	70%	3,478	2,417	1,061
Union North (North Bay)	30%	1,139	792	348
Weighted Average		**2,777**	**1,930**	**847**

- Total electricity savings are calculated by combining the two components of electricity usages:

Total Electricity Savings	Weight	Cooling Savings (kWh)	Exhaust Fan Motor Electricity Savings (kWh)	Total Savings (kWh)
Union South (London)	70%	1,061	30,054	31,115
Union North (North Bay)	30%	348	30,054	30,402
Weighted Average		**847**	**30,054**	**30,901**

- Baseline estimates of electricity consumption = 10HP x 4,817.4kWh/HP + 2,777 kWh = 51,051 kWh.
- Electricity Savings % = 30,901 kWh / 51,051 kWh = 61 %

Annual Water Savings	**0 L**

N/A

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
DCKV has an estimated service life of 10 years because the useful life of a CO_2 sensor is expected to be in excess of 10 years. Energy savings related to this measure will persist indefinitely as long as the sensor remains calibrated[3].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 15,000**
Typical costing information was provided by Melink Canada[4].	
Customer Payback Period (Natural Gas Only)[5]	**2.6 Years**
Using a 5-year average commodity cost (avoided cost)[6] of $0.38 / m^3 and an average commercial distribution cost[7] of $0.12 / m^3, the payback period for natural gas savings is determined to be 2.6 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $15,000/ (11,486 m^3/year * $0.5 / m^3) = 2.6 years	
Market Penetration[8]	**Low**
Based on the penetration rate in another jurisdiction (5% for Puget Sound Energy) and communication with local contractors, Navigant Consulting estimates a low market penetration in Ontario.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[9]	0.0385 / sqft	15	0.28	5%

Comments

Baseline therm reported on a square footage basis (eg 0.14 therms/sq.ft. for restaurant). Estimated 10% savings for new energy efficient technology is reported as a percent saving over the baseline. Incremental costs are based on per sqft basis. Equivalent natural gas savings is 10% x 0.14 therms/sq.ft = 0.014 therms/sq.ft = 0.0385 m^3 /sq.ft

[3] Pacific Gas and Electric Co, Heschong Mahone Group,, Demand Control Ventilation Measure Description, http://www.energy.ca.gov/title24/2005standards/archive/documents/measures/14/14_2002-03_DEMND_PGE_MAHONE.PDF

[4] Melink Canada, http://melinkcanada.com/

[5] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[6] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[7] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[8] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

[9] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Demand Control Kitchen Ventilation (DCKV – 15000 CFM)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Kitchen ventilation with DCKV hood exhaust (15000 CFM). Demand ventilation uses temperature and/or smoke sensing to adjust ventilation rates. This saves energy comparing with the traditional 100% on/off kitchen ventilation system.
Base Equipment and Technologies Description
Kitchen ventilation without DCKV.

Decision Type	Target Market(s)	End Use
Retrofit	Existing Commercial (Restaurants)	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	18,924	49,102	0	20,000	0
2	18,924	49,102	0	0	0
3	18,924	49,102	0	0	0
4	18,924	49,102	0	0	0
5	18,924	49,102	0	0	0
6	18,924	49,102	0	0	0
7	18,924	49,102	0	0	0
8	18,924	49,102	0	0	0
9	18,924	49,102	0	0	0
10	18,924	49,102	0	0	0
TOTALS	**189,240**	**491,020**	**0**	**20,000**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	18,924 m^3

- The demand control kitchen ventilation savings were determined using the method described in the Melink Detailed Energy Savings Report[1].
- Assuming the DCKV system is operating 16 hours/day, 7 days/week, 52 weeks/year, at 80% heating efficiency.
- Using design weather data from the Outdoor Airload Calculator[2], baseline net heating loads for London (Union South) and North Bay (Union North) at 15000 CFM exhaust volume are obtained. They are 1,872,332 kBtu and 2,409,797 kBtu respectively.
- Heating savings for London and North Bay are calculated by multiplying the individual baseline heating loads with (*1 – estimated average make-up air RPM factor*), which represents the savings% when using Demand Control Kitchen Ventilation.
- Weighted average natural gas savings is calculated by assigning 70% to Union Gas South consumption and 30% to Union Gas North consumption based on the customer population of Union Gas service territories.

NG Savings	Weight	Base Case Heating Load (kBTu)	Demand Ventilation Heating Load (kBTu)	Heating Savings (m^3)
Union South (London)	70%	1,872,332	1,245,101	17,423
Union North (North Bay)	30%	2,409,797	1,602,515	22,424
Weighted Average		**2,033,572**	**1,352,325**	**18,924**

- Baseline estimates of natural gas consumption = 2,033,572 kBtu = 56,488 m^3
- Natural Gas Savings % = 18,924 m^3 / 56,488 m^3 = 34 %

Annual Electricity Savings	49,102 kWh

- Electricity savings consists two parts: fan motor savings and cooling load savings.
- Assuming the motor capacity is 15 HP at 90% efficiency level, cooling system COP = 3.
- Total Operating Time per Year (G) = 16 hrs/day x 7 days/week x 52 weeks/year = 5,824 hours
- Baseline fan motor electricity consumption = 0.746 kW/HP x G / 0.9 = 4,827.4 kWh/HP
- DCKV fan motor electricity consumption is calculated as below:

[1] Detailed Energy Savings Report, Melink Corporation, http://www.melinkcorp.com/Intellihood/Energy_Analysis.pdf
[2] This freeware is available at www.archenergy.com/ckv/oac/default.htm.

% Rated RPM	% Run Time	Time HRS/YR	Output KW/HP	System Effic.	Input KW/HP	KWHR/ HP/YR
H	I	J=GxI	K	L	M=K/L	N=JxM
100	5	291.2	0.746	0.9	0.829	241
90	5	291.2	0.544	0.9	0.604	176
80	20	1164.8	0.382	0.9	0.424	494
70	20	1164.8	0.256	0.9	0.284	331
60	30	1747.2	0.161	0.9	0.179	313
50	10	582.4	0.093	0.9	0.103	60
40	10	582.4	0.048	0.9	0.053	31
30	0	0	0.020	0.9	0.022	0
20	0	0	0.015	0.9	0.017	0
10	0	0	0.010	0.90	0.011	0
O Total KWH/HP/YR (Total of Column N)						**1,647** kWh/HP

- The fan motor electricity savings = 15HP x (4,827.4 – 1,647) kWh/HP = 47,707 kWh.
- Cooling load savings are calculated using the same method as for heating load savings analysis. Baseline net cooling loads for London and North Bay are obtained using Outdoor Airload Calculator:
  - London = 53,404 kBtu
  - North Bay = 17,495 kBtu
- Multiplying the baseline cooling loads by (*1 – estimated average make-up air RPM factor*), and then assigning 70% weight to London and 30% weight to North Bay, cooling load savings are calculated.

Cooling Electricity Consumption	Weight	Base Case Cooling (kWh)	DCKV Cooling (kWh)	Cooling Savings (kWh)
Union South (London)	70%	5,217	3,469	1,748
Union North (North Bay)	30%	1,709	1,137	573
Weighted Average		**4,165**	**2,770**	**1,395**

- Total electricity savings are calculated by combining the two components of electricity usages:

Total Electricity Savings	Weight	Cooling Savings (kWh)	Exhaust Fan Motor Electricity Savings (kWh)	Total Savings (kWh)
Union South (London)	70%	1,748	47,707	49,455
Union North (North Bay)	30%	573	47,707	48,279
Weighted Average		**1,395**	**47,707**	**49,102**

- Baseline estimates of electricity consumption = 15HP x 4,827.4kWh/HP + 4,165 kWh = 76,577 kWh.
- Electricity Savings % = 49,102 kWh / 76,577 kWh = 64 %

Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
DCKV has an estimated service life of 10 years because the useful life of a CO_2 sensor is expected to be in excess of 10 years. Energy savings related to this measure will persist indefinitely as long as the sensor remains calibrated[3].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 20,000**
Typical costing information was provided by Melink Corp.	
Customer Payback Period (Natural Gas Only)[4]	**2.1 Years**
Using a 5-year average commodity cost (avoided cost)[5] of $0.38 / m^3 and an average commercial distribution cost[6] of $0.12 / m^3, the payback period for natural gas savings is determined to be 2.1 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $20,000/ (18,924 m^3/year * $0.5 / m^3) = 2.1 years	
Market Penetration[7]	**Low**
Based on the penetration rate in another jurisdiction (5% for Puget Sound Energy) and communication with local contractors, Navigant Consulting estimates a low market penetration in Ontario.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[8]	0.0385 per ft^2	15	0.28	5%

Comments

Baseline therm reported on a square footage basis (eg 0.14 therms/sq.ft. for restaurant). Estimated 10% savings for new energy efficient technology is reported as a percent saving over the baseline. Incremental costs are based on per sqft basis. Equivalent natural gas savings is 10% x 0.14 therms/sq.ft. = 0.014 therms / sqft = 0.0385 m^3 / sqft

---

[3] Pacific Gas and Electric Co, Heschong Mahone Group,, Demand Control Ventilation Measure Description, http://www.energy.ca.gov/title24/2005standards/archive/documents/measures/14/14_2002-03_DEMND_PGE_MAHONE.PDF

[4] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[5] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[6] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[7] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

[8] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Destratification Fan

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Destratification Fan. For fans of with minimum diameter of 20’ located in warehousing, manufacturing, industrial or retail buildings[1] with forced air space heating, including unit heaters .

Base Equipment and Technologies Description

No destratification fan.

Decision Type	Target Market(s)	End Use
New, Replacement	Commercial (New or Existing)	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	6,129	-511	0	7,021	0
2	6,129	-511	0	0	0
3	6,129	-511	0	0	0
4	6,129	-511	0	0	0
5	6,129	-511	0	0	0
6	6,129	-511	0	0	0
7	6,129	-511	0	0	0
8	6,129	-511	0	0	0
9	6,129	-511	0	0	0
10	6,129	-511	0	0	0
11	6,129	-511	0	0	0
12	6,129	-511	0	0	0
13	6,129	-511	0	0	0
14	6,129	-511	0	0	0
15	6,129	-511	0	0	0
TOTALS	**91,935**	**-7,665**	**0**	**7,021**	**0**

[1] Buildings with a minimum of 25” ceilings.

Resource Savings Assumptions

Annual Natural Gas Savings	6,129 m^3

- Natural gas savings for destratification fans are calculated based on the assumptions summarized in the below table.

Variable Names and Symbols	Unit	Fan Sizes	
		24' diameter	20' diameter
A = Average indoor air temperature before destratification	°F	75	75
B = Heating average outside air temperature	°F	37	37
C = Thermostat setpoint temperature	°F	70	70

- Variables **A**, **B**, **C** are NCI estimates.
- Total Heating = Internal Heating[2] + Space Heating[3] = 72,547 kBtu + 891, 706 kBtu = 964,254 kBtu
- Assuming seasonal heating efficiency = 70%, reduction in heating input = Total Heating x (A – C) / (A – B) / 70%, the reduction in heating for both sizes of fans are calculated as:

Results	Unit	Fan Sizes	
		24' diameter	20' diameter
Reduction in Heating Input	kBTu	245,343	170,378
Natural Gas Savings	m^3/year	6,815	4,733

* Conversion between kBtu and m^3/year is 1 m^3 = 0.036 MMBtu

- Market share information for these two sizes of fans was obtained from Envira-North Systems Ltd[4]. The actual natural gas consumption data was based on Union Gas billing data[5].

Results	Unit	Fan Sizes	
		24' diameter	20' diameter
Space Heating Gas Usage	m^3/year	51,579	35,819
Estimated Market Shares	%	55	27

- The weighted average of natural gas baseline consumption and savings are calculated based on 55% and 27% market share for the two types of fans. The results are summarized as below:

	Weighted Average
Natural Gas Savings (m^3)	6,129
Baseline NG Consumption (m3)	46,389
Natural Gas Savings %	**13.2%**

- Baseline estimate of Natural Gas consumption = 46,389 (m^3)
- Natural Gas Savings % = Natural Gas Savings / Baseline Natural Gas Consumption = 13.2 %

Annual Electricity Savings	-511 kWh

- Electricity use = Fan motor power x 8,760 hours/year

	Fan Motor Power (W)	Operating Hours	Fan Electricity Use (kWh)
24' Fan	60	8,760	525.6
20' Fan	55	8,760	481.8
Weighted Average (Based on market share)			**511**

---

[2] The internal heating includes heat from other sources inside the building (e.g. lighting, people, machinery/plug) for each building type taken from DOE modelling files adjusted for Union service territories. Space heating is central furnace or boiler heating and is estimated based on a heating degree days analysis by Union Gas.

[3] Both internal heating and space heating are estimated by Union Gas based on its destratification fan program record.

[4] Envira-North Systems Ltd, http://www.enviranorth.com/

[5] Union Gas Commercial Quasi-Prescriptive Destratification Fan Savings Screening Tool

Annual Water Savings	0 L/CFM
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	15 Years
The estimated equipment life for de-stratification fans is 15 years[6]. This value is also supported by ASHRAE[7], which lists the service life for propeller fans as 15 years.	

Base & Incremental Conservation Measure Equipment and O&M Costs	$7,021

The weighted average costs are based on market shares described above and cost data[8].

	Fan Sizes	
Results	24' diameter	20' diameter
Incremental Cost for 1 Fan	$7,088	$6,885
Market Share	55%	27%
Weighted Average Cost	$7,021	

According to Envira-North (a local Canadian manufacturer of destratification fans), the suggested retail price for a de-stratification fan with a 2' drop from the ceiling, 2 HP and stealth blade is $6,000. For the 20' fan with 1' drop, 1 HP and a stellar blade, the price is $5,200.

Customer Payback Period (Natural Gas Only)[9]	2.3Years

Using a 5-year average commodity cost (avoided cost)[10] of $0.38 / m^3 and an average commercial distribution cost[11] of $0.12 / m^3, the payback period for natural gas savings is determined to be 2.3 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= $7,021 / (6,129 m^3/year * $0.5 / m^3)
= 2.3 years

Market Penetration[12]	Low

Based on conversations with suppliers of destratification fans, Navigant Consulting estimates that fewer than 5% of buildings in Ontario capable of installing the technology currently have them installed. Although this is considered to be low market penetration, this technology is relatively new and the penetration is steadily growing.

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
N/A	N/A	N/A	N/A	N/A

Comments
N/A

6 SEED Program Guideline, J-20, December 2004, http://www.oregon.gov/ENERGY/CONS/SEED/docs/AppendixJ.pdf
7 ASHRAE Handbook, HVAC Applications SI Edition. Chapter 36 – Table 4. Pg.36.3, 2007.
8 Targeted Market Study. HVLS Fans on Wisconsin Dairy Farms. State of Wisconsin Department of Administration Division of Energy. June 12, 2006., RSMeans. Mechanical Cost Data – 29th Annual Edition. 2006, and communications with Manufactures.
9 Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
10 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
11 Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
12 Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,

Energy Recovery Ventilator (ERV)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Ventilation with Energy Recovery Ventilator (ERV)
Base Equipment and Technologies Description
Ventilation without Energy Recovery Ventilator (ERV)

Decision Type	Target Market(s)	End Use
Replacement	Existing Commercial	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/CFM)	Electricity (kWh)	Water (L)	($/CFM)	($)
1	3.95	0	0	3	0
2	3.95	0	0	0	0
3	3.95	0	0	0	0
4	3.95	0	0	0	0
5	3.95	0	0	0	0
6	3.95	0	0	0	0
7	3.95	0	0	0	0
8	3.95	0	0	0	0
9	3.95	0	0	0	0
10	3.95	0	0	0	0
11	3.95	0	0	0	0
12	3.95	0	0	0	0
13	3.95	0	0	0	0
14	3.95	0	0	0	0
15	3.95	0	0	0	0
16	3.95	0	0	0	0
17	3.95	0	0	0	0
18	3.95	0	0	0	0
19	3.95	0	0	0	0
20	3.95	0	0	0	0
TOTALS	**59.25**	**0**	**0**	**3**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	3.95 m^3/CFM

- Natural gas savings are determined from engineering calculations utilizing inputs such as air flow, indoor/outdoor temperatures, indoor/outdoor and relative humidity.
- For example, input assumptions for a typical Ontario retail store are:

Symbols	Variable Names	Values	Source
A	Supply air flow (cfm)	500	UG†
B	Exhaust air flow (cfm)	500	UG
C	Average indoor air temperature (°F)	70	UG
D	Average indoor relative humidity (%)	30	UG
E	Average outside air temperature (°F)	31.5	UG
F	Average outdoor relative humidity (%)	70	NCI$^{\Delta}$
G	Atmospheric pressure (psia)	14.3	UG
H	No. of hours in heating season (hrs)	4,800	UG
I1	Demand Controlled Ventilation	no	UG
I2	No. of hours of operation per week (hrs/wk)	108	UG
J	Make and Model of Heat Recovery Equipment	Eng A, HRW-2100	UG
K	Effectiveness of Heat Recovery Equipment (%)	60	NCI
L	Sensible Heat Recovery Only	no	UG
M	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET exhaust air	22.0	UG
N	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET supply air	10.4	UG
O	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of OUTLET supply air	17.3	UG
P	Average Temperature of OUTLET supply air (°F)	55	UG
Q	Average Hourly Moisture Addition (lb/hr)	2.6	UG
R	Defrost Control Derating Factor (%)	5	UG
S	Average Hourly Heat Recovery (MBH)	14.7	UG
T	Seasonal Efficiency of Gas-Fired Equipment (%)	82	UG
U	Average annual gas reduction (m^3)	1,571	UG
V	Incremental natural gas rate ($/$m^3$)	0.3	UG
W	Average annual gas savings ($)	471.3	UG

†UG: Union Gas

$^{\Delta}$NCI: Navigant Consulting, Inc

- **NG Savings** = # of Hours in Heating Season x (operating hours/168) x Average Hourly Heat Recovery / (35.3 m^3/MJ) / (Seasonal Efficiency / 100%) **(A)**
  - 168 hour = 7 days/week x 24hours/day
  - Average Hourly Heat Recovery = Supply air flow x 60 x (Supply air flow – Inlet supply air)/Specific Supply Air Conditions Volume x (1 – Defrost Control De-rating Factor[1] %) **(B)**
- Operating hours for each sectors being considered are as the following

Building Occupancy	Typical Hrs of Operation per week
Hotel	168
Restaurant	108
Retail	108
Office	60
School	84
Health Care	168

[1] From Union Gas, all air-to-air heat recovery equipment requires frost control in colder climates to prevent freeze-up of exhaust air condensate on heat exchange components. Depending on the defrost control system, annual heat recovery estimates should be reduced by 5 to 15 %. Equipment manufacturers and suppliers can provide an estimated defrost derating factor given the operating conditions of the equipment.

Warehouse	168

- Based on the NG Savings formula (A) and input assumptions above, the natural gas savings for each of the commercial sectors are calculated, and a simple average is taken to be the general savings.

		Existing Buildings	
Market Segment	ERV Capacity (CFM)	NG Savings (m^3)	NG Savings per CFM (m^3/CFM)
Hotel	500	2,569	5.14
Restaurant	500	1,652	3.30
Retail	500	1,652	3.30
Office	500	918	1.84
School	500	1,285	2.57
Health Care	500	2,569	5.14
Nursing Home	500	2,569	5.14
Warehouse	500	2,569	5.14
Average (m^3/CFM)			**3.95**

Annual Electricity Savings	**0 kWh**
N/A	

Annual Water Savings	**0 L/CFM**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	20 Years
ERVs have an estimated service life of 15 years based on Jacques Whitford study[2]. Questar Gas[3] and Puget Sound[4] both report 20 years as an ERV's effective useful life. Navigant Consulting estimates 20 years as an effective useful life for ERVs.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$3/CFM**
The incremental costs are based on relative scaling of incremental costs $2,500 / 1000 CFM[5]. Based on communication with local contractors, the incremental costs are $3/CFM.	
Customer Payback Period (Natural Gas Only)[6]	**1.5 Years**
Using a 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average commercial distribution cost[8] of $0.12 / m^3, the payback period for natural gas savings is determined to be 1.5 years, based on the following: On a per CFM basis, Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $3 / (3.95 m^3/year * $0.5 / m^3) = 1.5 years	
Market Penetration[9]	**Low**
Based on Jacques Whitford report[10] (less than 5% market penetration) and communication with local contractors, Navigant Consulting estimates the market penetration of ERV to be low.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy, 2007[11]	0.105 per sqft	20	1	N/A
Comments Baseline therm reported on a square footage basis (e.g. 0.19 therms/sq.ft. for offices). Estimated 20% savings over the baseline. Incremental cost is reported on a per square footage basis. Equivalent savings is 0.19 therms/sq.ft x 2.75 m^3/therms x 20% = 0.105 m^3 / sq.ft				

[2] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[3] Questar Gas, DSM Market Characterization Report, by Nexant, August 9, 2006
[4] Quantec — Puget Sound Energy Demand-Side Management Resource Assessment
[5] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[11] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

Energy Recovery Ventilator (ERV)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Ventilation with ERV
Base Equipment and Technologies Description
Ventilation without ERV

Decision Type	Target Market(s)	End Use
New	New Commercial	Space Heating

Codes, Standards, and Regulations

1) Restriction for new building construction: This measure is not applicable to system ≥5,000 CFM with ≥70% OA ratio because energy recovery is required by Ontario Building Code 2006.
2) Restriction for new building construction: This measure is not applicable to systems serving health care spaces indicated in **Table 1** because heat recovery is required by CSA Z317.2-01

Table 1 - Health Care Spaces Not Eligible		
Anaesthetic gas scavenging	Cart and can washers	Areas using hazardous gases
Animal facilities	Chemical storage	Isolation rooms
Autopsy suite	Cooking facilities	Perchloric hoods
Biohazard and fume hoods	Ethylene oxide	Radioisotope hoods

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/CFM)	Electricity (kWh)	Water (L)	($/CFM)	($)
1	3.75	0	0	3	0
2	3.75	0	0	0	0
3	3.75	0	0	0	0
4	3.75	0	0	0	0
5	3.75	0	0	0	0
6	3.75	0	0	0	0
7	3.75	0	0	0	0
8	3.75	0	0	0	0
9	3.75	0	0	0	0
10	3.75	0	0	0	0
11	3.75	0	0	0	0
12	3.75	0	0	0	0
13	3.75	0	0	0	0
14	3.75	0	0	0	0
15	3.75	0	0	0	0
16	3.75	0	0	0	0
17	3.75	0	0	0	0
18	3.75	0	0	0	0
19	3.75	0	0	0	0
20	3.75	0	0	0	0
TOTALS	**75**	**0**	**0**	**3**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	3.75 m^3/CFM

- Natural gas savings are determined from engineering calculations utilizing inputs such as air flow, indoor/outdoor temperatures, indoor/outdoor and relative humidity.
- For example, input assumptions for a typical Ontario retail store are:

Symbols	Variable Names	Values	Source
A	Supply air flow (cfm)	500	UG†
B	Exhaust air flow (cfm)	500	UG
C	Average indoor air temperature (^oF)	70	UG
D	Average indoor relative humidity (%)	30	UG
E	Average outside air temperature (^oF)	31.5	UG
F	Average outdoor relative humidity (%)	70	NCI$^\Delta$
G	Atmospheric pressure (psia)	14.3	UG
H	No. of hours in heating season (hrs)	4,800	UG
I1	Demand Controlled Ventilation	no	UG
I2	No. of hours of operation per week (hrs/wk)	108	UG
J	Make and Model of Heat Recovery Equipment	Eng A, HRW-2100	UG
K	Effectiveness of Heat Recovery Equipment (%)	60	NCI
L	Sensible Heat Recovery Only	no	UG
M	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET exhaust air	22.0	UG
N	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET supply air	10.4	UG
O	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of OUTLET supply air	17.3	UG
P	Average Temperature of OUTLET supply air (^oF)	55	UG
Q	Average Hourly Moisture Addition (lb/hr)	2.6	UG
R	Defrost Control Derating Factor (%)	5	UG
S	Average Hourly Heat Recovery (MBH)	14.7	UG
T	Seasonal Efficiency of Gas-Fired Equipment (%)	82	UG
U	Average annual gas reduction (m^3)	1,571	UG
V	Incremental natural gas rate (\$/m^3)	0.3	UG
W	Average annual gas savings (\$)	471.3	UG

†UG: Union Gas

$^\Delta$NCI: Navigant Consulting, Inc

NG Savings = # of Hours in Heating Season x (operating hours/168) x Average Hourly Heat Recovery / (35.3 m^3/MJ) / (Seasonal Efficiency / 100%) **(A)**

- 168 hour = 7 days/week x 24hours/day

Average Hourly Heat Recovery = Supply air flow x 60 x (Supply air flow – Inlet supply air)/Specific Supply Air Conditions Volume x (1 – Defrost Control De-rating Factor[1] %) **(B)**

- Operating hours for each sectors being considered are as the following

Building Occupancy	Typical Hrs of Operation per week
Hotel	168
Restaurant	108
Retail	108
Office	60
School	84
Health Care	168
Nursing Home	168

[1] From Union Gas, all air-to-air heat recovery equipment requires frost control in colder climates to prevent freeze-up of exhaust air condensate on heat exchange components. Depending on the defrost control system, annual heat recovery estimates should be reduced by 5 to 15 %. Equipment manufacturers and suppliers can provide an estimated defrost derating factor given the operating conditions of the equipment.

Warehouse	168

- New buildings and existing buildings mainly differ in the enthalpy (BTU/LBa) that is used to calculate the Specific Supply Air Conditions Volume in formula **(B).**
- Based on the NG Savings formula **(A)** and input assumptions above, the natural gas savings for each of the commercial sectors are calculated, and a simple average is taken to be the general savings.

Market Segment	ERV Capacity (CFM)	New Buildings: NG Savings (m^3)	New Buildings: NG Savings per CFM (m^3/CFM)
Hotel	500	2,444	4.89
Restaurant	500	1,571	3.14
Retail	500	1,571	3.14
Office	500	873	1.75
School	500	1,222	2.44
Health Care	500	2,444	4.89
Nursing Home	500	2,444	4.89
Warehouse	500	2,444	4.89
Average (m^3/CFM)			**3.75**

Annual Electricity Savings	**0 kWh**
N/A	
Annual Water Savings	**0 L**
N/A	

Other Input Assumptions

Effective Useful Life (EUL)	**20 Years**
ERVs have an estimated service life of 15 years based on Jacques Whitford study[2]. Questar Gas[3] and Puget Sound[4] both report 20 years as an ERV's effective useful life. Navigant Consulting estimates 20 years as an effective useful life for ERVs.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$3 / CFM**
The incremental costs are based on relative scaling of incremental costs $2,500 / 1000 CFM[5]. Based on communication with local contractors, the incremental costs are $3/CFM.	
Customer Payback Period (Natural Gas Only)[6]	**1.6 Years**
Using an 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average commercial distribution cost[8] of $0.12 / m^3, the payback period for natural gas savings is determined to be 1.6 years, based on the following:	

[2] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.

[3] Questar Gas, DSM Market Characterization Report, by Nexant, August 9, 2006

[4] Quantec — Puget Sound Energy Demand-Side Management Resource Assessment

[5] Ibid.

[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

On a per CFM basis, Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$3 / (3.75 m^3/year * \$0.5 / m^3) = 1.6 years

Market Penetration[9]	**Low**
Based on Jacques Whitford report[10] (less than 5% market penetration) and communication with local contractors, Navigant Consulting estimates the market penetration of ERV to be low.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost (\$)	Penetration/Market Share
Puget Sound Energy, 2007[11]	0.105 per sqft	20	1	N/A
Comments Baseline therm reported on a square footage basis (eg 0.19 therms/sq.ft. for offices). Estimated 20% savings over the baseline. Incremental cost is reported on a per square footage basis. Equivalent savings is 0.19 therms/sq.ft x 2.75 m^3/therms x 20% = 0.105 m^3 / sq.ft				

[9] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,

[10] “Prescriptive Incentives for Selected Natural Gas Technologies”, Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.

[11] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

Enhanced Furnace (Electronically Commutated Motor) – Existing Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Gas furnace equipped with an electronically commutated motor (ECM)

Base Equipment and Technologies Description
Gas furnace with a permanent split capacitor (PSC) motor

Decision Type	Target Market(s)	End Use
Replace	Commercial Existing Buildings	Space Heating

Codes, Standards, and Regulations

- Under Ontario's building code, all gas furnaces installed in new residential constructions must meet a minimum condensing efficiency level effective January 1, 2007.[1]
- There is no minimum energy performance standard restricting the electricity consumption of furnace fan blowers.
- NRCan proposes to increase the minimum performance level, the Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces with an input rate not exceeding 65.92 kW (225,000 Btu/h) to 90% for December 31, 2009[2].

[1] Ministry of Energy, "Heating and Cooling your Home: A Conservation Guide", Reproduced with the permission of Natural Resource Canada, 2004. http://www.energy.gov.on.ca/english/pdf/conservation/heating_and_cooling_your_home.pdf
[2] Office of Energy Efficiency, Canada's Energy Efficiency Regulations, Proposed Regulations Bulletin, March 2007. http://www.oee.nrcan.gc.ca/regulations/bulletin/gas-furnace-mar2007.cfm?Text=N&PrintView=N

Resource Savings Table (for 2 different cases)

Continuous Fan Usage

Year (EUL=)	Electricity and Other Resource Savings: Natural Gas (m³/kBtu/h)	Electricity (kWh/kBtu/h)	Water (L)	Equipment & O&M Costs of Conservation Measure ($)	Equipment & O&M Costs of Base Measure[3] ($)
1	-2.7	20.5	0	960	0
2	-2.7	20.5	0	0	0
3	-2.7	20.5	0	0	0
4	-2.7	20.5	0	0	0
5	-2.7	20.5	0	0	0
6	-2.7	20.5	0	0	0
7	-2.7	20.5	0	0	0
8	-2.7	20.5	0	0	0
9	-2.7	20.5	0	0	0
10	-2.7	20.5	0	0	0
11	-2.7	20.5	0	0	0
12	-2.7	20.5	0	0	0
13	-2.7	20.5	0	0	0
14	-2.7	20.5	0	0	0
15	-2.7	20.5	0	0	0
TOTALS	**-40.7**	**308.2**	**0**	**960**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	-2.7 m^3 / kBtu / h

Continuous fan usage and non-continuous fan usage is estimated to be 26% and 74%, respectively, based on Ontario customer survey results[4]. Navigant Consulting is assuming the same mix of furnace fan usage for commercial application.

A study conducted by the Canadian Center for Housing Technologies determined that the annual gas use of a typical existing home with a continuous ECM actually *increases* by 180m^3 for high efficiency furnaces (AFUE 92) and 202 m^3 for mid-efficiency furnaces (AFUE 82)[5]. The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency based on recent survey results for residential furnaces[6] (also assuming same mix for commercial application), resulting in an average increase of 183 m^3.

The CCHT study gives a baseline gas usage as 2,769 m^3 for high efficiency furnaces and 3,107m^3 for mid-efficiency furnaces[7]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical home with a PSC motor is expected to use 2,810 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 2,993 m^3 of natural gas (2,810 + 183), or an increase of 6.5% over the baseline.

According to the CCHT report[8], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the natural gas savings on a kBTU/h basis is -183 m^3 / 67.5 kBtu/h = -2.7m^3/kBtu/h.

---

[3] US DOE Energy Star Furnace Calculator, "Assumptions" tab. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls

[4] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.

[5] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

[6] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.

Annual Electricity Savings	20.5 kWh / kBtu / h

Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions Lists[9], the electricity savings for an existing home using an ECM are estimated to be 1,387 kWh/year for continuous furnace fan usage. This represents a saving of 72% over a conventional PSC motor.

These results are based on the same CCHT study, which determined that annual electricity savings for an existing home using a gas furnace with a continuous ECM for heating only are 1,535 kWh for high efficiency furnaces (AFUE 92) and 1,545 kWh for mid-efficiency furnaces (AFUE 82)[10]. Since it is unlikely that the furnace fan will run continuously during the shoulder season, the OPA assumes that during the shoulder season the same electricity savings from a non-continuous ECM are applicable. Navigant Consulting is assuming the same electricity savings for residential furnaces are applicable for commercial applications.

According to the CCHT report[11], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the electricity savings on a kBTU/h basis are estimated to be 1,387 / 67.5 kBtu/h = 20.5 kWh/kBtu/h

Annual Water Savings	0 L

N/A

Non-Continuous Fan Usage

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure[12]
Year (EUL=)	Natural Gas (m^3/kBtu/h)	Electricity (kWh/kBtu/h)	Water (L)	($)	($)
1	-0.4	4.8	0	960	0
2	-0.4	4.8	0	0	0
3	-0.4	4.8	0	0	0
4	-0.4	4.8	0	0	0
5	-0.4	4.8	0	0	0
6	-0.4	4.8	0	0	0
7	-0.4	4.8	0	0	0
8	-0.4	4.8	0	0	0
9	-0.4	4.8	0	0	0
10	-0.4	4.8	0	0	0
11	-0.4	4.8	0	0	0
12	-0.4	4.8	0	0	0
13	-0.4	4.8	0	0	0
14	-0.4	4.8	0	0	0
15	-0.4	4.8	0	0	0
TOTALS	**-5.3**	**72**	**0**	**960**	**0**

Resource Savings Assumptions

7 The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
8 Ibid.
9 Ontario Power Authority, 2009 OPA Measures and Assumptions List (Mass Market), November 2008.
10 The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
11 Ibid.
12 US DOE Energy Star Furnace Calculator, "Assumptions" tab. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls

Annual Natural Gas Savings	$-0.4\ m^3$ / kBtu / h

Continuous fan usage and non-continuous fan usage is estimated to be 26% and 74%, respectively, based on Ontario customer survey results[13]. Navigant Consulting is assuming the same mix of furnace fan usage for commercial application.

A study conducted by the Canadian Center for Housing Technologies determined that a the annual gas use of a typical existing home with a non-continuous ECM actually *increases* by 26 m^3 for high efficiency furnaces (AFUE 92) and 29 m^3 for mid-efficiency furnaces (AFUE 82)[14] The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency based on recent survey results for residential furnaces[15], resulting in an average increase of 26.4 m^3.

The CCHT study gives a baseline gas usage as 2,953 m^3 for high efficiency furnaces and 3,313 m^3 for mid-efficiency furnaces[16]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical home with a PSC motor is expected to use 2,996 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 3,022 m^3 of natural gas (2,996 + 26), or an increase of 0.9% over the baseline.

According to the CCHT report[17], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the natural gas savings on a kBTU/h basis is -26.4 m^3 / 67.5 kBtu/h = -0.4 m^3/kBtu/h.

Annual Electricity Savings	4.8 kWh / kBtu / h

Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions List[18], the electricity savings for a new home using an ECM are estimated to be 324 kWh/year for non-continuous furnace fan use. This represents a saving of 40% over a conventional PSC motor.

These results are based on the same CCHT study, which determined that annual electricity savings for a new home using a gas furnace with an ECM for heating only are 324 kWh for both high efficiency furnaces (AFUE 92) mid-efficiency furnaces (AFUE 82)[19]. Navigant Consulting is assuming the same electricity savings for residential furnaces are applicable for commercial applications.

According to the CCHT report[20], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the electricity savings on a kBTU/h basis is estimated to be 324 / 67.5 kBtu/h = 4.8 kWh/kBtu/h.

Annual Water Savings	0 L

N/A

---

13 Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
14 The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
15 Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
16 The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
17 Ibid.
18 Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.
19 The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
20 Ibid.

Other Input Assumptions

Effective Useful Life (EUL)	15 Years
An OPA commissioned study by Seeline Group Inc. suggests a useful life of 15 years. Furthermore, a June 2007 study by GDS Associates, Inc.[21] for New England State Program Working Group (SPWG) also suggests 15 years. Finally, Iowa Utilities[22] also uses 15 years as an effective useful life for an ECM.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**$960**
Based on the average of a survey of prices from HVAC contractors in Ontario[23], the incremental cost for residential ECM's are estimated to be $960. This incremental cost is assumed to be the same for commercial furnaces. Incremental costs were confirmed through communication with additional HVAC contractors.	
Customer Payback Period (Natural Gas Only)[24]	**Continuous = 14 years** **Non-Continuous = 31 years**

Since natural gas usage increases with an ECM, Navigant Consulting has used both natural gas and electricity savings to calculate the customer payback period.

For Natural Gas Usage:
Combining a 5-year average commodity cost (avoided cost)[25] of $0.38 / m^3 and an average commercial distribution cost[26] of $0.12 / m^3, the total cost of natural gas for typical commercial customers is determined to be $0.50.

For Electricity Savings:
An average commodity and distribution cost of $0.09 / kWh is assumed for commercial customers.

For customer payback calculations, Navigant Consulting is assuming a commercial furnace which to be double the size of a residential furnace, or 135 kBtu/h (67,500 Btu/h x 2 = 135,000 Btu/h or 135 kBTU/hr).

The payback period incorporating both natural gas usage and electricity savings is determined to be 14 years for continuous usage and 31 years for non-continuous furnace fan usage, based on the following:

Payback Period = Incremental cost / [(natural gas savings x natural gas cost) + (electricity savings x electricity cost)]

Continuous Fan Usage:
= $960 / [135 kBtu/hr x ((-2.7 m^3/ kBtu/h / year * $0.50 / m^3) + (20.5 kWh / kBtu/h / year * $0.09 / kWh))]
= 14 years

Non-Continuous Fan Usage:
= $960 / [135 kBtu/hr x ((-0.4 m^3/ kBtu/h / year * $0.50 / m^3) + (4.8 kWh / kBtu/h / year *

21 GDS Associates Inc, Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG) For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007.
22 Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
23 Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
24 Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
25 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
26 Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

$0.09 / kWh)] = 31 years

Market Share[27]	Low
Although the benefits of electronically commutated motors are increasingly being promoted by the industry, the overall market share still remains low in the commercial retrofit market, as seen in another jurisdiction (Iowa reports a 5% market penetration for commercial buildings[28]). Therefore, Navigant Consulting estimates the market share in Ontario to be low.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
2009 OPA Measures and Assumptions List[29]	-80.1m^3 (continuous) 22.6m^3 (non-continuous)	15	$960	N/A
Comments Assumptions made in the OPA Measures and Assumptions List are the same assumptions that are made in the above tables.				

[27] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[28] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[29] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.

Enhanced Furnace (Electronically Commutated Motor) – New Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Gas furnace equipped with an electronically commutated motor (ECM)
Base Equipment and Technologies Description
Gas furnace with a permanent split capacitor (PSC) motor

Decision Type	Target Market(s)	End Use
New	Commercial New Construction	Space Heating

Codes, Standards, and Regulations

- Under Ontario's building code, all gas furnaces installed in new residential constructions must meet a minimum condensing efficiency level effective January 1, 2007.[1]
- There is no minimum energy performance standard restricting the electricity consumption of furnace fan blowers.
- NRCan proposes to increase the minimum performance level, the Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces with an input rate not exceeding 65.92 kW (225,000 Btu/h) to 90% for December 31, 2009.[2]

Resource Savings Table (for 2 different cases)

Continuous Fan Usage

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/kBtu/h)	Electricity (kWh/kBtu/h)	Water (L)	($)	($)
1	-2.5	20.8	0	960	0
2	-2.5	20.8	0	0	0
3	-2.5	20.8	0	0	0
4	-2.5	20.8	0	0	0
5	-2.5	20.8	0	0	0
6	-2.5	20.8	0	0	0
7	-2.5	20.8	0	0	0
8	-2.5	20.8	0	0	0
9	-2.5	20.8	0	0	0
10	-2.5	20.8	0	0	0
11	-2.5	20.8	0	0	0
12	-2.5	20.8	0	0	0
13	-2.5	20.8	0	0	0
14	-2.5	20.8	0	0	0
15	-2.5	20.8	0	0	0
TOTALS	**-36.9**	**311.8**	**0**	**960**	**0**

[1] Ministry of Energy, "Heating and Cooling your Home: A Conservation Guide." Reproduced with the permission of Natural Resource Canada, 2004. http://www.energy.gov.on.ca/english/pdf/conservation/heating_and_cooling_your_home.pdf
[2] Office of Energy Efficiency, Canada's Energy Efficiency Regulations, Proposed Regulations Bulletin, March 2007. http://www.oee.nrcan.gc.ca/regulations/bulletin/gas-furnace-mar2007.cfm?Text=N&PrintView=N

Resource Savings Assumptions

Annual Natural Gas Savings	-2.5 m^3 / kBtu / h

Continuous fan usage and non-continuous fan usage is estimated to be 26% and 74%, respectively, based on Ontario customer survey results[3]. Navigant Consulting is assuming the same mix of furnace fan usage for commercial application.

A study conducted by the Canadian Center for Housing Technologies determined that a the annual gas use of a typical new home with a continuous ECM actually *increases* by 164m^3 for high efficiency furnaces (AFUE 92) and 184m^3 for mid-efficiency furnaces (AFUE 82)[4]. The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency based on recent survey results for residential furnaces[5], resulting in an average increase of 166.4m^3. Navigant Consulting is assuming the same mix of furnace fan usage for commercial application.

The CCHT study gives a baseline gas usage as 1,744 m^3 for high efficiency furnaces and 1,957 m^3 for mid-efficiency furnaces[6]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical furnace with a PSC motor is expected to use 1,770 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 1,936 m^3 of natural gas (1,770 + 166), or an increase of 9.4 % over the baseline.

According to the CCHT report[7], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the natural gas savings on a kBTU/h basis is -166 m^3 / 67.5 kBtu/h = -2.5 m^3/kBtu/h.

[3] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[4] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[5] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[6] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
[7] Ibid.

Annual Electricity Savings	20.8 kWh / kBtu / h

Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions Lists[8], the electricity savings for a new home using an ECM are estimated to be 1,403 kWh/year for continuous furnace fan use. This represents a savings of 78% over a conventional PSC motor.

These results are based on the same CCHT study, which determined that annual electricity savings for a new home using a gas furnace with an ECM for heating only are 1,569 kWh for high efficiency furnaces (AFUE 92) and 1,571 kWh for mid-efficiency furnaces (AFUE 82)[9] Since it is unlikely that the furnace fan will run continuously during the shoulder season, the OPA assumes that during the shoulder season the same electricity savings from a non-continuous ECM are applicable. Navigant Consulting is assuming the same electricity savings for residential furnaces are applicable for commercial applications.

According to the CCHT report[10], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the electricity savings on a kBTU/h basis are estimated to be 1,403 / 67.5 kBtu/h = 20.8 kWh/kBtu/h.

Annual Water Savings	0 L

N/A

Non-Continuous Fan Usage

Year (EUL=)	Electricity and Other Resource Savings: Natural Gas (m^3/kBtu/h)	Electricity (kWh/kBtu/h)	Water (L)	Equipment & O&M Costs of Conservation Measure ($)	Equipment & O&M Costs of Base Measure[11] ($)[12]
1	-0.3	3.1	0	960	0
2	-0.3	3.1	0	0	0
3	-0.3	3.1	0	0	0
4	-0.3	3.1	0	0	0
5	-0.3	3.1	0	0	0
6	-0.3	3.1	0	0	0
7	-0.3	3.1	0	0	0
8	-0.3	3.1	0	0	0
9	-0.3	3.1	0	0	0
10	-0.3	3.1	0	0	0
11	-0.3	3.1	0	0	0
12	-0.3	3.1	0	0	0
13	-0.3	3.1	0	0	0
14	-0.3	3.1	0	0	0
15	-0.3	3.1	0	0	0
TOTALS	**-4.5**	**46**	**0**	**960**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	-0.3 m^3 / kBtu / h

Continuous fan usage and non-continuous fan usage is estimated to be 26% and 74%, respectively, based on Ontario customer survey results[13]. Navigant Consulting is assuming the same mix of furnace fan usage for commercial application.

---

8 Ontario Power Authority, 2009 OPA Measures and Assumptions List (Mass Market), November 2008.
9 The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf
10 Ibid.
11 USDOE Energy Star Furnace Calculator, "Assumptions" tab. http://www.energystar.gov/ia/business/bulk_purchasing/bpsavings_calc/Calc_Furnaces.xls
12 The 2007 average exchange rate from US dollar to Canadian dollar is US$1 = CA$1.07. This rate is used to convert USDOE base furnace cost to Canadian dollars. http://www.x-rates.com/d/CAD/USD/hist2007.html
13 Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.

A study conducted by the Canadian Center for Housing Technologies determined that a the annual gas use of a typical new home with a non-continuous ECM actually *increases* by 18 m^3 for high efficiency furnaces (AFUE 92) and 20 m^3 for mid-efficiency furnaces (AFUE 82)[14] The increase in natural gas consumption is a result of the reduction of heat added to the home from the decrease in electricity usage by the furnace motor. NCI assumes that 12% of new furnaces are mid-efficiency and 88% of furnaces are high efficiency on recent survey results for residential furnaces[15], resulting in an average increase of 18.2 m^3. Navigant Consulting is assuming the same mix of furnace fan usage for commercial application.

The CCHT study gives a baseline gas usage as 1,907 m^3 for high efficiency furnaces and 2,140 m^3 for mid-efficiency furnaces[16]. Using the same mix of high-efficiency and mid-efficiency furnaces as above, a typical home with a PSC motor is expected to use 1,935 m^3. Using an energy efficient motor (ECM), a typical home is expected to use 1,953 m^3 of natural gas (1,935 + 18), or an increase of 0.9% over the baseline.

According to the CCHT report[17], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the natural gas savings on a kBTU/h basis is -18.2 m^3 / 67.5 kBtu/h = -0.3 m^3/kBtu/h.

Annual Electricity Savings	3.1 kWh / kBtu / h

Based on the Ontario Power Authority's 2009 OPA Measure and Assumptions List[18], the electricity savings for a new home using an ECM are estimated to be 207 kWh/year for non-continuous furnace fan use. This represents a savings of 40% over a conventional PSC motor.

These results are based on the same CCHT study, which determined that annual electricity savings for a new home using a gas furnace with an ECM for heating only are 207 kWh for both high efficiency furnaces (AFUE 92) mid-efficiency furnaces (AFUE 82)[19]. Navigant Consulting is assuming the same electricity savings for residential furnaces are applicable for commercial applications.

According to the CCHT report[20], the residential furnace capacity is 67,500 Btu/h. Assuming savings for an ECM used for commercial applications do not significantly differ from a residential furnace, the electricity savings on a kBTU/h basis is estimated to be 207 / 67.5 kBtu/h =3.1 kWh/kBtu/h.

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	15 Years

An OPA commissioned study by Seeline Group Inc. suggests a useful life of 15 years. Furthermore, a June 2007 study by GDS Associates, Inc.[21] for New England State Program Working Group (SPWG) also suggests 15 years. Finally, Iowa Utilities[22] also uses 15 years as an effective useful life for an ECM.

---

[14] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

[15] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.

[16] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

17 Ibid.

[18] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.

[19] The Canadian Center for Housing Technologies, "Final Report on the Effects of ECM Furnace Motors on Electricity and Gas Use: Results from the CCHT Research Facility and Projections" http://irc.nrccnrc.gc.ca/pubs/fulltext/nrcc38500/nrcc38500.pdf

20 Ibid.

[21] GDS Associates Inc, Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG) For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007.

[22] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131

Base & Incremental Conservation Measure Equipment and O&M Costs	$960

Based on the average of a survey of prices from HVAC contractors in Ontario[23], the incremental cost is estimated to be $960. Incremental costs were confirmed through communication with additional HVAC contractors.

Customer Payback Period (Natural Gas and Electricity)	Continuous = 11 years Non-Continuous = 55 years

Since natural gas usage increases with an ECM, Navigant Consulting has used both natural gas and electricity savings to calculate the customer payback period.

For Natural Gas Usage:

Combining a 5-year average commodity cost (avoided cost)[24] of $0.38 / m^3 and an average commercial distribution cost[25] of $0.12 / m^3, the total cost of natural gas for typical commercial customers is determined to be $0.50.

For Electricity Savings:

An average commodity and distribution cost of $0.09 / kWh is assumed for commercial customers.

For customer payback calculations, Navigant Consulting is assuming a commercial furnace to be double the size of a residential furnace, or 135 kBtu/h (67,500 Btu/h x 2 = 135,000 Btu/h or 135 kBTU/hr).

The payback period incorporating both natural gas usage and electricity savings is determined to be 11 years for continuous usage and 55 years for non-continuous furnace fan usage, based on the following:

Payback Period = Incremental cost / [(natural gas savings x natural gas cost) + (electricity savings x electricity cost)]

Continuous Fan Usage:

= $960 / [135 kBtu/hr x ((-2.5 m^3/ kBtu/h / year * $0.50 / m^3) + (20.8 kWh / kBtu/h / year * $0.09 / kWh))]

= 11 years

Non-Continuous Fan Usage:

= $960 / [135 kBtu/hr x ((-0.3 m^3/ kBtu/h / year * $0.50 / m^3) + (3.1 kWh / kBtu/h / year * $0.09 / kWh)]

= 55 years

Market Share[26]	Low

Although the benefits of electronically commutated motors are increasingly being promoted by the industry, the overall market share still remains low in the commercial retrofit market, as seen in another jurisdictions (Iowa reports a 5% market penetration for commercial buildings[27]). Therefore, Navigant Consulting estimates the market share in Ontario to be low.

[23] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008, based on Navigant Consulting, Evaluation Report: 2007 Hot and Cool Savings Programs, prepared for the Ontario Power Authority (OPA), July 2008.
[24] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[25] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[26] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[27] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
Efficiency Vermont Technical Resources[28]	0	18	$200 (USD)	
Comments A furnace meeting minimum Federal efficiency standards using a low-efficiency permanent split capacitor (PSC) fan motor is replaced with a high efficiency an ENERGY STAR® qualified furnace with a high-efficiency ECM. Vermont suggests electricity savings of 393 kWh/yr for space heating.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
2009 OPA Measures and Assumptions List[29]	-66.8m^3 (continuos usage) 30.6m^3 (non-continuos)	15	$960	
Comments Assumptions made in the OPA Measures and Assumptions Lists are the same assumptions that are made in the above tables.				

[28] Efficiency Vermont. Residential Master Technical Reference Manual. Number 2005-37 Measure Savings Algorithms and Cost Assumptions. February 2006.

[29] Ontario Power Authority, 2009 OPA Measures and Assumptions Lists (Mass Market), November 2008.

Heat Recovery Ventilator (HRV) – Existing Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Ventilation with HRV
Base Equipment and Technologies Description
Ventilation without HRV

Decision Type	Target Market(s)	End Use
Retrofit	Existing Commercial	Space Heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/CFM)	Electricity (kWh)	Water (L)	($/CFM)	($)
1	3.77	0	0	3.4	0
2	3.77	0	0	0	0
3	3.77	0	0	0	0
4	3.77	0	0	0	0
5	3.77	0	0	0	0
6	3.77	0	0	0	0
7	3.77	0	0	0	0
8	3.77	0	0	0	0
9	3.77	0	0	0	0
10	3.77	0	0	0	0
11	3.77	0	0	0	0
12	3.77	0	0	0	0
13	3.77	0	0	0	0
14	3.77	0	0	0	0
15	3.77	0	0	0	0
16	3.77	0	0	0	0
17	3.77	0	0	0	0
18	3.77	0	0	0	0
19	3.77	0	0	0	0
20	3.77	0	0	0	0
TOTALS	**75.4**	**0**	**0**	**3.4**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	$3.77\ m^3$ / CFM

- Natural gas savings are determined from engineering calculations utilizing inputs such as air flow, indoor/outdoor temperatures, indoor/outdoor and relative humidity.
- For example, input assumptions for a typical Ontario retail store are:

Symbols	Variable Names	Values	Source
A	Supply air flow (cfm)	500	UG[†]
B	Exhaust air flow (cfm)	500	UG
C	Average indoor air temperature (^oF)	70	UG
D	Average indoor relative humidity (%)	30	UG
E	Average outside air temperature (^oF)	31.5	UG
F	Average outdoor relative humidity (%)	70	NCI[Δ]
G	Atmospheric pressure (psia)	14.3	UG
H	No. of hours in heating season (hrs)	4,800	UG
I1	Demand Controlled Ventilation	no	UG
I2	No. of hours of operation per week (hrs/wk)	108	UG
J	Make and Model of Heat Recovery Equipment	Eng A, HRW-2100	UG
K	Effectiveness of Heat Recovery Equipment (%)	70	NCI
L	Sensible Heat Recovery Only	yes	UG
M	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET exhaust air	22.0	UG
N	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET supply air	10.4	UG
O	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of OUTLET supply air	16.9	UG
P	Average Temperature of OUTLET supply air (^oF)	58	UG
Q	Average Hourly Moisture Addition (lb/hr)	0.0	UG
R	Defrost Control Derating Factor (%)	5	UG
S	Average Hourly Heat Recovery (MBH)	13.7	UG
T	Seasonal Efficiency of Gas-Fired Equipment (%)	82	UG
U	Average annual gas reduction (m^3)	1,461	UG
V	Incremental natural gas rate ($/$m^3$)	0.3	UG
W	Average annual gas savings ($)	438.4	UG

[†] *UG: Union Gas*

[Δ] *NCI: Navigant Consulting, Inc*

- **NG Savings** = # of Hours in Heating Season x (operating hours/168) x Average Hourly Heat Recovery / (35.3 m^3/MJ) / (Seasonal Efficiency / 100%) **(A)**
  - 168 hour = 7 days/week x 24hours/day
  - Average Hourly Heat Recovery = Supply air flow x 60 x (Supply air flow – Inlet supply air)/Specific Supply Air Conditions Volume x (1 – Defrost Control De-rating Factor[1] %) **(B)**
- Operating hours for each sectors being considered are as the following

Building Occupancy	Typical Hrs of Operation per week
Hotel	168
Restaurant	108
Retail	108
Office	60
School	84
Health Care	168
Nursing Home	168
Warehouse	168

- New buildings and existing buildings mainly differ in enthalpy (BTU/LBa) that is used to calculate the

[1] From Union Gas, all air-to-air heat recovery equipment requires frost control in colder climates to prevent freeze-up of exhaust air condensate on heat exchange components. Depending on the defrost control system, annual heat recovery estimates should be reduced by 5 to 15 %. Equipment manufacturers and suppliers can provide an estimated defrost derating factor given the operating conditions of the equipment.

Specific Supply Air Conditions Volume in formula **(B).**

- Based on the NG Savings formula **(A)** and input assumptions above, the natural gas savings for each of the commercial sectors are calculated, and a simple average is taken to be the general savings.

Market Segment	HRV Capacity (CFM)	Existing Buildings NG Savings (m^3)	Existing Buildings NG Savings per CFM (m^3/CFM)
Hotel	500	2,452	4.90
Restaurant	500	1,576	3.15
Retail	500	1,576	3.15
Office	500	876	1.75
School	500	1,226	2.45
Health Care	500	2,452	4.90
Nursing Home	500	2,452	4.90
Warehouse	500	2,452	4.90
Average (m^3/CFM)			**3.77**

Annual Electricity Savings	**0 kWh**

N/A

Annual Water Savings	**0 L / CFM**

N/A

Other Input Assumptions

Effective Useful Life (EUL)	**20 Years**

HRVs have an estimated service life of 15 years based on Jacques Whitford study[2]. Since Questar Gas[3] and Puget Sound[4] both report 20 years as its effective useful life, Navigant also estimates the EUL to be 20 years.

Base & Incremental Conservation Measure Equipment and O&M Costs	**$3.4 / CFM**

The incremental costs are based on relative scaling of incremental costs $1,700 / 500 CFM[5].

Customer Payback Period (Natural Gas Only)[6]	**1.8 Years**

Using an 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average commercial distribution cost[8] of $0.12 / m^3, the payback period for natural gas savings is determined to be 1.8 years, based on the following:

On a per CFM basis,

Payback Period = Incremental cost / (natural gas savings x natural gas cost)

= $3.4 / (3.77 m^3/year * $0.5 / m^3)

= 1.8 years

---

[2] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[3] Questar Gas, DSM Market Characterization Report, by Nexant, August 9, 2006
[4] Quantec — Puget Sound Energy Demand-Side Management Resource Assessment
[5] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration[9]	Low
Based on Jacques Whitford report[10] (less than 5% market penetration) and communication with local contractors, Navigant Consulting estimates the market penetration of HRV to be low.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Questar Gas[11]	670	20	1,785	N/A
Comments Specifications for HRVs are not provided in the report, nor the baseline assumptions.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Puget Sound Energy[12]	0.1045 per ft^2	20	1	N/A
Comments Baseline therm reported on a square footage basis (eg 0.19 therms/sq.ft. for offices). Estimated 20% savings for new energy efficient technology is reported as a percent saving over the baseline. Incremental cost is reported on a per square footage basis. Equivalent savings is 0.19 therms/sq.ft. x 2.75 m^3/therms x 20% = 0.1045 m^3				

[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[11] Questar Gas, DSM Market Characterization Report, by Nexant, August 9, 2006
[12] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Heat Recovery Ventilator (HRV) – New Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Ventilation with HRV
Base Equipment and Technologies Description
Ventilation without HRV

Decision Type	Target Market(s)	End Use
New	Commercial	Space Heating

Codes, Standards, and Regulations

- Restriction for New Building Construction: This measure is not applicable to system ≥5,000 CFM with ≥70% OA ratio because energy recovery is required by Ontario Building Code 2006.
- Restriction for New Building Construction: This measure is not applicable to systems serving health care spaces indicated in **Table 1** because heat recovery is required by CSA Z317.2-01

Table 1 - Health Care Spaces Not Eligible		
Anaesthetic gas scavenging	Cart and can washers	Areas using hazardous gases
Animal facilities	Chemical storage	Isolation rooms
Autopsy suite	Cooking facilities	Perchloric hoods
Biohazard and fume hoods	Ethylene oxide	Radioisotope hoods

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/CFM)	Electricity (kWh)	Water (L)	($/CFM)	($)
1	3.49	0	0	3.4	0
2	3.49	0	0	0	0
3	3.49	0	0	0	0
4	3.49	0	0	0	0
5	3.49	0	0	0	0
6	3.49	0	0	0	0
7	3.49	0	0	0	0
8	3.49	0	0	0	0
9	3.49	0	0	0	0
10	3.49	0	0	0	0
11	3.49	0	0	0	0
12	3.49	0	0	0	0
13	3.49	0	0	0	0
14	3.49	0	0	0	0
15	3.49	0	0	0	0
16	3.49	0	0	0	0
17	3.49	0	0	0	0
18	3.49	0	0	0	0
19	3.49	0	0	0	0
20	3.49	0	0	0	0
TOTALS	**69.8**	**0**	**0**	**3.4**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	3.49 m^3/CFM

- Natural gas savings are determined from engineering calculations utilizing inputs such as air flow, indoor/outdoor temperatures, indoor/outdoor and relative humidity.
- For example, input assumptions for a typical Ontario retail store are:

Symbols	Variable Names	Values	Source
A	Supply air flow (cfm)	500	UG†
B	Exhaust air flow (cfm)	500	UG
C	Average indoor air temperature (^{o}F)	70	UG
D	Average indoor relative humidity (%)	30	UG
E	Average outside air temperature (^{o}F)	31.5	UG
F	Average outdoor relative humidity (%)	70	NCI$^{\Delta}$
G	Atmospheric pressure (psia)	14.3	UG
H	No. of hours in heating season (hrs)	4,800	UG
I1	Demand Controlled Ventilation	no	UG
I2	No. of hours of operation per week (hrs/wk)	108	UG
J	Make and Model of Heat Recovery Equipment	Eng A, HRW-2100	UG
K	Effectiveness of Heat Recovery Equipment (%)	70	NCI
L	Sensible Heat Recovery Only	yes	UG
M	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET exhaust air	22.0	UG
N	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of INLET supply air	10.4	UG
O	Enthalpy (Btu/lba) & Humidity Ratio (lbw/lba) of OUTLET supply air	16.9	UG
P	Average Temperature of OUTLET supply air (^{o}F)	58	UG
Q	Average Hourly Moisture Addition (lb/hr)	0.0	UG
R	Defrost Control Derating Factor (%)	5	UG
S	Average Hourly Heat Recovery (MBH)	13.7	UG
T	Seasonal Efficiency of Gas-Fired Equipment (%)	82	UG
U	Average annual gas reduction (m^3)	1,461	UG
V	Incremental natural gas rate ($/$m^3$)	0.3	UG
W	Average annual gas savings ($)	438.4	UG

†UG: Union Gas

$^{\Delta}$NCI: Navigant Consulting, Inc

- **NG Savings** = # of Hours in Heating Season x (operating hours/168) x Average Hourly Heat Recovery / (35.3 m^3/MJ) / (Seasonal Efficiency / 100%) **(A)**
  - 168 hour = 7 days/week x 24hours/day
  - Average Hourly Heat Recovery = Supply air flow x 60 x (Supply air flow – Inlet supply air)/Specific Supply Air Conditions Volume x (1 – Defrost Control De-rating Factor[1] %) **(B)**
- Operating hours for each sectors being considered are as the following

Building Occupancy	Typical Hrs of Operation per week
Hotel	168
Restaurant	108
Retail	108
Office	60
School	84
Health Care	168
Nursing Home	168
Warehouse	168

- New buildings and existing buildings mainly differ in enthalpy (BTU/LBa) that is used to calculate the

[1] From Union Gas, all air-to-air heat recovery equipment requires frost control in colder climates to prevent freeze-up of exhaust air condensate on heat exchange components. Depending on the defrost control system, annual heat recovery estimates should be reduced by 5 to 15 %. Equipment manufacturers and suppliers can provide an estimated defrost derating factor given the operating conditions of the equipment.

Specific Supply Air Conditions Volume in formula **(B).**

- Based on the NG Savings formula **(A)** and input assumptions above, the natural gas savings for each of the commercial sectors are calculated, and a simple average is taken to be the general savings.

Market Segment	HRV Capacity (CFM)	New Buildings NG Savings (m^3)	New Buildings NG Savings per CFM (m^3/CFM)
Hotel	500	2,273	4.55
Restaurant	500	1,461	2.92
Retail	500	1,461	2.92
Office	500	812	1.62
School	500	1,137	2.27
Health Care	500	2,273	4.55
Nursing Home	500	2,273	4.55
Warehouse	500	2,273	4.55
Average (m^3/CFM)			**3.49**

Annual Electricity Savings	**0 kWh**

N/A

Annual Water Savings	**0 L/CFM**

N/A

Other Input Assumptions

Effective Useful Life (EUL)	**20 Years**

HRVs have an estimated service life of 15 years based on Jacques Whitford study[2]. Since Questar Gas[3] and Puget Sound[4] both report 20 years as its effective useful life, Navigant also estimates the EUL to be 20 years.

Base & Incremental Conservation Measure Equipment and O&M Costs	**$3.4 / CFM**

The incremental costs are based on relative scaling of incremental costs $1,700 / 500 CFM[5].

Customer Payback Period (Natural Gas Only)[6]	**2 Years**

Using an 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average commercial distribution cost[8] of $0.12 / m^3, the payback period for natural gas savings is determined to be 2 years, based on the following:

On a per CFM basis,

Payback Period = Incremental cost / (natural gas savings x natural gas cost)

= $3.4 / (3.49 m^3/year * $0.5 / m^3)

= 2 years

[2] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[3] Questar Gas, DSM Market Characterization Report, by Nexant, August 9, 2006
[4] Quantec — Puget Sound Energy Demand-Side Management Resource Assessment
[5] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration[9]	Low

Based on Jacques Whitford report[10] (less than 5% market penetration) and communication with local contractors, Navigant Consulting is estimating the market penetration of HRV to be low.

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Questar Gas[11]	670	20	1,785	N/A

Comments
Specifications for HRVs are not provided in the report, nor the baseline assumptions.

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[12]	0.1045 per ft^2	20	1	N/A

Comments
Baseline therm reported on a square footage basis (eg 0.19 therms/sq.ft. for offices). Estimated 20% savings for new energy efficient technology is reported as a percent saving over the baseline. Incremental cost is reported on a per square footage basis. Equivalent savings is 0.19 therms/sq.ft. x 2.75 m^3/therms x 20% = 0.1045 m^3

[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., by Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.
[11] Questar Gas, DSM Market Characterization Report, by Nexant, August 9, 2006
[12] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

High Efficiency (Condensing) Furnace - Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
High-efficiency condensing furnace with regular PSC motor – AFUE 90, 92 and 96.
Base Equipment and Technologies Description
Mid-efficiency furnace AFUE 80.[1]

Decision Type	Target Market(s)	End Use
New, Retrofit	Commercial office buildings	Space Heating

Codes, Standards, and Regulations

- Under Ontario's building code, all gas furnaces installed in new residential construction must meet a minimum condensing efficiency level effective January 1, 2007.[2]
- NRCan proposes to increase the minimum performance level, the Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces with an input rate not exceeding 65.92 kW (225,000 Btu/h) to 90% for December 31, 2009.[3]

Resource Savings Table (for 3 different cases)

AFUE 90

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/kBtu/h)	Electricity (kWh)	Water (L)	($)	($)
1	3.6	0	0	2,900	2,233
2	3.6	0	0	0	0
3	3.6	0	0	0	0
4	3.6	0	0	0	0
5	3.6	0	0	0	0
6	3.6	0	0	0	0
7	3.6	0	0	0	0
8	3.6	0	0	0	0
9	3.6	0	0	0	0
10	3.6	0	0	0	0
11	3.6	0	0	0	0
12	3.6	0	0	0	0
13	3.6	0	0	0	0
14	3.6	0	0	0	0
15	3.6	0	0	0	0
16	3.6	0	0	0	0
17	3.6	0	0	0	0
18	3.6	0	0	0	0
TOTALS	**64.7**	**0**	**0**	**2,900**	**2,233**

[1] The federal baseline is AFUE 78, but very few are sold below 80. *Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers*. ACEEE, September 2004, Page 9.
[2] Ministry of Energy, “Heating and Cooling your Home: A Conservation Guide.” Reproduced with the permission of Natural Resource Canada, 2004. http://www.energy.gov.on.ca/english/pdf/conservation/heating_and_cooling_your_home.pdf
[3] Office of Energy Efficiency, Canada’s Energy Efficiency Regulations, Proposed Regulations Bulletin, March 2007. http://www.oee.nrcan.gc.ca/regulations/bulletin/gas-furnace-mar2007.cfm?Text=N&PrintView=N

Resource Savings Assumptions

Annual Natural Gas Savings	$3.6\ m^3$ / kBtu / h

- Gas savings associated with upgrading from a mid-efficiency furnace to a high efficiency furnace are based on the following formula:
- Annual Savings = 1 – Base Technology AFUE / Efficient Equipment AFUE
  - = 1 – 80/90
  - = 11.1%
- The US DOE reports an 11.7% gas savings for an AFUE 90 furnace (based on an AFUE 80 baseline).[4]
- Natural gas savings are based on Enbridge research[5] indicating that the average consumption for a residential mid-efficiency furnace[6] is 2,436 m^3.
- Using the calculated percent savings (11.1%) multiplied by the base energy consumption (2,436 m^3) the annual gas savings are estimated to be 270.4m^3.
- Assuming a typical commercial furnace input of 75,000 BTU/h, natural gas savings on a per thousand BTU/h basis are 270.4m^3 / 75 kBtu/h = 3.6 kBtu/h

Annual Electricity Savings	0 kWh

Electricity savings resulting from high efficiency furnaces are assumed to be negligible.

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	18 Years

ACEEE[7] and State of Iowa[8] both estimate an effective useful life of 18 years. Puget Sound Energy[9] and New England State Program Working Group (SPWG)[10] also suggest 18 years for high efficiency furnaces.

Base & Incremental Conservation Measure Equipment and O&M Costs	\$6.7 / kBtu / h

Average incremental cost is based on communication with local HVAC contractors. Navigant Consulting is assuming that the ratio of the incremental cost between a commercial AFUE 80 furnace and a commercial AFUE 90 furnace is the same as for the residential market. Therefore, assuming 30% increase over a baseline commercial AFUE 80 furnace (\$3,000), the incremental cost would be \$900 for a 135,000 Btu/hr furnace, or \$6.7/kBtu/hr.

Customer Payback Period (Natural Gas Only)[11]	3.7 Years

Using an 5-year average commodity cost (avoided cost)[12] of \$0.38/ m^3 and an average commercial distribution cost[13] of \$0.12 / m^3, the payback period for natural gas savings is determined to be 3.7 years, based on the following:

---

[4] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls

[5] Based on information provided by Enbridge Gas, based on Decision for the Enbridge 2006 DSM Plan (EB2005-0001).

[6] Average commercial baseline consumption for a mid-efficiency furnace was not available from either of the Ontario gas utilities, therefore, residential baseline furnace consumption will be used and computed on a per thousand Btu/h basis.

[7] Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers. ACEEE, September 2004.

[8] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131

[9] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

[10] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG), For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= $6.7/kBtu/hr / (3.6m^3/kBtu/hr/year* $0.50 / m^3)
= 3.7 years

Market Share[14]	**Medium**

Based on market share information for residential furnaces[15], Navigant Consulting is assuming a similar trend for the commercial sector. Therefore, Navigant Consulting estimates the market share in Ontario to be medium.

AFUE 92

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/kBtu/h)	Electricity (kWh)	Water (L)	($)	($)
1	4.2	0	0	3,300	2,233
2	4.2	0	0	0	0
3	4.2	0	0	0	0
4	4.2	0	0	0	0
5	4.2	0	0	0	0
6	4.2	0	0	0	0
7	4.2	0	0	0	0
8	4.2	0	0	0	0
9	4.2	0	0	0	0
10	4.2	0	0	0	0
11	4.2	0	0	0	0
12	4.2	0	0	0	0
13	4.2	0	0	0	0
14	4.2	0	0	0	0
15	4.2	0	0	0	0
16	4.2	0	0	0	0
17	4.2	0	0	0	0
18	4.2	0	0	0	0
TOTALS	**75.8**	**0**	**0**	**3611**	**2,233**

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[14] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,
[15] NRCan, Office of Energy Efficiency, Comprehensive Energy Use Database: Table 22: Single detached heating system stock by heating system type, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_on.cfm, updated September 2008.

Resource Savings Assumptions

Annual Natural Gas Savings	4.2 m^3 / kBtu / h

- Gas savings associated with upgrading from a mid-efficiency furnace to a high efficiency furnace are based on the following formula:
- Annual Savings = 1 – Base Technology AFUE / Efficient Equipment AFUE
  = 1 – 80/92
  = 13.0%
- The US DOE reports a 12.9% gas savings for an AFUE 92 furnace (based on an AFUE 80 baseline).[16]
- Natural gas savings are based on Enbridge research[17] indicating that the average consumption for a mid-efficiency furnace[18] is 2,436 m^3.
- Using the calculated percent savings (13.0%) multiplied by the base energy consumption (2,436 m^3) the annual gas savings are estimated to be 316.7 m^3.
- Assuming a typical commercial furnace input of 75,000 BTU/h, natural gas savings on a per thousand BTU/h basis are 316.7 m^3 / 75 kBtu/h = 4.2 kBtu/h

Annual Electricity Savings	0 kWh

Electricity savings resulting from high efficiency furnaces are negligible.

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	18 Years

ACEEE[19] and State of Iowa[20] both estimate an effective useful life of 18 years. Puget Sound Energy[21] and New England State Program Working Group (SPWG)[22] also suggest 18 years for high efficiency furnaces.

Base & Incremental Conservation Measure Equipment and O&M Costs	\$11 / kBtu / hr

Average incremental cost is based on communication with local HVAC contractors. Navigant Consulting is assuming that the ratio of the incremental cost between a commercial AFUE 80 furnace and a commercial AFUE 92 furnace is the same as for residential market. Therefore, assuming 47% increase over a baseline commercial AFUE 80 furnace (\$3,000), the incremental cost would be \$1,500 for a 135,00 Btu/hr furnace, or \$11/kBtu/hr.

Customer Payback Period (Natural Gas Only)[23]	5.2 Years

Using an 5-year average commodity cost (avoided cost)[24] of \$0.38/ m^3 and an average commercial distribution cost[25] of \$0.12 / m^3, the payback period for natural gas savings is determined to be 5.2 years, based on the following:

---

[16] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls
[17] Based on information provided by Enbridge Gas, based on Decision for the Enbridge 2006 DSM Plan (EB2005-0001).
[18] Average commercial baseline consumption for a mid-efficiency furnace was not available from either of the Ontario gas utilities, therefore, residential baseline furnace consumption will be used and computed on a per thousand Btu/h basis.
[19] Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers. ACEEE, September 2004.
[20] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[21] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
[22] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG), For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007
[23] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[24] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $11/kBtu/hr / (4.2m^3/kBtu/hr/year* $0.50 / m^3) = 5.2 Years

Market Share[26]	**Medium**
Based on market share information for residential furnaces[27], Navigant Consulting is assuming a similar trend for the commercial sector. Therefore, Navigant Consulting estimates the market share in Ontario to be medium.	

AFUE 96

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/kBtu/h)	Electricity (kWh)	Water (L)	($)	($)
1	5.4	0	0	4,667	2,233
2	5.4	0	0	0	0
3	5.4	0	0	0	0
4	5.4	0	0	0	0
5	5.4	0	0	0	0
6	5.4	0	0	0	0
7	5.4	0	0	0	0
8	5.4	0	0	0	0
9	5.4	0	0	0	0
10	5.4	0	0	0	0
11	5.4	0	0	0	0
12	5.4	0	0	0	0
13	5.4	0	0	0	0
14	5.4	0	0	0	0
15	5.4	0	0	0	0
16	5.4	0	0	0	0
17	5.4	0	0	0	0
18	5.4	0	0	0	0
TOTALS	**97.4**	**0**	**0**	**4,667**	**2,233**

[25] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[26] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[27] NRCan, Office of Energy Efficiency, Comprehensive Energy Use Database: Table 22: Single detached heating system stock by heating system type, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_on.cfm, updated September 2008.

Resource Savings Assumptions

Annual Natural Gas Savings	5.4 m^3 / kBtu / h

- Gas savings associated with upgrading from a mid-efficiency furnace to a high efficiency furnace are based on the following formula:
- Annual Savings = 1 – Base Technology AFUE / Efficient Equipment AFUE
  = 1 – 80/96
  = 16.7%
- The US DOE reports a 16.1% gas savings for an AFUE 96 furnace (based on an AFUE 80 baseline).[28]
- Natural gas savings are based on Enbridge research[29] indicates the average consumption for a mid-efficiency furnace[30] is 2,436 m^3.
- Using the calculated percent savings (16.7%) multiplied by the base energy consumption (2,436 m^3) the annual gas savings are estimated to be 406.8 m^3.
- Assuming a typical commercial furnace input of 75,000 BTU/h, natural gas savings on a per thousand BTU/h basis are 406.8 m^3 / 75 kBtu/h = 5.4 kBtu/h

Annual Electricity Savings	0 kWh

Electricity savings resulting from high efficiency furnaces are negligible.

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	18 Years

ACEEE[31] and State of Iowa[32] both estimate an effective useful life of 18 years. Puget Sound Energy[33] and New England State Program Working Group (SPWG)[34] also suggest 18 years for high efficiency furnaces.

Base & Incremental Conservation Measure Equipment and O&M Costs	\$18.5 / kBtu / h

Average incremental cost is based on communication with local HVAC contractors. Navigant Consulting is assuming that the ratio of the incremental cost between a commercial AFUE 80 furnace and a commercial AFUE 96 furnace is the same as for residential market. Therefore, assuming 85% increase over a baseline commercial AFUE 80 furnace (\$3,000), the incremental cost would be \$2,500 for a 135,000 Btu/hr furnace, or \$18.5/kBtu/hr.

Customer Payback Period (Natural Gas Only)[35]	8.1 Years

Using an 5-year average commodity cost (avoided cost)[36] of \$0.36/ m^3 and an average commercial distribution cost[37] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 8.1 years, based on the following:

---

[28] US DOE Residential Furnaces and Boilers Technical Support Document Analytical Tools. Life Cycle Cost Results for Non-Weatherized Gas Furnaces. http://www1.eere.energy.gov/buildings/appliance_standards/residential/docs/lcc_nwgf_gt6000hdd.xls
[29] Based on information provided by Enbridge Gas, based on Decision for the Enbridge 2006 DSM Plan (EB2005-0001).
[30] Average commercial baseline consumption for a mid-efficiency furnace was not available from either of the Ontario gas utilities, therefore, residential baseline furnace consumption will be used and computed on a per thousand Btu/h basis.
[31] Powerful Priorities: Updating Energy Efficiency Standards for Residential Furnaces, Commercial Air Conditioners, and Distribution Transformers. ACEEE, September 2004.
[32] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[33] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
[34] GDS Associates, Inc., Measure Life Report: Residential and Commercial/Industrial Lighting and HVAC Measures, Prepared for The New England State Program Working Group (SPWG), For use as an Energy Efficiency Measures/Programs Reference Document for the ISO Forward Capacity Market (FCM), June 2007
[35] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[36] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= $22/kBtu/hr / (5.4m^3/kBtu/hr/year* $0.50 / m^3)
= 8.1 Years

Market Share[38]	Medium

Based on market share information for residential furnaces[39], Navigant Consulting is assuming a similar trend for the commercial sector. Therefore, Navigant Consulting estimates the market share in Ontario to be medium.

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Questar Gas, 2006[40]	841.5	20	487.5	N/A
Comments Questar Gas reported 30.6 DTH annual natural gas savings, which translates to 841.5 m^3.				
Puget Sound Energy[41]	0.0396 m^3/sq.ft.	20	$0.1/sq.ft.	N/A
Comments Puget Sound reports 12% savings based on a baseline gas furnace of AFUE 75 and energy efficient furnace of AFUE 85. Baseline usage is 0.12 therms/sq.ft., therefore savings is 12% x 0.12 therms/sq.ft. x 2.75 m^3/therm = 0.0396 m^3 /sq.ft.				

37 Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
38 Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
39 NRCan, Office of Energy Efficiency, Comprehensive Energy Use Database: Table 22: Single detached heating system stock by heating system type, http://oee.nrcan.gc.ca/corporate/statistics/neud/dpa/trends_res_on.cfm, updated September 2008.
40 Nexant, Questar Gas DSM Market Characterization Report, 2006
41 Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007

Infrared Heaters

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Infrared heater (up to 300,000 Btu/hour)
Base Equipment and Technologies Description
Regular unit heater

Decision Type	Target Market(s)	End Use
New/Retrofit	New/Existing Commercial buildings	Space Heating

Codes, Standards, and Regulations

The old code CAN 1-2.16-M81 (R1996) has been withdrawn.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/Btu/hour)	Electricity (kWh)	Water (L)	($/Btu/hour)	($)
1	0.015	245 ~ 870	0	0.0122	0
2	0.015	245 ~ 870	0	0	0
3	0.015	245 ~ 870	0	0	0
4	0.015	245 ~ 870	0	0	0
5	0.015	245 ~ 870	0	0	0
6	0.015	245 ~ 870	0	0	0
7	0.015	245 ~ 870	0	0	0
8	0.015	245 ~ 870	0	0	0
9	0.015	245 ~ 870	0	0	0
10	0.015	245 ~ 870	0	0	0
11	0.015	245 ~ 870	0	0	0
12	0.015	245 ~ 870	0	0	0
13	0.015	245 ~ 870	0	0	0
14	0.015	245 ~ 870	0	0	0
15	0.015	245 ~ 870	0	0	0
16	0.015	245 ~ 870	0	0	0
17	0.015	245 ~ 870	0	0	0
18	0.015	245 ~ 870	0	0	0
19	0.015	245 ~ 870	0	0	0
20	0.015	245 ~ 870	0	0	0
TOTALS	**0.3**	**4,900 ~ 17,400**	**0**	**0.0122**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings — $0.015\ m^3$ / Btu/ h

- The infrared heater gas savings were based on the analysis procedures previously created by Agviro Inc. for Union Gas[1]. The analysis was supplemented by adding 20% oversizing factor for the equipment, based on recommendations by Union Gas.

Location	Heater Range (Btu/h)	Annual Gas Savings (m^3/year)		
		Single Stage	2-Stage	High Intensity
London	0 - 75,000	898	1,508	898
	76,000 - 150,000	1,786	3,017	1,786
	151,000 - 300,000	3,591	6,033	3,591
Sudbury	0 - 75,000	971	1,631	971
	76,000 - 150,000	1,942	3,262	1,942
	151,000 - 300,000	3,883	6,524	3,883

- An average rate of savings of 0.015 m^3/Btu/hour was determined by taking a weighted average of the savings from both locations: 70% of Union Gas South (London) and 30% of Union Gas North (Sudbury) based on customer population distribution in Union Gas service territories.

Weighted Average				
Heater Range (Btu/h)	Single Stage (m^3/year)	2-Stage (m^3/year)	High Intensity (m^3/year)	**Average (m^3/year)**
0 - 75,000	920	1,545	920	**1,128**
76,000 - 150,000	1,833	3,091	1,833	**2,252**
151,000 - 300,000	3,679	6,180	3,679	**4,513**
Heater Range (Btu/h)	Single Stage (m^3/Btu/hr/year)	2-Stage (m^3/Btu/hr/year)	High Intensity (m^3/Btu/hr/year)	**Average (m^3/Btu/h/year)**
0 - 75,000	0.0123	0.0206	0.0123	**0.015**
76,000 - 150,000	0.0122	0.0206	0.0122	**0.015**
151,000 - 300,000	0.0123	0.0206	0.0123	**0.015**

- Baseline estimates of natural gas consumption[2]:

Heater Range (Btu/h)	Annual Gas Use (m^3/year)
0 - 75,000	6,131
76,000 - 150,000	12,262
151,000 - 300,000	24,525

- Percentage of natural gas savings = Average Savings / Baseline Gas Consumption = 18.4%

Annual Electricity Savings — 245 ~ 870 kWh

- Electricity savings are determined by taking the difference in electricity consumption for infrared

[1] Assessment of Average Infrared Heater Savings, Agviro, December 1, 2004
[2] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., Prepared by: Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.

heater and a comparable unit heater.

- Electricity savings are based on Solaronics models that use a 1/24 hp motor[3].

Capacity	Capacities: Unit Heater (kW)	Capacities: Infrared (kW)	Operating Hours: Unit Heater	Operating Hours: Infrared	Electricity Savings (kWh)	Baseline Consumption (kWh)	Savings%
< 50,000 Btu/hr	0.124	0.031	2,509	2,133	**245**	311	79%
<165,000 Btu/hr	0.249	0.031	2,509	2,133	**559**	625	89%
>165,000 Btu/hr	0.373	0.031	2,509	2,133	**870**	936	93%

- Electricity savings = Unit heater capacity x operating hours – Infrared Capacity x operating hours, the savings are summarised above for three ranges of capacities.
- Electricity savings % = Electricity savings (kWh) / Baseline Consumption (kWh)

Annual Water Savings	**0 L**

N/A

Other Input Assumptions

Effective Useful Life (EUL)	**20 Years**

Infrared heaters have an estimated service life of 20 years[4].

Base & Incremental Conservation Measure Equipment and O&M Costs	**$ 0.0122 / Btu / h**

An incremental cost of $350 was used based on past input assumptions filed by Union[5]. Local retailers reported an average of $0.009 / Btu/hr incremental cost. Navigant Consulting therefore is estimating an average of $0.0122 / Btu/hour.

Customer Payback Period (Natural Gas Only)[6]	**1.6 Years**

Using an 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average commercial distribution cost[8] of $0.12 / m^3, the payback period for natural gas savings is determined to be 1.6 years, based on the following:

On a per Btu/hour basis,

Payback Period = Incremental cost / (natural gas savings x natural gas cost)

= $0.0122/ (0.015 m^3/year * $0.5 / m^3)

= 1.6 years

[3] Solaronics specification sheet, http://solaronics.thomasnet.com/Asset/SSTG-SSTU-GB_200010_Spec_Sheet.pdf

[4] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., Prepared by: Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000.

[5] EB-2005-0211, Union Gas Settlement Agreement, April 7, 2005

[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Market Penetration[9]	Medium
Based on communication with local contractors, Navigant Consulting is estimating a medium market penetration in Ontario. Infrared systems are currently used in approximately 5% of existing heating applications and 10% and 25% of new space heating applications[10].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Questar Gas[11]	32.64	17	1,391	N/A
Comments Specifications for infrared heaters are not provided in the report or the baseline assumptions.				

[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., Prepared by: Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000. Union Gas Heating Product Database.
[11] Questar Gas, DSM Market Characterization Report, by Nexant, August 9, 2006

Gas-fired Rooftop Unit

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Two-stage rooftop units (5 ton per unit)
Base Equipment and Technologies Description
Single-stage rooftop units (5 ton per unit)

Decision Type	Target Market(s)	End Use
New	Commercial buildings	Space Heating

Codes, Standards, and Regulations

- Residential gas furnaces are prescribed as regulated products under Canada's Energy Efficiency Regulations[1]
- NRCan proposes to increase the minimum performance level, Annual Fuel Utilization Efficiency (AFUE), for gas-fired furnaces with an input rate not exceeding 65.92 kW (225 000 Btu/h) to 90%. The amendment is intended to introduce new MEPS and associated reporting and compliance requirements for Commercial and industrial gas unit heaters.
- DOE currently has no regulation on AFUE level for commercial gas-fired rooftop units[2].

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	255	0	0	375	0
2	255	0	0	0	0
3	255	0	0	0	0
4	255	0	0	0	0
5	255	0	0	0	0
6	255	0	0	0	0
7	255	0	0	0	0
8	255	0	0	0	0
9	255	0	0	0	0
10	255	0	0	0	0
11	255	0	0	0	0
12	255	0	0	0	0
13	255	0	0	0	0
14	255	0	0	0	0
15	255	0	0	0	0
TOTALS	**3,825**	**0**	**0**	**375**	**0**

[1] Canada's Energy Efficiency Regulations (OEE), http://oee.nrcan.gc.ca/regulations/bulletin/gas-furnace-jan2008.cfm?attr=0
[2] U.S. Department of Energy, http://www1.eere.energy.gov/buildings/appliance_standards/commercial/ac_hp.html

Resource Savings Assumptions

Annual Natural Gas Savings	255 m^3

- Baseline reference case is for a typical new 10,000 sq ft office building, occupant density of 200 sq ft per person. Ventilation is through the five 5 ton rooftop HVAC units using the unit fans[3].
- Energy efficiency option is five 5 ton units with 2 stage burners in the heating section.
- Baseline estimates of natural gas consumption = 25,500 m^3.
- Natural Gas Savings % = 1,275 m^3 / 25,500 m^3 = 5%
- OBC 2006 does not have more stringent efficiency requirements than OBC 1997 for the furnace section of rooftop units, so the energy savings from the Jacques Whitford study[4] were not modified.

Equipment Description	Incremental Cost Estimate	Efficiency	Gas Consumption (m^3/year)
Single stage units	$0	80%	25,500
2-stage heating (5)	$1,250	85%	24,225
Savings			**1,275**

- Therefore, one 5 ton unit with 2 stage burners is estimated to save 1,275 m^3 / 5 units = 255 m^3.

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	15 Years

Estimated equipment life is 15 years[5].

Base & Incremental Conservation Measure Equipment and O&M Costs	$ 375

The incremental cost of two-stage rooftop units compared single-stage units is $1,250 for five units, which equates to $250 per 5 ton unit[6]. Local Canadian manufacturer disclosed incremental cost of $500 for 2-stage rooftop units comparing with single stage rooftop units. Therefore, an average cost of $375 is assumed.

Customer Payback Period (Natural Gas Only)[7]	2.9 Years

Using an 5-year average commodity cost (avoided cost)[8] of $0.38 / m^3 and an average commercial distribution cost[9] of $0.12 / m^3, the payback period for natural gas savings is determined to be 2.9 years, based on the following:

[3] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., Prepared by: Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000. A survey of manufacturers and distributors was conducted to solicit updated information as per Union Gas' Heating Product Database. Detailed lists were developed for each technology and integrated with the Heating Products Database.

[4] Ibid.

[5] ASHRAE Handbook, 2008

[6] "Prescriptive Incentives for Selected Natural Gas Technologies", Prepared for Enbridge Consumers Gas and Union Gas Ltd., Prepared by: Jacques Whitford Environment Limited, Agviro Inc., and Engineering Interface Ltd., September 27, 2000. A survey of manufacturers and distributors was conducted to solicit updated information as per Union Gas' Heating Product Database. Detailed lists were developed for each technology and integrated with the Heating Products Database.

[7] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[8] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[9] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= $375 / (255 m^3/year * $0.5 / m^3)
= 2.9 years

Market Penetration[10]	Medium
Based on communication with local contractors and manufacturers, 2-stage rooftop units are popular and more efficient technology for space heating. Therefore, Navigant Consulting is estimating a medium market penetration in Ontario.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Emerging Technologies & Practice, ACEEE[11]	770	15	1,000	N/A

Comments

28 MMBtu/year is approximately equal to 770 m^3 natural gas.

Equipment Description	Incremental Cost Estimate	Efficiency	Gas Consumption (MMBtu/year)
10 ton gas-fired rooftop unit	$0	0.80	178.5
10 ton gas-fired condensing rooftop unit	$1,000	0.95	150.3

[10] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[11] ACEEE, High Efficiency Gas-fired Rooftop Units, www.aceee.org/pubs/a042_h16.pdf

Programmable Thermostat - Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Programmable thermostat.
Base Equipment and Technologies Description
Standard thermostat.

Decision Type	Target Market(s)	End Use
Retrofit	Commercial buildings	Space Heating

Codes, Standards, and Regulations

- For a programmable thermostat to receive Energy Star® qualification, it must meet specific criteria such as having at least two different programming periods (for weekday and weekend programming), at least four possible temperature settings and allow for temporary overriding by the user.
- In Canada, applicable CSA standards can be found in CSA C828-99- CAN/CSA Performance Requirements for Thermostats used with Individual Room Electric Space Heating Devices.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	239	251	0	110	0
2	239	251	0	0	0
3	239	251	0	0	0
4	239	251	0	0	0
5	239	251	0	0	0
6	239	251	0	0	0
7	239	251	0	0	0
8	239	251	0	0	0
9	239	251	0	0	0
10	239	251	0	0	0
11	239	251	0	0	0
12	239	251	0	0	0
13	239	251	0	0	0
14	239	251	0	0	0
15	239	251	0	0	0
TOTALS	**3,585**	**3,765**	**0**	**110**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	239 m^3

- The natural gas savings are based on average space heating gas consumption for office buildings in the Union Gas franchise area.
- Normalized average natural gas use per customer are summarized below:

Natural Gas (m^3)	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Office Total	1,693	2,274	1,782	1,235	750	367	246	208	240	325	798	1,143	**11,061**
Baseload							**265**						
Savings	1,428	2,009	1,517	970	485	102	-	-	-	60	533	878	**7,980**

- Baseload consumption (e.g., non-space heating gas usage) is assumed to be the average consumption between June and September
- Monthly Natural Gas Savings = Monthly Office Total – Monthly Baseload Consumption
- According to the Puget Sound report[1], a programmable thermostat results in 2% annual natural gas savings in commercial settings.
- According to the State of Iowa Utilities Board[2], a programmable thermostat results in 3% annual natural gas savings in commercial settings.
- Navigant Consulting uses 3% savings because of the comparable weather conditions between Iowa and Ontario.
- Therefore, natural gas savings = 3% x 7,980 m^3 = 239 m^3 for using programmable thermostat.
- Baseline estimates of natural gas consumption = 7,980 m^3
- Natural Gas Savings percentage = 3%

Annual Electricity Savings	251.1 kWh

- Navigant Consulting is assuming the space cooling to space heating ratio for residential is the same as for commercial applications. From HOT2000 residential simulations, the ratio of space cooling to space heating was found to be 1.05 kWh / m^3. Applying this ratio to the space heating gas consumption result, the annual electricity consumption for space cooling is estimated to be 8,370 kWh (7,980 m^3 x 1.05 kWh / m^3).
- According to the State of Iowa Utilities Board[3], a programmable thermostat results in 3% annual saving in electricity for commercial space cooling needs. Therefore, electricity savings = 3% x 8,370 m^3 = 251.1 m^3 for using programmable thermostat.
- Baseline estimates of electricity consumption = 8,370 kWh.
- Natural Gas Savings % = 3 %

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	15 Years

Navigant Consulting is estimating 15 years as the effective useful life based on the average lifetime of programmable thermostat from Energy Star ® website.

Base & Incremental Conservation Measure Equipment and O&M Costs	$ 110

The incremental cost of $109.00 was found based on average incremental cost for various commercial settings based on the Iowa Stated DSM study[4]. Local retail price for a commercial programmable

1 Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
2 Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
3 Ibid.

thermostat is $110.	
Natural Gas Payback Period	**0.9 Years**

Using an 5-year average commodity cost (avoided cost)[5] of $0.38 / m^3 and an average commercial distribution cost[6] of $0.12 / m^3, the payback period for natural gas savings is determined to be 0.9 years, based on the following:

Payback Period = Incremental cost / (natural gas savings x natural gas cost)
= $110/ (239 m^3/year * $0.5 / m^3)
= 0.9 years

Market Penetration[7]	**Medium**

Based on the observation of medium penetration in one jurisdiction (e.g., Puget Sound Energy) of low penetration in another (e.g., Iowa) and communication with local retailers, Navigant Consulting estimates the penetration in Ontario to be medium.

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[8]	0.01045 per ft^2	10	$0.01 per ft^2 - (Office)	48%

Comments
Base equipment is a non-programmable thermostat. Baseline consumption is reported on a per square footage basis (e.g. 0.19 therms per ft^2 for office). Estimated 2% savings for programmable thermostats are reported as a percent saving over the baseline. Equivalent natural gas savings is 2% x 0.19 therms/sq.ft. x 2.75 m^3/therm = 0.01045 m^3

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
State of Iowa Utilities Board[9]	0.03383	15	$0.017 per ft^2 (Large Office) - $0.034 per ft^2 (Small Office)	13% (large office) 13% (small office)

Comments
Base equipment is a non-programmable thermostat. Baseline consumption is reported on a square footage basis (e.g.0.35 therms/sqft for large office, and 0.41 therms/sqft for small office). Estimated 3% savings for a programmable thermostat is reported as a percent saving over the baseline. Equivalent natural gas savings is 3% x 0.41 therms/sq.ft. x 2.75 m^3/therm = 0.3383 m^3

[4] Ibid.
[5] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[6] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[7] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[8] Quantec, Comprehensive Demand-Side Management Resource Assessment, Prepared for Puget Sound Energy, May 2007
[9] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Prescriptive Schools – Elementary

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Space heating, hydronic boiler with combustion efficiency of 83% or higher.
Base Equipment and Technologies Description
Space heating, hydronic boiler with combustion efficiency of 80% to 82%.

Decision Type	Target Market(s)	End Use
Replacement	Institutional Buildings	Space Heating

Codes, Standards, and Regulations

- ASHRAE Standard 155P: test and calculation procedures result in an application-specific seasonal efficiency of commercial space heating boiler systems[1].
- ASHRAE Standard 90.1-2004: minimum boiler efficiencies for buildings except low-rise residential buildings[2].

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	10,830	0	0	5,646	0
2	10,830	0	0	0	0
3	10,830	0	0	0	0
4	10,830	0	0	0	0
5	10,830	0	0	0	0
6	10,830	0	0	0	0
7	10,830	0	0	0	0
8	10,830	0	0	0	0
9	10,830	0	0	0	0
10	10,830	0	0	0	0
11	10,830	0	0	0	0
12	10,830	0	0	0	0
13	10,830	0	0	0	0
14	10,830	0	0	0	0
15	10,830	0	0	0	0
16	10,830	0	0	0	0
17	10,830	0	0	0	0
18	10,830	0	0	0	0
19	10,830	0	0	0	0
20	10,830	0	0	0	0
21	10,830	0	0	0	0
22	10,830	0	0	0	0
23	10,830	0	0	0	0
24	10,830	0	0	0	0
25	10,830	0	0	0	0
TOTALS	**270,750**	**0**	**0**	**5,646**	**0**

[1] Boiler System Efficiency, ASHRAE Journal, July 2006
[2] Ibid.

Resource Savings Assumptions

Annual Natural Gas Savings	10,830 m^3

- The Agviro study[3] analyzed the gas usage of 859 elementary school based on 2006 billing record. The analysis determined:
  - The consumption and size of an average elementary school
  - The size of boiler required to heat the typical elementary school
  - The manufacturer's suggested retail price for boilers based on the determined size
  - The savings of higher efficiency boilers versus a base case of 80 to 82% efficiency
  - Incremental cost associated with the higher efficiency boiler
- Based on Enbridge project records[4] the study found that 2 smaller boilers are typically installed (2 x 400 MBH boilers) for elementary schools. Also, based on project records, the study found that boiler upgrades will be weighted 89% towards the efficiency range of 85% to 88% and 11% towards boilers with combustion efficiencies ranging from 83% to 84%.

	Estimated Annual Gas Consumption (m^3)	Estimated Annual Gas Savings (m^3)	Weighted Average NG Savings (m^3)
Base Case (81%)	51,753		
Mid Efficiency (83.5%)	44,073	7,680	10,830
High Efficiency (86.5%)	40,534	11,219	

- Baseline estimates of natural gas consumption = 51,753 m^3.
- Natural Gas Savings % = 10,830 m^3 / 51,753 m^3 = 21%

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	25 Years

Boilers have an estimated service life of 25 years according to ASHRAE[5].

Base & Incremental Conservation Measure Equipment and O&M Costs	$ 5,646

Average MSRP for 2x400 MBH Boiler		
Combustion Efficiency	Average MSRP	Incremental Cost
80 - 82 % [Base Case]	2 x $5,500 = $11,000	$5,646
83 - 84% [Mid Efficiency]	2 x $7,700 = $15,400	
85 - 88% [High Efficiency]	2 x $8,400 = $16,800	

- Incremental costs are based on the weighted average of boiler types as noted above[6].

Customer Payback Period (Natural Gas Only)	1.0 Years

Using an 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average commercial distribution cost[8] of $0.12 / m^3, the payback period for natural gas savings is determined to be 1.0 years, based on the following:

[3] Agviro Inc, Elementary Schools Prescriptive Savings Analysis, November 23, 2007
[4] Ibid.
[5] ASHRAE Applications Handbook – 2003, Chapter 36 – Owning and Operating Costs, Table 3
[6] Agviro Inc, Elementary Schools Prescriptive Savings Analysis, November 23, 2007

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $5,646/ (10,830 m^3/year * $0.5 / m^3) = 1.0 years

Market Penetration[9]	**Low**
Based on communication with local contractors and other jurisdiction penetration rates, the market penetration for high efficiency boilers in schools is low. Therefore, Navigant Consulting is estimating a low market penetration.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Iowa State Utility Board Assessment Study[10]	0.077 per ft^2	20	24.589 per ft^2	5%
Comments Greater than 300 kBTUh, upgrade from 80% thermal baseline efficiency to 85% thermal efficiency. Baseline Therm reported on a square footage basis (eg 0.50 therms/sq.ft.for education sector). Estimated 5.6% savings for new energy efficient technology is reported as a percent saving over the baseline. Equivalent natural gas savings is 5.6% x 0.50 therms/sq.ft.= 0.028 therms = 0.077 m^3				
Iowa State Utility Board Assessment Study[11]	0.135 per ft^3	20	30.182 per ft^2	5%
Comments Greater than 300 kBTUh, upgrade from 80% thermal baseline efficiency to 89% thermal efficiency. **y,** Baseline Therm reported on a square footage basis (eg 0.50 therms/sq.ft.for education sector). Estimated 5.6% savings for new energy efficient technology is reported as a percent saving over the baseline. Equivalent natural gas savings is 9.8% x 0.50 therms/sq.ft. =0.049 therms = 0.135 m^3				

[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[11] Ibid.

Prescriptive Schools – Secondary

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Space heating, hydronic boiler with combustion efficiency of 83% or higher.
Base Equipment and Technologies Description
Space heating, hydronic boiler with combustion efficiency of 80% to 82%.

Decision Type	Target Market(s)	End Use
Retrofit	Institutional Buildings	Space Heating

Codes, Standards, and Regulations

- ASHRAE Standard 155P: test and calculation procedures result in an application-specific seasonal efficiency of commercial space heating boiler systems[1].
- ASHRAE Standard 90.1-2004: minimum boiler efficiencies for buildings except low-rise residential buildings[2].

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	43,859	0	0	8,470	0
2	43,859	0	0	0	0
3	43,859	0	0	0	0
4	43,859	0	0	0	0
5	43,859	0	0	0	0
6	43,859	0	0	0	0
7	43,859	0	0	0	0
8	43,859	0	0	0	0
9	43,859	0	0	0	0
10	43,859	0	0	0	0
11	43,859	0	0	0	0
12	43,859	0	0	0	0
13	43,859	0	0	0	0
14	43,859	0	0	0	0
15	43,859	0	0	0	0
16	43,859	0	0	0	0
17	43,859	0	0	0	0
18	43,859	0	0	0	0
19	43,859	0	0	0	0
20	43,859	0	0	0	0
21	43,859	0	0	0	0
22	43,859	0	0	0	0
23	43,859	0	0	0	0
24	43,859	0	0	0	0
25	43,859	0	0	0	0
TOTALS	**1,096,475**	**0**	**0**	**8,470**	**0**

[1] Boiler System Efficiency, ASHRAE Journal, July 2006
[2] Ibid.

Resource Savings Assumptions

Annual Natural Gas Savings	43,859 m^3

- The Agviro study[3] analyzed the gas usage of 147 elementary school based on 2006 billing record. The analysis determined:
  - The consumption and size of an average elementary school
  - The size of boiler required to heat the typical elementary school
  - The manufacturer's suggested retail price for boilers based on the determined size
  - The savings of higher efficiency boilers versus a base case of 80 to 82% efficiency
  - Incremental cost associated with the higher efficiency boiler
- Based on Enbridge project records the study found that 2 smaller boilers are typically installed (2 x 1500 MBH boilers for elementary schools). Also, based on project records, the study found that boiler upgrades will be weighted 89% towards the efficiency range of 85% to 88% and 11% towards boilers with combustion efficiencies ranging from 83% to 84%.
- Baseline estimates of natural gas consumption = 209,596 m^3.

	Estimated Annual Gas Consumption (m^3)	Estimated Annual Gas Savings (m^3)	Weighted Average NG Savings (m^3)
Base Case (81%)	209,596		
Mid Efficiency (83.5%)	178,494	31,102	43,859
High Efficiency (86.5%)	164,160	45,436	

- Natural Gas Savings % = 43,859 m^3 / 209,596 m^3 = 21%

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	0 L

N/A

Other Input Assumptions

Effective Useful Life (EUL)	25 Years

Boilers have an estimated service life of 25 years according to ASHRAE[4].

Base & Incremental Conservation Measure Equipment and O&M Costs	$ 8,470

Average MSRP for 2x400 MBH Boiler		
Combustion Efficiency	Average MSRP	Incremental Cost
80 - 82 % [Base Case]	2 x $18,100 = $36,200	$8,470
83 - 84% [Mid Efficiency]	2 x $21,000 = $42,000	
85 - 88% [High Efficiency]	2 x $22,500 = $45,000	

- Incremental costs are based on the weighted average of boiler types as noted above[5].

Customer Payback Period (Natural Gas Only)[6]	0.4 Years

Using an 5-year average commodity cost (avoided cost)[7] of $0.38 / m^3 and an average commercial distribution cost[8] of $0.12 / m^3, the payback period for natural gas savings is determined to be 0.4 years, based on the following:

[3] Agviro Inc, Secondary Schools Prescriptive Savings Analysis, November 23, 2007
[4] ASHRAE Applications Handbook – 2003, Chapter 36 – Owning and Operating Costs, Table 3
[5] Agviro Inc, Secondary Schools Prescriptive Savings Analysis, November 23, 2007
[6] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$8,470/ (43,859 m^3/year * \$0.5 / m^3) = 0.4 years	
Market Penetration[9]	**Low**
Based on communication with local contractors and other jurisdiction penetration rates, the market penetration for high efficiency boilers in schools is low. Therefore, Navigant Consulting is estimating a low market penetration.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m^3)	Effective Useful Life (Years)	Incremental Cost (\$)	Penetration/Market Share
Iowa State Utility Board Assessment Study[10]	0.077 per ft^2	20	24.589 per ft^2	5%
Comments Greater than 300 kBTUh, upgrade from 80% thermal baseline efficiency to 85% thermal efficiency. Baseline Therm reported on a square footage basis (eg 0.50 therms/sq.ft.for education sector). Estimated 5.6% savings for new energy efficient technology is reported as a percent saving over the baseline. Equivalent natural gas savings is 5.6% x 0.50 therms/sq.ft. = 0.28 therms = 0.077 m^3				
Iowa State Utility Board Assessment Study[11]	0.135 per ft^2	20	30.182 per ft^2	5%
Comments Greater than 300 kBTUh, upgrade from 80% thermal baseline efficiency to 89% thermal efficiency. Baseline Therm reported on a square footage basis (eg 0.50 therms/sq.ft.for education sector). Estimated 5.6% savings for new energy efficient technology is reported as a percent saving over the baseline. Equivalent natural gas savings is 9.8% x 0.50 therms/sq.ft = 0.049 therms = 0.135 m^3				

[7] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[8] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[9] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[10] Joint Assessment Study, MidAmerican Energy Company, Appendix C. State of Iowa Utilities Board Docket No. EEP-08-2, 2008, C-131
[11] Ibid.

COMMERCIAL WATER HEATING

Condensing Gas Water Heater - Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Condensing Gas Water Heater[1] (95% thermal efficiency), 50 gallons.

Due to the variability in energy savings for commercial buildings resulting from the quantity of daily water use, resource savings were calculated for three scenarios of daily hot water use[2]:

Scenario **A**: 100 gallons (378 litres)
Scenario **B**: 500 gallons (1,893 litres)
Scenario **C**: 1,000 gallons (3,786 litres)

Base Equipment and Technologies Description

Conventional storage tank gas water heater[3] (thermal efficiency[4]=80%), 91 gallons.

Decision Type	Target Market(s)	End Use
New/Retrofit	Commercial (New/Existing)	Water heating

Codes, Standards, and Regulations

Ontario's Energy Efficiency Act[5] applies only to water heaters with an input rating of less than 75,000 Btu/hr.

---

[1] Locally available commercial condensing gas water heater, trade name: Polaris, model #: PC 199-50 http://www.johnwoodwaterheaters.com/pdfs/GSW_PolarisSpecSheet.pdf

[2] One of the input assumptions required for calculating resource savings for this measure is the stand-by heat loss of storage tank water heaters. Hourly stand-by losses are treated as constant using values drawn from GAMA's *Consumer Directory* (see citation below). This means that marginal percentage gas savings will fall as hot water use rises.

[3] Locally available commercial conventional (non-condensing) gas water heater with the same input rating as the Polaris. Manufacturer: Rheem, model #: G91-200.

[4] Although the required minimum thermal efficiency to be in compliance with ASHRAE 90.1 is 78%, http://www.energycodes.gov/comcheck/pdfs/404text.pdf, only an very small percentage of commercial gas water heaters listed in the GAMA *Consumer's Directory of Certified Efficiency Ratings* had a thermal efficiency of less than 80%. http://www.neo.ne.gov/neq_online/july2006/commgaswtrhtr.pdf

[5] http://www.energy.gov.on.ca/english/pdf/conservation/2006%20-%20EEA%20Guide%20C%20-%20Water%20Heaters.pdf

Resource Savings Table

Year (EUL=)	Natural Gas (m³)	Electricity (kWh)	Water (L)	Equipment & O&M Costs of Conservation Measure ($)	Equipment & O&M Costs of Base Measure ($)
	Electricity and Other Resource Savings				
1	**A**: 338 **B**: 905 **C**: 1,614	0	0	5,880	3,650
2	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
3	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
4	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
5	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
6	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
7	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
8	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
9	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
10	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
11	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
12	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
13	**A**: 338 **B**: 905 **C**: 1,614	0	0	0	0
TOTALS	**A**: 4,395 **B**: 11,769 **C**: 20,985	**0**	**0**	**5,880**	**3,650**

Resource Savings Assumptions

Annual Natural Gas Savings	A: 338 m³ B: 905 m³ C: 1,614 m³

Assumptions and inputs:

- Daily hot water draw:
  - Scenario A: 100 gallons (378 litres)
  - Scenario B: 500 gallons (1,893 litres)
  - Scenario C: 1,000 gallons (3,786 litres)
- Input rating for efficient and base equipment: 199,000 Btu.

- Average water inlet temperature: 7.22 °C (45 °F)[6]
- Average water heater set point temperature: 54 °C (130 °F)[7]
- Stand-by loss of (condensing) Polaris PC 199-50 3NV: 244 Btu/hr[8].
- Stand-by loss of (non-condensing) Rheem G91-200: 1,050 Btu/hr[9].

Annual gas savings calculated as follows:

$$Savings = \left[W * 8.33 * (T_{out} - T_{in}) * \left(\frac{1}{Eff_{base}} - \frac{1}{Eff_{eff}} \right) + \left(Stby_{base} - Stby_{eff} \right) * 24 * 365 \right] * 10^{-6} * 27.8$$

Where:

W = Annual hot water use (gallons)
8.33 = Energy content of water (Btu/gallon/°F)
T_{out} = Water heater set point temperature (°F)
T_{in} = Water inlet temperature (°F)
Eff_{base} = Thermal efficiency of base equipment
Eff_{eff} = Thermal efficiency of efficient equipment
10^{-6} = Factor to convert Btu to MMBtu
$Stby_{base}$ = Stand-by loss per hour for base equipment (Btu)
$Stby_{eff}$ = Stand-by loss per hour for efficient equipment (Btu)
24 = Hours per day
365 = Days per year
27.8 = Factor to convert MMBtu to m^3

Scenario A: Gas savings were determined to be 29% over base measure
Scenario B: Gas savings were determined to be 19% over base measure
Scenario C: Gas savings were determined to be 17% over base measure

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff} \right)}{G_{base}}$$

G_{eff} = Annual natural gas use with efficient equipment,
Scenario **A:** 816 m^3
Scenario **B:** 3,841 m^3
Scenario **C:** 7,622 m^3
G_{base} = Annual natural gas use with base equipment,
Scenario **A:** 1,154 m^3
Scenario **B:** 4,746 m^3
Scenario **C:** 9,236 m^3

---

[6] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004
http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf
[7] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4
[8] *Consumer's Directory of Certified Efficiency Ratings*
http://www.neo.ne.gov/neq_online/july2006/commgaswtrhtr.pdf
In this case stand-by losses are constant. Recalculating gas savings using the WHAM algorithm, in which stand-by losses are a function of water draw, results in less than 3% variation over the figures presented above.
Lutz, J.D., C.D. Whitehead, A.B. Lekov, G.J. Rosenquist., and D.W. Winiarski. 1999. *WHAM: Simplified tool for calculating water heater energy use*. ASHRAE Transactions 105 (1): 1005-1015.
[9] *Consumer's Directory of Certified Efficiency Ratings*
http://www.neo.ne.gov/neq_online/july2006/commgaswtrhtr.pdf.

Annual Electricity Savings	0 kWh
N/A	
Annual Water Savings	**0 L**
Navigant has assumed that adopting the measure would not affect the quantity of water consumed.	

Other Input Assumptions

Effective Useful Life (EUL)	13 Years
Studies conducted in two different jurisdictions (Iowa[10] and Washington State[11]) use an EUL of 13 years, whereas one conducted for Enbridge and Union in 2000[12] uses an EUL of 15 years. Given that the two most recent studies both use 13 years, Navigant Consulting also recommends adopting 13 years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**2,230 $**
Incremental cost determined from communication with local distributor[13]	
Customer Payback Period (Natural Gas Only)[14]	**A: 13 Years B: 5 Years C: 2.8 Years**
Using a 5-year average commodity cost (avoided cost)[15] of $0.38 / m^3 and an average commercial distribution cost[16] of $0.12 / m^3, the payback period for natural gas savings is determined to be 13 years for Scenario A, 5 years for Scenario B and 2.8 years for Scenario C, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) Scenario A = $2,230/ (338 m^3/year * $0.5 / m^3) = 13 years Scenario B = $2,230/ (905 m^3/year * $0.5 / m^3) = 5 years Scenario C = $2,230/ (1,614 m^3/year * $0.5 / m^3) = 2.8 years	
Market Penetration[17]	**Low**
Based on the observation of low penetration in another jurisdiction (Washington State[18] – 5%), the paucity of distributors in Ontario and of the relatively high incremental cost, Navigant Consulting estimates the penetration in Ontario to be low.	

[10] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[11] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[12] Jacques Whitford Environment Ltd, *Prescriptive Incentives for Select Natural Gas Technologies*, Sept 2000
[13] Rheem G91-200: $3,650
Polaris PC 199-50: $5,880
[14] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[15] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[16] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[17] Navigant Consulting is defining “Low” as below 5%, “Medium” as between 5-50%, and “High” as above 50%,
[18] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Pacific Gas & Electric, April 2007[19]	2,107	N/A	N/A	N/A
Comments Average daily hot water use 2,083 gallons per day, thermal efficiency of new technology (60 gallon tank), 95%, thermal efficiency of base measure (standard efficiency tankless water heater), 82%. Measure provides savings of 28% over 7,496 m^3 required for heating water used with base equipment.				

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy, 2007[20]	0.78 per ft^2.	13	N/A	5%
Comments Savings calculated for an existing restaurant. Measure saves 34% of 2.28 m^3 per square foot required for water heating.				

[19] Karras, A. and D. Fisher, *Energy Efficiency Potential of Gas-Fired Water Heating Systems in a Quick Service Restaurant.* Pacific Gas & Electric, April 2007 http://www.fishnick.com/publications/appliancereports/special/Commercial_Water_Heating_Systems.pdf

[20] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

Pre-Rinse Spray Nozzle (1.6 GPM)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow pre-rinse spray nozzle/valve (1.6 GPM)

Base Equipment and Technologies Description

Standard pre-rinse spray nozzle/valve (3.0 GPM)

Decision Type	Target Market(s)	End Use
Retrofit	Commercial (existing)	Water heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/hour of daily use)	Electricity (kWh)	Water (L)	($)	($)
1	387	0	116,086	41	0
2	387	0	116,086	0	0
3	387	0	116,086	0	0
4	387	0	116,086	0	0
5	387	0	116,086	0	0
TOTALS	**1,934**	**0**	**580,430**	**41**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	387 m^3 / hour daily use

Assumptions and inputs:

- Average water inlet temperature: 7.22 °C (45 °F)[1]
- Average water heater set point temperature: 54 °C (130 °F)[2]
- Water heater thermal efficiency: 0.78[3]
- Percentage of water used that is hot: 50%[4]

Annual gas savings calculated as follows:

$$Savings = Ws * Phot * 8.33 * (T_{out} - T_{in}) * \frac{1}{Eff} * 10^{-6} * 27.8$$

Where:

Ws = Water savings (gallons)
Phot = Percentage of water used that is hot
T_{out} = Water heater set point temperature (°F)
T_{in} = Water inlet temperature (°F)
Eff = Water heater thermal efficiency
8.33 = Energy content of water (Btu/gallon/°F)
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 47% over base equipment:

$$Percent\ Savings = \frac{(G_{base} - G_{eff})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 442 m^3
G_{base} = Annual natural gas use with base equipment, 829 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	116,086 L /hour daily use

Assumptions and inputs:

- Water use for one nozzle can vary enormously depending on the type of establishment using it. The U.S. DOE Federal Energy Management Program[5] calculates savings based on four hours of use per day for prisons and military bases. A 2008 Calgary study by Veritec[6] focuses on grocery

[1] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices*,EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[2] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4

[3] Minimum thermal efficiency for compliance with ASHRAE 90.1 standard.

[4] Empirical finding of:

Veritec Consulting & Canadian Meter Installation Services, Inc. City of Calgary *Pre-Rinse Spray Valve Replacement Program*, June 2008

http://www.calgary.ca/docgallery/bu/water_services/conservation/indoor/calgary_pre_rinse_report.pdf

[5] U.S. DOE, Federal Energy Management Program, *How to Buy a Low-Flow Pre-Rinse Spray Valve* http://www1.eere.energy.gov/femp/pdfs/prerinsenozzle.pdf

[6] Veritec Consulting (2008)

stores and fast-food restaurants and finds that average use is 47 minutes per day. Due to the variability of the establishments and the daily water use, savings were determined based on an hour of use per day.

- Veritec's 2008 Calgary Study found a 6% increase in average daily use after the introduction of a low-flow valve, but did not test the significance of this change. Navigant Consulting is therefore assuming that daily water use remains the same after the introduction of the efficient equipment.

Annual water savings calculated as follows:

$$Savings = (Fl_{base} - Fl_{eff}) * 60 * Hr * 365$$

Where:

Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)
60 = Minutes per hour
Hr = Hours used per day
365 = Days per year

Water savings were determined to be 47% over base equipment:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water consumed with efficient equipment, 132,670 litres (35,040 gallons)
W_{base} = Annual water consumed by showers with base equipment: 248,756 litres (65,700 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	**5 Years**
Studies conducted for the City of Calgary[7], the U.S. DOE's FEMP[8] and by Puget Sound Energy[9] all give EUL for this measure as five years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**41 $**
Incremental cost based on a survey of online retailers[10].	
Customer Payback Period (Natural Gas Only)[11]	**0.2 Years**
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average commercial distribution cost[13] of \$0.12 / m^3, the payback period for natural gas savings is determined to be 0.2 years, based on the following:	

[7] Ibid.
[8] U.S. DOE, Federal Energy Management Program, *How to Buy a Low-Flow Pre-Rinse Spray Valve* http://www1.eere.energy.gov/femp/pdfs/prerinsenozzle.pdf
[9] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[10] Niagara 1.6 GPM Pre-rinse Spray Valve N2180 http://www.conservationmart.com/p-301-niagara-16-gpm-prerinse-spray-valve-n2180.aspx
[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $41/ (387 m^3/year * $0.50 / m^3) = 0.2 years	
Market Penetration[14]	**Medium**
Based on the observation of high penetration in one jurisdiction (Washington State[15] – 70%), of medium penetration in another (Iowa[16] – 45%) and of the relatively low cost/benefit ratio, Navigant Consulting estimates the penetration in Ontario to be medium.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
City of Calgary, 2008[17]	469	5	0 (City installed)	N/A
Comments Daily mean use estimated to be 47 minutes before measure installed and 50 minutes with the efficient measure installed. On-site water use data reveal an even mix of hot and cold water used. Average flow rate of base equipment was found to be 3 GPM, while the average flow rate after efficient equipment installed was found to be 1.1 GPM. No indication given of percentage savings or base natural gas consumption for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
U.S. Department of Energy, Federal Energy Management Program[18]	2,021	5	N/A	N/A
Comments Assumptions: four hours of use per day, switch from a 3.0 GPM pre-rinse spray valve to a 1.6 GPM pre-rinse spray valve. Measure provides savings of 47% over 4,340 m3 required for heating water used with base equipment.				

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[14] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[17] Veritec Consulting (2008)
http://www.calgary.ca/docgallery/bu/water_services/conservation/indoor/calgary_pre_rinse_report.pdf
[18] U.S. DOE, Federal Energy Management Program, *How to Buy a Low-Flow Pre-Rinse Spray Valve*
http://www1.eere.energy.gov/femp/pdfs/prerinsenozzle.pdf

Pre-Rinse Spray Nozzle (1.24 GPM)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow pre-rinse spray nozzle/valve (1.24 GPM)

Base Equipment and Technologies Description

Standard pre-rinse spray nozzle/valve (3.0 GPM)

Decision Type	Target Market(s)	End Use
Retrofit	Commercial (existing)	Water heating

Codes, Standards, and Regulations

N/A

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3/hour of daily use)	Electricity (kWh)	Water (L)	($)	($)
1	486	0	145,937	60	0
2	486	0	145,937	0	0
3	486	0	145,937	0	0
4	486	0	145,937	0	0
5	486	0	145,937	0	0
TOTALS	**2,431**	**0**	**729,683**	**60**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	486 m^3 / hour daily use

Assumptions and inputs:

- Average water inlet temperature: 7.22 °C (45 °F)[1]
- Average water heater set point temperature: 54 °C (130 °F)[2]
- Water heater thermal efficiency: 0.78[3]
- Percentage of water used that is hot: 50%[4]

Annual gas savings calculated as follows:

$$Savings = Ws * Phot * 8.33 * (T_{out} - T_{in}) * \frac{1}{Eff} * 10^{-6} * 27.8$$

Where:

Ws = Water savings (gallons)
Phot = Percentage of water used that is hot
T_{out} = Water heater set point temperature (°F)
T_{in} = Water inlet temperature (°F)
Eff = Water heater thermal efficiency
8.33 = Energy content of water (Btu/gallon/°F)
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 59% over base equipment:

$$Percent\ Savings = \frac{(G_{base} - G_{eff})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 343 m^3
G_{base} = Annual natural gas use with base equipment, 829 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	145,937 L /hour daily use

Assumptions and inputs:

- Water use for one nozzle can vary enormously depending on the type of establishment using it. The U.S. DOE Federal Energy Management Program[5] calculates savings based on four hours of use per day for prisons and military bases. A 2008 Calgary study by Veritec[6] focuses on grocery stores and fast-food restaurants and finds that average use is 47 minutes per day. Due to the

---

[1] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[2] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4

[3] Minimum thermal efficiency for compliance with ASHRAE 90.1 standard.

[4] Empirical finding of:

Veritec Consulting & Canadian Meter Installation Services, Inc. City of Calgary *Pre-Rinse Spray Valve Replacement Program*, June 2008 http://www.calgary.ca/docgallery/bu/water_services/conservation/indoor/calgary_pre_rinse_report.pdf

[5] U.S. DOE, Federal Energy Management Program, *How to Buy a Low-Flow Pre-Rinse Spray Valve* http://www1.eere.energy.gov/femp/pdfs/prerinsenozzle.pdf

[6] Veritec Consulting (2008)

variability of the establishments and the daily water use, savings were determined based on an hour of use per day.

- Veritec's 2008 Calgary Study found a 6% increase in average daily use after the introduction of a low-flow valve, but did not test the significance of this change. Navigant Consulting is therefore assuming that daily water use remains the same after the introduction of the efficient equipment.

Annual water savings calculated as follows:

$$Savings = \left(Fl_{base} - Fl_{eff}\right) * 60 * Hr * 365$$

Where:

Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)
60 = Minutes per hour
Hr = Hours used per day
365 = Days per year

Water savings were determined to be 59% over base equipment:

$$Percent\ Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed with efficient equipment, 102,819 litres (27,196 gallons)
W_{base} = Annual water consumed by showers with base equipment: 248,756 litres (65,700 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	**5 Years**
Studies conducted for the City of Calgary[7], the U.S. DOE's FEMP[8] and by Puget Sound Energy[9] all give EUL for this measure as five years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**60 $**
Incremental cost based on a survey of online retailers[10].	
Customer Payback Period (Natural Gas Only)[11]	**0.3 Years**
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average commercial distribution cost[13] of \$0.12 / m^3, the payback period for natural gas savings is determined to be 0.3 years, based on the following:	

[7] Ibid.

[8] U.S. DOE, Federal Energy Management Program, *How to Buy a Low-Flow Pre-Rinse Spray Valve* http://www1.eere.energy.gov/femp/pdfs/prerinsenozzle.pdf

[9] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

[10] T & S Brass (B-0107-C35) - JetSpray 1.24 GPM low flow spray valve http://www.foodservicewarehouse.com/t-s-brass/b-0107-c35/p345921.aspx?source=googleps

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$60/ (486 m^3/year * \$0.50 / m^3) = 0.3 years

Market Penetration[14]	Low
Although 1.6 GPM spray nozzles have a high penetration in one jurisdiction (Washington State[15] – 70%) and a medium penetration in another (Iowa[16] – 45%), no figures were uncovered for 1.24 GPM spray nozzles. Given the relative novelty of this newer, lower flow rate spray nozzle, Navigant Consulting estimates the penetration in Ontario to be low.	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
City of Calgary, 2008[17]	469	5	0 (City installed)	N/A
Comments Daily mean use estimated to be 47 minutes before measure installed and 50 minutes with the efficient measure installed. On-site water use data reveal an even mix of hot and cold water used. Average flow rate of base equipment was found to be 3 GPM, while the average flow rate after efficient equipment installed was found to be 1.1 GPM. No indication given of percentage savings or base natural gas consumption for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
U.S. Department of Energy, Federal Energy Management Program[18]	2,021	5	N/A	N/A
Comments Assumptions: four hours of use per day, switch from a 3.0 GPM pre-rinse spray valve to a 1.6 GPM pre-rinse spray valve. Measure provides savings of 47% over 4,340 m3 required for heating water used with base equipment.				

[14] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[17] Veritec Consulting (2008) http://www.calgary.ca/docgallery/bu/water_services/conservation/indoor/calgary_pre_rinse_report.pdf
[18] U.S. DOE, Federal Energy Management Program, *How to Buy a Low-Flow Pre-Rinse Spray Valve* http://www1.eere.energy.gov/femp/pdfs/prerinsenozzle.pdf

Tankless Water Heater - Commercial

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Gas Tankless Water Heater (Thermal efficiency = 84%).

Due to the variability in energy savings for commercial buildings resulting from the quantity of daily water use, resource savings were calculated for three scenarios of daily hot water use[1]:

Scenario **A**: 100 gallons (378 litres)
Scenario **B**: 500 gallons (1,893 litres)
Scenario **C**: 1,000 gallons (3,786 litres)

Base Equipment and Technologies Description

Conventional storage tank gas water heater (Thermal efficiency[2] = 80%), 91 gallons

Decision Type	Target Market(s)	End Use
New	Commercial (New)	Water heating.

Codes, Standards, and Regulations

Ontario's Energy Efficiency Act[3] applies only to water heaters with an input rating of less than 75,000 Btu/hr.

[1] One of the input assumptions required for calculating resource savings for this measure is the stand-by heat loss of storage tank water heaters. Hourly stand-by losses are treated as constant using values drawn from GAMA's *Consumer Directory* (see citation below). This means that marginal percentage gas savings will fall as hot water use rises.

[2] Although the required minimum thermal efficiency to be in compliance with ASHRAE 90.1 is 78%, http://www.energycodes.gov/comcheck/pdfs/404text.pdf, only an very small percentage of commercial gas water heaters listed in the GAMA *Consumer's Directory of Certified Efficiency Ratings* had a thermal efficiency of less than 80%. http://www.neo.ne.gov/neq_online/july2006/commgaswtrhtr.pdf.

[3] http://www.energy.gov.on.ca/english/pdf/conservation/2006%20-%20EEA%20Guide%20C%20-%20Water%20Heaters.pdf

Resource Savings Table

Year (EUL=)	Electricity and Other Resource Savings: Natural Gas (m^3)	Electricity (kWh)	Water (L)	Equipment & O&M Costs of Conservation Measure ($)	Equipment & O&M Costs of Base Measure ($)
1	**A:** 215 **B:** 57 **C:** -142	0	0	**A:** $2,080 **B:** $4,160 **C:** $6,240	$3,650
2	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
3	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
4	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
5	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
6	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
7	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
8	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
9	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
10	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
11	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
12	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
13	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
14	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
15	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
16	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
17	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
18	**A:** 215 **B:** 57 **C:** -142	0	0	0	0
TOTALS	**A:** 3,870 **B:** 1,026 **C:** -2,556	**0**	**0**	**A:** $2,080 **B:** $4,160 **C:** $6,240	$3,650

Resource Savings Assumptions

Annual Natural Gas Savings	A: 215 m^3 B: 57 m^3 C: -142 m^3

Assumptions and inputs:

- Following a recommendation made in 2006 to the California Energy Commission that the Alternative Calculation Method (ACM) be amended to recognise the disparity between the nominal recovery efficiency of tankless water heaters drawing less than 11 gallons and the actual energy efficiency, savings are calculated using an thermal efficiency degraded by 8.8%[4]
- Adjusted thermal efficiency[5]: 0.77.
- Input rating for new technology and base equipment: 199,000 Btu.
- Stand-by loss of Rheem G91-200: 1,050 Btu/hr[6].
- Daily hot water draw:
  - Scenario A: 100 gallons (378 litres)
  - Scenario B: 500 gallons (1,893 gallons)
  - Scenario C: 1,000 gallons (3,786 litres)
- Average water inlet temperature: 7.22 ^oC (45 ^oF)[7]
- Average water heater set point temperature: 54 ^oC (130 ^oF)[8]

Annual gas savings calculated as follows:

$$Savings = \left[W * 8.33 * (T_{out} - T_{in}) * \left(\frac{1}{Eff_{base}} - \frac{1}{Eff_{eff}} \right) + \left(Stby_{base} - Stby_{eff} \right) * 24 * 365 \right] * 10^{-6} * 27.8$$

Where:

W = Annual hot water use (gallons)
8.33 = Energy content of water (Btu/gallon/^oF)
T_{out} = Water heater set point temperature (^oF)
T_{in} = Water inlet temperature (^oF)
Eff_{base} = Thermal efficiency of base equipment
Eff_{eff} = Adjusted thermal efficiency of efficient equipment
10^{-6} = Factor to convert Btu to MMBtu
$Stby_{base}$ = Stand-by loss per hour for base equipment (Btu)
$Stby_{eff}$ = Stand-by loss per hour for efficient equipment (Btu)
24 = Hours per day
365 = Days per year
27.8 = Factor to convert MMBtu to m^3

Scenario A: Gas savings were determined to be 18% over base measure

---

[4] Davis Energy Group, *Measure Information Template: Tankless Gas Water Heaters*, April 2008 http://www.energy.ca.gov/title24/2008standards/prerulemaking/documents/2006-05-18_workshop/2006-05-11_GAS_WATER.PDF

[5] It should be noted that an alternative study, by Exelon Services for Okaloosa Gas, conducted carefully controlled tests to determine the thermal efficiency of a tankless and a storage tank gas water heater. This study found that, in fact, the listed energy factor *underestimated* the tankless water heater's true thermal efficiency. This result is not reflected in this substantiation sheet due to the more recent findings cited above, arrived at with a larger sample than the Okaloosa study. Exelon Services and Okaloosa Gas District, Performance Comparison of Residential Water Heating Systems,December 2002

[6] *Consumer's Directory of Certified Efficiency Ratings* http://www.neo.ne.gov/neq_online/july2006/commgaswtrhtr.pdf

[7] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[8] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4

Scenario B: Gas savings were determined to be 1% over base measure Scenario C: Gas savings were determined to be -2% over base measure $$Percent\,Savings = \frac{(G_{base} - G_{eff})}{G_{base}}$$ Where: G_{eff} = Annual natural gas use with efficient equipment, Scenario **A:** 938 m^3 Scenario **B:** 4,689 m^3 Scenario **C:** 9,378 m^3 G_{base} = Annual natural gas use with base equipment, Scenario **A:** 1,154 m^3 Scenario **B:** 4,746 m^3 Scenario **C:** 9,236 m^3	
Annual Electricity Savings	**0 kWh**
N/A	
Annual Water Savings	**0 L**
Navigant has assumed that adopting the measure would not affect the quantity of water consumed.	

Other Input Assumptions

Effective Useful Life (EUL)	**18 Years**
Navigant Consulting recommends using an EUL of 18 years, the mean of estimated measure lifetimes used two other jurisdictions (Iowa[9], 20 years, and Puget Sound Energy[10], 13 years) and that quoted by an academic paper[11] (20 years).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**A: -1,570 $** **B: 510 $** **C: 2,590 $**
Commercial tankless water heaters are typically scaled up by unit - a commercial user would likely need several tankless water heaters to replace a single storage tank. The tankless model cited has a maximum flow rate of 4.7 – 7.4 GPM depending on temperature rise required. Any large commercial enterprise would likely require 2 – 3 tankless units to accommodate peak demand[12]. Costs for the two systems were determined to be: • WaiWela PH28CIFS tankless water heater and installation kit = $2,080 ea[13]. • Rheem G91-200 storage tank water heater = $3,650[14].	
Customer Payback Period (Natural Gas Only)[15]	**A: 0** **B: 18 Years** **C: N/A**

[9] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[10] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[11] Aguilar, C., White, D.J., and Ryan, David L. *Domestic Water Heating and Water Heater Energy Consumption in Canada*, April 2005,
[12] A study for Pacific Gas and Electric of a chain casual dining restaurant found peak water draws of up to 20 GPM. Wallace, C. and D. Fisher, Energy Efficiency Potential of Gas-Fired Commercial Hot Water Heating Systems in Restaurants.April 2007
[13] http://www.tanklesswaterheaters.ca/waiwelaph28ci.html
[14] From correspondence with local distributor.
[15] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

Using a 5-year average commodity cost (avoided cost)[16] of $0.38 / m^3$ and an average commercial distribution cost[17] of $0.12 / m^3$, the payback period for natural gas savings is determined to be immediate for Scenario A and 17 years for Scenario B.

For Scenario C, natural gas use increases, no natural gas payback is determined.

Payback Period = Incremental cost / (natural gas savings x natural gas cost)

Scenario A = Incremental cost is negative for this scenario; payback is immediate as efficient equipment costs less than base equipment.

Scenario B = $510/ (57 m^3/year * $0.52 / m^3)

= 18 years

Market Penetration[18]	**Low**

Based on the observation of low penetration in two other jurisdictions (Washington State[19] – 5%, Iowa[20] – 0%), communications with local contractors and the logistical requirements for large commercial installations, Navigant Consulting estimates the penetration in Ontario to be low.

[16] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[17] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[18] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,

[19] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

[20] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy, 2007[21]	0.09 per ft^2 (school)	15	N/A	5%
Comments Assuming base equipment to be a conventional water tank with an EF=0.64. No indication that efficiency assumptions change from residential to commercial. Measure saves 27% of 0.33 m^3 per square foot required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[22]	0.017 per ft^3 (school)	20	9,167 US$	0%
Comments Compare a tankless water heater with an EF = 0.82 against a conventional storage tank water heater with 80% thermal efficiency. Measure saves 30% of 0.56 m^3 per square foot required for water heating.				

[21] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[22] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

MULTI-FAMILY WATER HEATING

Energy Star Front-Loading Clothes Washer

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Energy Star high efficiency front load washers for application in the Multi-Family sector (MEF[1]=1.72 , WF[2]=8.0, tub size = 2.8 ft^3)

Base Equipment and Technologies Description

Conventional top loading vertical axis washers (MEF = 1.26, WF=9.5, tub size = 2.8 ft^3)

Decision Type	Target Market(s)	End Use
New/Replacement	Multi-Family	Water heating

Codes, Standards, and Regulations

NRCan Federal Energy Efficiency Regulations require:

- Top loading washers are required to have a minimum MEF of 1.26 and a maximum tub size of 3.5 cubic feet.
- Front loading washers are required to have a minimum MEF of 1.26 and a maximum tub size of 4 cubic feet.

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	79	201	19,814	$1,000	$850
2	79	201	19,814	0	0
3	79	201	19,814	0	0
4	79	201	19,814	0	0
5	79	201	19,814	0	0
6	79	201	19,814	0	0
7	79	201	19,814	0	0
8	79	201	19,814	0	0
9	79	201	19,814	0	0
10	79	201	19,814	0	0
11	79	201	19,814	0	0
TOTALS	**869**	**2,211**	**217,954**	$1,000	$850

[1] Modified Energy Factor.
[2] Water Factor: the number of gallons per load cycle per cubic foot that the clothes washer uses. The lower the water factor, the more efficient the washer is.

Resource Savings Assumptions

Annual Natural Gas Savings	79 m^3

Assumptions and inputs:

- Percentage of water used by base equipment which is hot water: 17%.
- Percentage of water used by efficient equipment which is hot water: 10%[3]
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater set point temperature: 54 °C (130 °F)[5]
- Water heater thermal efficiency: 0.78[6]
- Gas use per cycle[7] for commercial gas dryer with base equipment: 0.138 m^3
- Gas use per cycle for commercial gas dryer with Energy Star clothes washer: 0.117 m^3
- Gas dryer penetration in Ontario Multi-Family market: 25.5%[8]
- Annual gas savings from reduced dryer use: 7 m^3
- Annual gas savings from reduced hot water use: 73 m^3

Annual gas savings calculated as follows:

$$Savings = \left[\left(W_{base} * Hot_{base} - W_{eff} * Hot_{eff} \right) * 8.33 * \frac{1}{Eff} * \left(T_{out} - T_{in} \right) + \left(Dr_{base} - Dr_{eff} \right) * Pene \right] * 10^{-6} * 27.8$$

Where:

W_{base} = Annual water use with base equipment (gallons)
W_{eff} = Annual water use with efficient equipment (gallons)
Hot_{base} = Percentage of water used that's hot with base equipment
Hot_{eff} = Percentage of water used that's hot with efficient equipment
8.33 = Energy content of water (Btu/gallon/°F)
Eff = Eff = Water heater thermal efficiency
T_{out} = Water heater set point temperature (°F)
T_{in} = Water inlet temperature (°F)
Dr_{base} = Annual dryer gas use with base equipment (Btu)
Dr_{eff} = Annual dryer gas use with efficient equipment (Btu)
Pene = Penetration rate of natural gas powered clothes dryers in Ontario
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 43% over base equipment.

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff} \right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 110 m^3
G_{base} = Annual natural gas use with base equipment, 182 m^3

---

[3] Base equipment uses 4.4 gallons of hot water per cycle, efficient equipment uses 2.3 gallons of hot water per cycle. U.S. DOE Federal Energy Management Program, Life-Cycle and Cost and Payback Period spreadsheet, http://www1.eere.energy.gov/buildings/appliance_standards/commercial/clothes_washers.html

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] As suggested by NRCan: http://oee.nrcan.gc.ca/residential/personal/new-homes/water-conservation.cfm?attr=4

Annual Electricity Savings	201 kWh

Assumptions and inputs:

- Water heated by natural gas (see above).
- Washer electricity use per cycle, base equipment: 0.13 kWh[9].
- Washer electricity use per cycle, efficient equipment: 0.11 kWh.
- Dryer electricity use per cycle, base equipment: 1.3 kWh.
- Dryer electricity use per cycle, efficient equipment: 1.11 kWh.
- Average number of cycles per year for clothes washer serving Multi-Family: 1246 cycles[10].

Annual electricity savings calculated as follows:

$$Savings = \left[\left(Wa_{base} - Wa_{eff}\right) + \left(Dr_{base} - Dr_{eff}\right) * \left(1 - Pene\right)\right] * Cyc$$

Where:

Wa_{base} = Washer electricity use per cycle, base equipment (kWh)
Wa_{eff} = Washer electricity use per cycle, efficient equipment (kWh)
Dr_{base} = Dryer electricity use per cycle, base equipment (kWh)
Dr_{eff} = Dry electricity use per cycle, efficient equipment (kWh)
Pene = Penetration rate of natural gas powered clothes dryers in Ontario
Cyc = Average number of cycles per year machine is used

Electricity savings were determined to be 15% over base equipment:

$$Percent\ Savings = \frac{\left(Elec_{base} - Elec_{new}\right)}{Elec_{base}}$$

Where:

$Elec_{eff}$ = Annual natural gas use with efficient equipment, 1,167 kWh
$Elec_{base}$ = Annual natural gas use with base equipment, 1,369 kWh

Annual Water Savings	19,814 L

Assumptions and inputs:

- Water use per cycle, base equipment: 101 litres (26.6 gallons).
- Water use per cycle, new technology: 85 litres (22.4 gallons).
- Average number of cycles per year for clothes washer serving Multi-Family: 1,246 cycles[11]

Annual water savings calculated as follows:

---

[6] Minimum thermal efficiency for compliance with ASHRAE 90.1 standard.
[7] U.S. DOE Federal Energy Management Program, National Energy Savings and Shipments spreadsheet http://www1.eere.energy.gov/buildings/appliance_standards/commercial/clothes_washers.html
[8] Average residential penetration rate of gas dryers in Union and Enbridge territories. The commercial/Multi-Family clothes dryers is likely to be slightly higher. Enbridge Gas Distribution, *Enbridge Gas Distribution to the Ontario Power Authority in the matter of the province's energy supply mix,* August 26, 2005. http://www.energy.gov.on.ca/opareport/Part%205%20-%20Submissions%20and%20Presentations/5.1%20Written%20Submissions%20to%20the%20Supply%20Mix%20Project/Enbridge_Gas_Distribution_Supply_Mix_Submission_Aug_26_2005.pdf
[9] U.S. DOE Federal Energy Management Program, Life-Cycle and Cost and Payback Period spreadsheet, http://www1.eere.energy.gov/buildings/appliance_standards/commercial/clothes_washers.html
[10] U.S. DOE Federal Energy Management Program, National Energy Savings and Shipments spreadsheet http://www1.eere.energy.gov/buildings/appliance_standards/commercial/clothes_washers.html
[11] Ibid.

$$Savings = (W_{base} - W_{eff}) * Cyc$$

Where:

W_{base} = Annual water use with base equipment (gallons or litres)
W_{eff} = Annual water use with efficient equipment (gallons or litres)
Cyc = Average number of cycles per year machine is used

Water savings were determined to be 16% over base measure:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water consumed with efficient equipment, 105,675 litres (27,910 gallons).
W_{base} = Annual water consumed by showers with base equipment: 125,489 litres (33,144 gallons).

Other Input Assumptions

Effective Useful Life (EUL)	11 Years
The U.S. DOE's Federal Energy Management Program has determined that commercial/Multi-Family clothes washers have an average EUL of 11.25 years[12]. Navigant Consulting recommends adopting an EUL of 11 years.	
Base & Incremental Conservation Measure Equipment and O&M Costs	**150 $**
Incremental cost based on prices offered online by a local retailer[13].	
Customer Payback Period (Natural Gas Only)[14]	**3.8 Years**
Using a 5-year average commodity cost (avoided cost)[15] of \$0.38 / m³ and an average commercial distribution cost[16] of \$0.12 / m³, the payback period for natural gas savings is determined to be 3.8 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$150/ (79 m³/year * \$0.50 / m³) = 3.8 years	
Market Share[17]	**High**
Based on the observation of high market penetration in two other jurisdictions (Washington State[18] – 48%, Iowa[19] – 72%) and of the fact that the majority of clothes washers offered for sale on the website of a major retailer are Energy Star, Navigant Consulting estimates the penetration in Ontario to be high.	

[12] Ibid.
[13] Base measure (3.5 cu/ft top loader, GE): \$850
New technology (3.5 cu/ft front loader, LG): \$1,000
www.homedepot.ca. Assuming the base equipment cost/ efficient equipment cost ratio of the two 3.5 cu/ft washers is equivalent to that of two 2.8 cu/ft washers.
[14] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[15] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[16] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[17] Navigant Consulting is defining "Low" as below 5%, "Medium" as between 5-50%, and "High" as above 50%,
[18] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy, 2007[20]	70	14	600	48%
Comments No explicit assumptions made about base and efficient equipment for commercial clothes washers. For residential clothes washers, assumptions: base equipment, MEF = 1.0, efficient equipment, Energy Star Clothes Washer, MEF = 1.8. Measure saves 13% of 539 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
Efficiency Vermont, 2005[21]	20	14	$750	N/A
Comments Cost is reported as the full cost of the energy efficient equipment rather than the incremental cost. Savings calculated are per customer basis rather than a per machine basis. No indication given of percentage savings or base natural gas consumption for water heating.				

[19] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2
[20] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[21] Efficiency Vermont, Technical Reference User Manual (TRM) No. 2005 - 37

Faucet Aerator (Muti-Family Bathroom)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Faucet Aerator (Bathroom) (1.5 GPM)

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1]

Decision Type	Target Market(s)	End Use
Retrofit	Multi-Family (existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires bathroom and kitchen faucets to have a maximum flow of 2.2 GPM (8.35 L/min).

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	7	0	**1,382**	2	0
2	7	0	**1,382**	0	0
3	7	0	**1,382**	0	0
4	7	0	**1,382**	0	0
5	7	0	**1,382**	0	0
6	7	0	**1,382**	0	0
7	7	0	**1,382**	0	0
8	7	0	**1,382**	0	0
9	7	0	**1,382**	0	0
10	7	0	**1,382**	0	0
TOTALS	**70**	**0**	**13,,820**	**2**	**0**

[1] From on-site audit data. Resource Management Strategies, Inc. *Regional Municipality of York Water Efficiency Master Plan Update,* 2007. Cited in: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.
[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	7 m^3

Assumptions and inputs:

- Average faucet water temperature: 32 ^oC (90 ^oF)[3]
- Average water inlet temperature: 7.22 ^oC (45 ^oF)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W = Water savings (gallons)
8.33 = Energy content of water (Btu/gallon/^oF)
T_{out} = Faucet water temperature (^oF)
T_{in} = Water inlet temperature (^oF)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 22% over base case:

$$Percent\ Savings = \frac{(G_{base} - G_{new})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 23 m^3
G_{base} = Annual natural gas use with base equipment, 30 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	1,382 L

Assumptions and inputs:

- Average household size: 2.14 persons[6]
- Baseline faucet use (all faucets) per capita per day: 53 litres (14 gallons)[7]
- Bathroom faucet use as a percentage of total faucet use: 15%[8]

---

[3] Average of findings in two studies. Mayer, P. W. et al, *Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in East Bay Municipal Utility District Service Area,* 2003 and Skeel, T. and Hill, S. *Evaluation of Savings from Seattle's "Home Water Saver" Apartment/Condominium Program*, 1994. Both cited in: Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] Summit Blue (2008) and Census 2006. To maintain consistency with Summit Blue number but to reflect the fact that apartments are generally occupied by fewer people than houses, the Summit Blue number was degraded by the ratio of the average number of inhabitants per apartment in an Ontario building over five stories (2) to the average number of inhabitants of a fully detached house in Ontario (2.9).

[7] Ibid.

[8] DeOreo, W. and P. Mayer, *The End Uses of Hot Water in Snigle Family Homes from Flow Trace Analysis*, 1999 cited in Summit Blue (2008).

- Point estimate of quantity of water that goes straight down the drain: 70%[9]

Annual water savings calculated as follows:

$$Savings = Fu * Ppl * 365 * Ba * \left((1 - Dr) - \left(1 - \frac{Fl_{base} - Fl_{eff}}{Fl_{base}} \right) * Dr \right)$$

Where:

Fu = Faucet use per capita (gallons)
Ppl = Number of people per household
365 = Days per year
Dr = Percentage of water that goes straight down the drain
Ba = Individual bathroom faucet use as a percentage of total faucet use
Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)

Water savings was determined to be 22% over base case:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water use with efficient equipment: 4,823 litres (1,274 gallons)
W_{base}= Annual water use with base equipment: 6,205 litres (1,639 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
The U.S. DOE assumes a 10 year life for faucet aerators[10].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**2 $**
Average equipment cost based on communication with local hardware stores.	
Customer Payback Period (Natural Gas Only)[11]	**0.5 Years**
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average residential distribution cost[13] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.5 years, based on the following:	

[9] Summit Blue (2008).
[10] U.S. Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Lavatory Faucets* http://www1.eere.energy.gov/femp/procurement/eep_faucets.html
[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$2/ (7 m^3/year * \$0.52 / m^3) = 0.5 years	
Market Penetration	**90%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of faucet aerators (bathroom and kitchen) across all sectors to be 90%[14].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
Puget Sound Energy[15]	5	5	N/A	50%
Comments For a switch from a 2.5 GPM to a 1.8 GPM aerator. Measure saves 1% of 539 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/ Market Share**
State of Iowa Utilities Board[16]	27	9	14 US$	90%
Comments For a switch from a 3.0 GPM to a 1.5 GPM aerator. In neither study is any distinction made between kitchen and bathroom faucet use. Measure saves 8.5% of 320 m^3 required for water heating.				

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008
[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy
[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Faucet Aerator (Multi-Family Kitchen)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Faucet Aerator (kitchen) (1.5 GPM)

Base Equipment and Technologies Description

Average existing stock (2.5 GPM)[1]

Decision Type	Target Market(s)	End Use
Retrofit	Multi-Family (existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires bathroom and kitchen faucets to have a maximum flow of 2.2 GPM (8.35 L/min).

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	26	0	5,377	2	0
2	26	0	5,377	0	0
3	26	0	5,377	0	0
4	26	0	5,377	0	0
5	26	0	5,377	0	0
6	26	0	5,377	0	0
7	26	0	5,377	0	0
8	26	0	5,377	0	0
9	26	0	5,377	0	0
10	26	0	5,377	0	0
TOTALS	**260**	**0**	**53,770**	**2**	**0**

[1] From on-site audit data. Resource Management Strategies, Inc. *Regional Municipality of York Water Efficiency Master Plan Update,* 2007. Cited in: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.
[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	26 m^3

Assumptions and inputs:

- Average faucet water temperature: 32 °C (90 F)[3]
- Average water inlet temperature: 7.22 °C (45 F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = W * 8.33 * (T_{out} - T_{in}) * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W = Water savings (gallons)
8.33 = Energy content of water (Btu/gallon/°F)
T_{out} = Faucet water temperature (°F)
T_{in} = Water inlet temperature (°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 20% over base case:

$$Percent\ Savings = \frac{(G_{base} - G_{new})}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 104 m^3
G_{base} = Annual natural gas use with base equipment, 130 m^3

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	5,377 L

Assumptions and inputs:

- Average household size: 2.14 persons[6]
- Baseline faucet use (all faucets) per capita per day: 53 litres (14 gallons)[7]

---

[3] Average of findings in two studies. Mayer, P. W. et al, *Residential Indoor Water Conservation Study: Evaluation of High Efficiency Indoor Plumbing Fixture Retrofits in Single-Family Homes in East Bay Municipal Utility District Service Area,* 2003 and Skeel, T. and Hill, S. *Evaluation of Savings from Seattle's "Home Water Saver" Apartment/Condominium Program*, 1994. Both cited in: Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004, http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] Summit Blue (2008) and Census 2006. To maintain consistency with Summit Blue number but to reflect the fact that apartments are generally occupied by fewer people than houses, the Summit Blue number was degraded by the ratio of the average number of inhabitants per apartment in an Ontario building over five stories (2) to the average number of inhabitants of a fully detached house in Ontario (2.9). Statistics Canada. No date. *Structural Type of Dwelling (10) and Household Size (9) for Occupied Private Dwellings of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census - 100% Data* (Table) *Census 2006.* Last updated Dec 6, 2008. http://www12.statcan.ca/english/census06/data/topics/RetrieveProductTable.cfm?ALEVEL=3&APATH=3&CATNO=&DETAIL=0&DIM=&DS=99&FL=0&FREE=0&GAL=0&GC=99&GID=837983&GK=NA&GRP=1&IPS=&METH=0&ORDER=1&PID=89071&PTYPE=88971&RL=0&S=1&SUB=0&ShowAll=No&StartRow=1&Temporal=2006&Theme=69&VID=0&VNAMEE=&VNAMEF=

- Kitchen faucet use as a percentage of total faucet use: 65%[8]
- Point estimate of quantity of water that goes straight down the drain: 50%[9]

Annual water savings calculated as follows:

$$Savings = Fu * Ppl * 365 * Ki * \left((1 - Dr) - \left(1 - \frac{Fl_{base} - Fl_{eff}}{Fl_{base}} \right) * Dr \right)$$

Where:

Fu = Faucet use per capita (gallons)
Ppl = Number of people per household
365 = Days per year
Dr = Percentage of water that goes straight down the drain
Ki = Kitchen faucet use as a percentage of total faucet use
Fl_{base} = Flow rate of base equipment (GPM)
Fl_{eff} = Flow rate of efficient equipment (GPM)

Water savings was determined to be 20% over base case:

$$Percent\ Savings = \frac{(W_{base} - W_{eff})}{W_{base}}$$

Where:

W_{eff} = Annual water use with efficient equipment: 21,509 litres (5,681gallons)
W_{base}= Annual water use with base equipment: 26,887litres (7,101 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
The U.S. DOE assumes a 10 year life for faucet aerators[10].	
Base & Incremental Conservation Measure Equipment and O&M Costs	**2 $**
Average equipment cost based on communication with local hardware stores.	
Customer Payback Period (Natural Gas Only)[11]	**0.2 Years**
Using a 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average residential distribution cost[13] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.2 years, based on the following:	

[7] Ibid.
[8] DeOreo, W. and P. Mayer, *The End Uses of Hot Water in Snigle Family Homes from Flow Trace Analysis*, 1999 cited in Summit Blue (2008).
[9] Summit Blue (2008).
[10] U.S. Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Lavatory Faucets* http://www1.eere.energy.gov/femp/procurement/eep_faucets.html
[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

Payback Period = Incremental cost / (natural gas savings x natural gas cost) = $2/ (26 m^3/year * $0.52 / m^3) = 0.2 years

Market Penetration	90%
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of faucet aerators (bathroom and kitchen) across all sectors to be 90%[14].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
Puget Sound Energy[15]	5	5	N/A	50%
Comments For a switch from a 2.5 GPM to a 1.8 GPM aerator. Measure saves 1% of 539 m^3 required for water heating.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[16]	27	9	14 US$	90%
Comments For a switch from a 3.0 GPM to a 1.5 GPM aerator. In neither study is any distinction made between kitchen and bathroom faucet use. Measure saves 8.5% of 320 m^3 required for water heating.				

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

[15] Quantec *Comprehensive Assessment of Demand-Side Resource Potentials (2008-2027)* Prepared for Puget Sound Energy

[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.5 Gpm, Muti-Family, UG ESK)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow Showerhead (1.5 Gpm) – distributed to participants under Union Gas' ESK program.

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1] .

Decision Type	Target Market(s)	End Use
Retrofit	Multi-Family (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

Resource Savings Table

Year (EUL=)	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	23	0	4,369	6	0
2	23	0	4,369	0	0
3	23	0	4,369	0	0
4	23	0	4,369	0	0
5	23	0	4,369	0	0
6	23	0	4,369	0	0
7	23	0	4,369	0	0
8	23	0	4,369	0	0
9	23	0	4,369	0	0
10	23	0	4,369	0	0
TOTALS	**230**	**0**	**43,690**	**6**	**0**

[1] Shower-heads distributed under Union Gas's ESK program are installed by homeowners rather than Union contractors. No observation is made of the base equipment's GPM. It is therefore assumed to be the full-on flow rate corresponding to the as-used flow from York Region monitoring study calculated using the equation cited below.
Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007. Cited by: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.

[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	23 m^3

Assumptions and inputs:

- Average shower temperature with base equipment: 40 °C (104 °F)
- Average shower temperature with efficient equipment: 41 °C (106 °F) [3]
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (°F)
$T_{out,new}$ = Shower temperature with efficient equipment (°F)
T_{in} = Water inlet temperature (°F)
8.33 = Energy content of water (Btu/gallon/°F)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Gas savings were determined to be 12% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 194 m^3.
G_{base} = Annual natural gas use with base equipment, 172 m^3.

Annual Electricity Savings	0 kWh

N/A

Annual Water Savings	4,369 L

Assumptions and inputs:

- As-used flow rate with base equipment: 1.89 GPM[6]
- Average household size: 2.14 persons[7]

---

[3] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008).
Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.

- Showers per capita per day: 0.75[8]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[9]
- Average showering time per capita per day with base equipment: 7.32 minutes
- Average showering time per capita per day with new technology: 7.5 minutes[10]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household
Sh = Showers per capita per day
365 = Days per year
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes)
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used

Water savings were determined to be 14% over base technology:

$$Percent\ Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment, 26,302 litres (6,947 gallons)
W_{base}= Annual water consumed by showers with base equipment: 30,671 litres (8,101 gallons)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	6$

[7] To maintain consistency with Summit Blue number but to reflect the fact that apartments are generally occupied by fewer people than houses, the Summit Blue number was degraded by the ratio of the average number of inhabitants per apartment in an Ontario building over five stories (2) to the average number of inhabitants of a fully detached house in Ontario (2.9).
Statistics Canada. No date. *Structural Type of Dwelling (10) and Household Size (9) for Occupied Private Dwellings of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census - 100% Data* (Table) *Census 2006.* Last updated Dec 6, 2008.
http://www12.statcan.ca/english/census06/data/topics/RetrieveProductTable.cfm?ALEVEL=3&APATH=3&CATNO=&DETAIL=0&DIM=&DS=99&FL=0&FREE=0&GAL=0&GC=99&GID=837983&GK=NA&GRP=1&IPS=&METH=0&ORDER=1&PID=89071&PTYPE=88971&RL=0&S=1&SUB=0&ShowAll=No&StartRow=1&Temporal=2006&Theme=69&VID=0&VNAMEE=&VNAMEF=
[8] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007
[9] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)
[10] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)

Incremental cost based on a survey of online retailers[11].	
Customer Payback Period (Natural Gas Only)[12]	**0.5 Years**
Using a 5-year average commodity cost (avoided cost)[13] of \$0.38 / m^3 and an average residential distribution cost[14] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.5 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$6/ (23 m^3/year * \$0.52 / m^3) = 0.5 years	
Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[15].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[16].	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[17]	48	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 15% of 320 m^3 required for water heating.				

[11] Whedon Products 1.5 GPM Ultra Saver Showerhead. http://www.antonline.com/p_USB3C-GP_398829.htm
[12] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.
[13] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.
[14] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).
[15] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008
[16] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html
[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.25 Gpm, Muti-Family, Enbridge TAPS)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description
Low-flow Showerhead (1.25 Gpm) – Installed by Enbridge-designated contractors.
Base Equipment and Technologies Description
Average existing stock within one of three ranges. Range mid-points used as point estimates: • Scenario **A** – 2.0 GPM • Scenario **B –** 2.25 GPM • Scenario **C** – 3.0 GPM When new showerheads are installed contractors use a bag-test to determine base equipment flow-rate.

Decision Type	Target Market(s)	End Use
Retrofit	Multi-Family (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[1] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

[1] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Table

Year (EUL=)	Electricity and Other Resource Savings: Natural Gas (m^3)	Electricity (kWh)	Water (L)	Equipment & O&M Costs of Conservation Measure ($)	Equipment & O&M Costs of Base Measure ($)
1	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	13	0
2	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
3	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
4	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
5	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
6	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
7	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
8	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
9	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
10	**A:** 34 **B:** 43 **C:** 70	0	**A:** 6,081 **B:** 7,507 **C:** 11,840	0	0
TOTALS	**A:** 340 **B:** 430 **C:** 700	**0**	**A:** 60,810 **B:** 75,070 **C:** 118,400	**13**	**0**

Resource Savings Assumptions

Annual Natural Gas Savings	**A: 34 m^3** **B: 43 m^3** **C: 70 m^3**

Assumptions and inputs:

- Average shower temperature with base equipment: 40 °C (104 °F)[2]
- Average shower temperature with efficient equipment: 41 °C (106 °F)
- Average water inlet temperature: 7.22 °C (45 °F)[3]
- Average water heater energy factor: 0.57[4]

Annual gas savings calculated as follows:

[2] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).

[3] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices,*EPA, Energy Star for homes, March 2004 http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[4] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (^oF)
$T_{out,new}$ = Shower temperature with efficient equipment (^oF)
T_{in} = Water inlet temperature (^oF)
8.33 = Energy content of water (Btu/gallon/^oF)
EF = Water heater energy factor
10^{-6} = Factor to convert Btu to MMBtu
27.8 = Factor to convert MMBtu to m^3

Scenario **A:** Gas savings were determined to be 18% over base equipment:
Scenario **B:** Gas savings were determined to be 22% over base equipment:
Scenario **C:** Gas savings were determined to be 30% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment,
Scenario **A:** 150 m^3
Scenario **B:** 153 m^3
Scenario **C:** 162 m^3
G_{base} = Annual natural gas use with base equipment,
Scenario **A:** 184 m^3
Scenario **B:** 196 m^3
Scenario **C:** 232 m^3

Annual Electricity Savings	**0 kWh**
N/A	
Annual Water Savings	**A: 6,081 L** **B: 7,507 L** **C: 11,840 L**

Assumptions and inputs:

- As-used flow rate with base equipment[5]:
  Scenario **A:** 1.78 GPM
  Scenario **B:** 1.91 GPM
  Scenario **C:** 2.32 GPM
- Average household size: 2.14 persons[6]

[5] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}. Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008).
Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.
[6] To maintain consistency with Summit Blue number but to reflect the fact that apartments are generally occupied by fewer people than houses, the Summit Blue number was degraded by the ratio of the average number of inhabitants per apartment in an Ontario building over five stories (2) to the average number of inhabitants of a fully detached house in Ontario (2.9). Statistics Canada. No date. *Structural Type of Dwelling (10) and Household Size (9) for Occupied Private Dwellings of Canada, Provinces,*

- Showers per capita per day: 0.75[7]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used): 76%[8]
- Average showering time per capita per day with base equipment:
  - Scenario **A:** 7.37 minutes
  - Scenario **B:** 7.31 minutes
  - Scenario **C:** 7.13 minutes
- Average showering time per capita per day with new technology: 7.61 minutes[9]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household.
Sh = Showers per capita per day.
365 = Days per year.
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes).
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used.

Scenario **A:** Water savings were determined to be 21% over base equipment
Scenario **B:** Water savings were determined to be 24% over base equipment
Scenario **C:** Water savings were determined to be 32% over base equipment

$$Percent\,Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment,
Scenario **A:** 22,999 litres (6,074 gallons)
Scneario **B:** 23,450 litres (6,193 gallons)
Scenario **C:** 24,818 litres (6,555 gallons)
W_{base}= Annual water consumed by showers with base equipment:
Scenario **A:** 29,080 litres (7,680 gallons)
Scenario **B:** 30,957 litres (8,176 gallons)
Scenario **C:** 36,658 litres (9,682 gallons)

Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census - 100% Data (Table) *Census 2006.* Last updated Dec 6, 2008. http://www12.statcan.ca/english/census06/data/topics/RetrieveProductTable.cfm?ALEVEL=3&APATH=3&CATNO=&DETAIL=0&DIM=&DS=99&FL=0&FREE=0&GAL=0&GC=99&GID=837983&GK=NA&GRP=1&IPS=&METH=0&ORDER=1&PID=89071&PTYPE=88971&RL=0&S=1&SUB=0&ShowAll=No&StartRow=1&Temporal=2006&Theme=69&VID=0&VNAMEE=&VNAMEF=

[7] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007

[8] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)

[9] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**13$**
Incremental cost based on a survey of online retailers[10].	
Customer Payback Period (Natural Gas Only)[11]	**A: 0.7 Years** **B: 0.6 Years** **C: 0.4 Years**
Using an 5-year average commodity cost (avoided cost)[12] of \$0.38 / m^3 and an average residential distribution cost[13] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.7 years for Scenario A, 0.6 years for Scenario B and 0.4 years for Scenario C, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) Scenario A = \$13/ (34 m^3/year * \$0.52 / m^3) = 0.7 years Scenario B = \$13/ (43 m^3/year * \$0.52 / m^3) = 0.6 years Scenario C = \$13/ (70 m^3/year * \$0.52 / m^3) = 0.4 years	
Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[14].	

[10] Earth Massage Showerhead 1.25 GPM http://cgi.ebay.com/Earth-Massage-Showerhead-Water-Saver-1-25-gpm-flow_W0QQitemZ130256063752QQihZ003QQcategoryZ71282QQcmdZViewItemQQ_trksidZp1742.m153.l1262

[11] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[12] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[13] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[14] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/Market Share
U. S. Dept. of Energy, Federal Energy Management Program[15]	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/Market Share**
State of Iowa Utilities Board[16]	48	10	US$ 36	65%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 15% of 320 m^3 required for water heating.				

[15] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html

[16] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2

Low-Flow Showerhead (1.25 Gpm, Muti-Family, UG ESK)

Revision #	Description/Comment	Date Revised

Efficient Equipment and Technologies Description

Low-flow Showerhead (1.25 Gpm) – distributed to participants under Union Gas' ESK program.

Base Equipment and Technologies Description

Average existing stock (2.2 GPM)[1].

Decision Type	Target Market(s)	End Use
Retrofit	Multi-Family (Existing)	Water heating

Codes, Standards, and Regulations

Ontario Building Code (2006)[2] requires shower heads to have a maximum flow of 2.5 GPM (9.5 L/min)

Resource Savings Table

	Electricity and Other Resource Savings			Equipment & O&M Costs of Conservation Measure	Equipment & O&M Costs of Base Measure
Year (EUL=)	Natural Gas (m^3)	Electricity (kWh)	Water (L)	($)	($)
1	42	0	7,289	13	0
2	42	0	7,289	0	0
3	42	0	7,289	0	0
4	42	0	7,289	0	0
5	42	0	7,289	0	0
6	42	0	7,289	0	0
7	42	0	7,289	0	0
8	42	0	7,289	0	0
9	42	0	7,289	0	0
10	42	0	7,289	0	0
TOTALS	**420**	**0**	**72,890**	**13**	0

[1] Shower-heads distributed under Union Gas's ESK program are installed by homeowners rather than Union contractors. No observation is made of the base equipment's GPM. It is therefore assumed to be the full-on flow rate corresponding to the as-used flow from York Region monitoring study calculated using the equation cited below. Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007. Cited by: Summit Blue, *Resource Savings Values in Selected Residential DSM Prescriptive Programs*, June 2008.

[2] Ontario Regulations 350/06, 2006 Building Code

Resource Savings Assumptions

Annual Natural Gas Savings	42 m^3

Assumptions and inputs:

- Average shower temperature with base equipment: 40 °C (104 °F)[3]
- Average shower temperature with efficient equipment: 41 °C (106 °F)
- Average water inlet temperature: 7.22 °C (45 °F)[4]
- Average water heater energy factor: 0.57[5]

Annual gas savings calculated as follows:

$$Savings = \left(W_{base} * \left(T_{out,base} - T_{in}\right) - W_{eff} * \left(T_{out,eff} - T_{in}\right)\right) * 8.33 * \frac{1}{EF} * 10^{-6} * 27.8$$

Where:

W_{base} = annual water use with base equipment (gallons)
W_{eff} = annual water use with efficient equipment (gallons)
$T_{out,base}$ = Shower temperature with base equipment (°F)
$T_{out,new}$ = Shower temperature with efficient equipment (°F)
T_{in} = Water inlet temperature (°F)
8.33 = Energy content of water (Btu/gallon/°F)
EF = Water heater energy factor.
10^{-6} = Factor to convert Btu to MMBtu.
27.8 = Factor to convert MMBtu to m^3.

Gas savings were determined to be 21% over base equipment:

$$Percent\ Savings = \frac{\left(G_{base} - G_{eff}\right)}{G_{base}}$$

Where:

G_{eff} = Annual natural gas use with efficient equipment, 153 m^3.
G_{base} = Annual natural gas use with base equipment, 194 m^3.

Annual Electricity Savings	0 kWh
N/A	

Annual Water Savings	7,289 L

Assumptions and inputs:

- As-used flow rate with base equipment: 1.89 GPM[6]
- Average household size: 2.14 persons[7]

---

[3] Although evidence for this increase in shower temperature remains anecdotal, Summit Blue suggest it is likely enough to include its effect in the analysis. Summit Blue (2008).

[4] Chinnery, Glen. *Policy Recommendations for the HERS Community to Consider regarding HERS point credit for Waste Water Heat Recovery Devices*, EPA, Energy Star for homes, March 2004
http://www.energystar.gov/ia/partners/bldrs_lenders_raters/downloads/Waste_Water_Heat_Recovery_Guidelines.pdf

[5] Assumption of the Ministry of Energy of Ontario. See Table 4, http://www.energy.gov.on.ca/index.cfm?fuseaction=conservation.guide13

[6] As-used flow is calculated as a function of "full-on" or label flow: as-used flow = min{ 0.691+0.542*full-on flow, full-on flow}.
Proctor, J. Gavelis, B. and Miller, B. *Savings and Showers: It's All in the Head*, (PGE) Home Energy Magazine, July/Aug 1994. Cited in Summit Blue (2008).
Summit Blue uses the equation without assuming that it is a min function, implicitly assuming that participants will have the expertise or desire to make minor adjustments to the house water pressure to compensate for reduced shower flow.

- Showers per capita per day: 0.75[8]
- Proportion of showering affected by measure (i.e. percentage of the time the low-flow showerhead used) : 76%[9]
- Average showering time per capita per day with base equipment: 7.32 minutes
- Average showering time per capita per day with new technology: 7.61 minutes[10]

Annual water savings calculated as follows:

$$Savings = Ppl * Sh * 365 * \Pr * \left(T_{base} * Fl_{base} - T_{eff} * Fl_{eff}\right)$$

Where:

Ppl = Number of people per household.
Sh = Showers per capita per day.
365 = Days per year.
T_{base} = Showering time with base equipment (minutes)
T_{eff} = Showering time with efficient equipment (minutes).
Fl_{base} = As-used flow rate with base equipment (GPM)
Fl_{eff} = As-used flow rate with efficient equipment (GPM)
Pr = Percentage of showers where efficient equipment used.

Water savings were determined to be 24% over base equipment:

$$Percent\ Savings = \frac{\left(W_{base} - W_{eff}\right)}{W_{base}}$$

Where:

W_{eff} = Annual water consumed by showers with efficient equipment, 23,381 litres (6,175 gallons).
W_{base} = Annual water consumed by showers with base equipment: 30,671 litres (8,101 gallons).

Other Input Assumptions

Effective Useful Life (EUL)	10 Years
Summit Blue (2008) suggests an EUL of 10 years based on a survey of five studies of showerheads in other jurisdictions (California – two studies, New England, Vermont, Arkansas).	
Base & Incremental Conservation Measure Equipment and O&M Costs	**13$**

[7] To maintain consistency with Summit Blue number but to reflect the fact that apartments are generally occupied by fewer people than houses, the Summit Blue number was degraded by the ratio of the average number of inhabitants per apartment in an Ontario building over five stories (2) to the average number of inhabitants of a fully detached house in Ontario (2.9).
Statistics Canada. No date. *Structural Type of Dwelling (10) and Household Size (9) for Occupied Private Dwellings of Canada, Provinces, Territories, Census Metropolitan Areas and Census Agglomerations, 2006 Census - 100% Data* (Table) *Census 2006.* Last updated Dec 6, 2008.
http://www12.statcan.ca/english/census06/data/topics/RetrieveProductTable.cfm?ALEVEL=3&APATH=3&CATNO=&DETAIL=0&DIM=&DS=99&FL=0&FREE=0&GAL=0&GC=99&GID=837983&GK=NA&GRP=1&IPS=&METH=0&ORDER=1&PID=89071&PTYPE=88971&RL=0&S=1&SUB=0&ShowAll=No&StartRow=1&Temporal=2006&Theme=69&VID=0&VNAMEE=&VNAMEF=
[8] Ibid, based on data from: Resource Management Strategies, Inc., Regional Municipality of York Water Efficiency Master Plan Update, April 2007
[9] Survey of participants, 116 from Enbridge, 111 from Union, Summit Blue (2008)
[10] Relationship modeled as: Average shower length = 8.17 – 0.448 * as-used GPM. From Energy Center of Wisconsin Analysis of data from Resource Management Strategies, Inc., *Regional Municipality of York Water Efficiency Master Plan Update,* April 2007. Cited in Summit Blue (2008)

Incremental cost based on a survey of online retailers[11].	
Customer Payback Period (Natural Gas Only)[12]	**0.6 Years**
Using a 5-year average commodity cost (avoided cost)[13] of \$0.38 / m^3 and an average residential distribution cost[14] of \$0.14 / m^3, the payback period for natural gas savings is determined to be 0.6 years, based on the following: Payback Period = Incremental cost / (natural gas savings x natural gas cost) = \$13/ (42 m^3/year * \$0.52 / m^3) = 0.6 years	
Market Penetration	**65%**
Based on previous research conducted for the OPA, Navigant Consulting estimates penetration of low-flow showerheads of all flow rates across all sectors to be 65%[15].	

Measure Assumptions Used by Other Jurisdictions

Source	Annual Natural Gas Savings (m3)	Effective Useful Life (Years)	Incremental Cost ($)	Penetration/ Market Share
U. S. Dept. of Energy, Federal Energy Management Program[16]	108	10	N/A	N/A
Comments Based on switching from a 2.2 GPM to a 1.5 GPM showerhead. Assumptions include: 10mins per shower, 2 showers per day, shower temperature of 106F, inlet water temp of 58F. Measure provides savings of 81% over 133 m^3 required for heating water used with base equipment.				
Source	**Annual Natural Gas Savings (m3)**	**Effective Useful Life (Years)**	**Incremental Cost ($)**	**Penetration/ Market Share**
State of Iowa Utilities Board[17]	48	10	US$ 36	75%
Comments Based on switching from a 4 GPM to a 2.5 GPM showerhead. Measure saves 15% of 320 m^3 required for water heating.				

[11] Earth Massage Showerhead 1.25 GPM http://cgi.ebay.com/Earth-Massage-Showerhead-Water-Saver-1-25-gpm-flow_W0QQitemZ130256063752QQihZ003QQcategoryZ71282QQcmdZViewItemQQ_trksidZp1742.m153.l1262

[12] Customer payback period has been calculated using natural gas savings only. Where applicable, payback period is expected to decrease when electricity and/or water savings are included.

[13] 2009 Avoided gas cost provided by Union Gas. 5 year average avoided gas cost determined by taking average for baseload and weather sensitive avoided gas cost.

[14] Average distribution cost taken calculated from both Union Gas website (http://www.uniongas.com/residential/rates/) and Enbridge Gas websites (https://portal-plumprod.cgc.enbridge.com/portal/server.pt?open=512&objID=248&PageID=0&cached=true&mode=2&userID=2).

[15] Navigant Consulting, Inc. for the Ontario Power Authority, *Residential Rebate Program: Participation Forecast and Incentive Bundling Strategy – Key Findings Summary*, December 2008

[16] U.S Department of Energy, Federal Energy Management Program, *FEMP Designated Product: Showerheads* http://www1.eere.energy.gov/femp/procurement/eep_showerhead.html

[17] Iowa Utilities Board. Docket No. EEP-08-02 MidAmerican Energy Company. Volume IV, Appendix D, Part 1 of 2