Compendium and Reference List - Issue 5.1(a)

EB-2013-0321

Sustainability-Journal.ca
(613) 271-9543

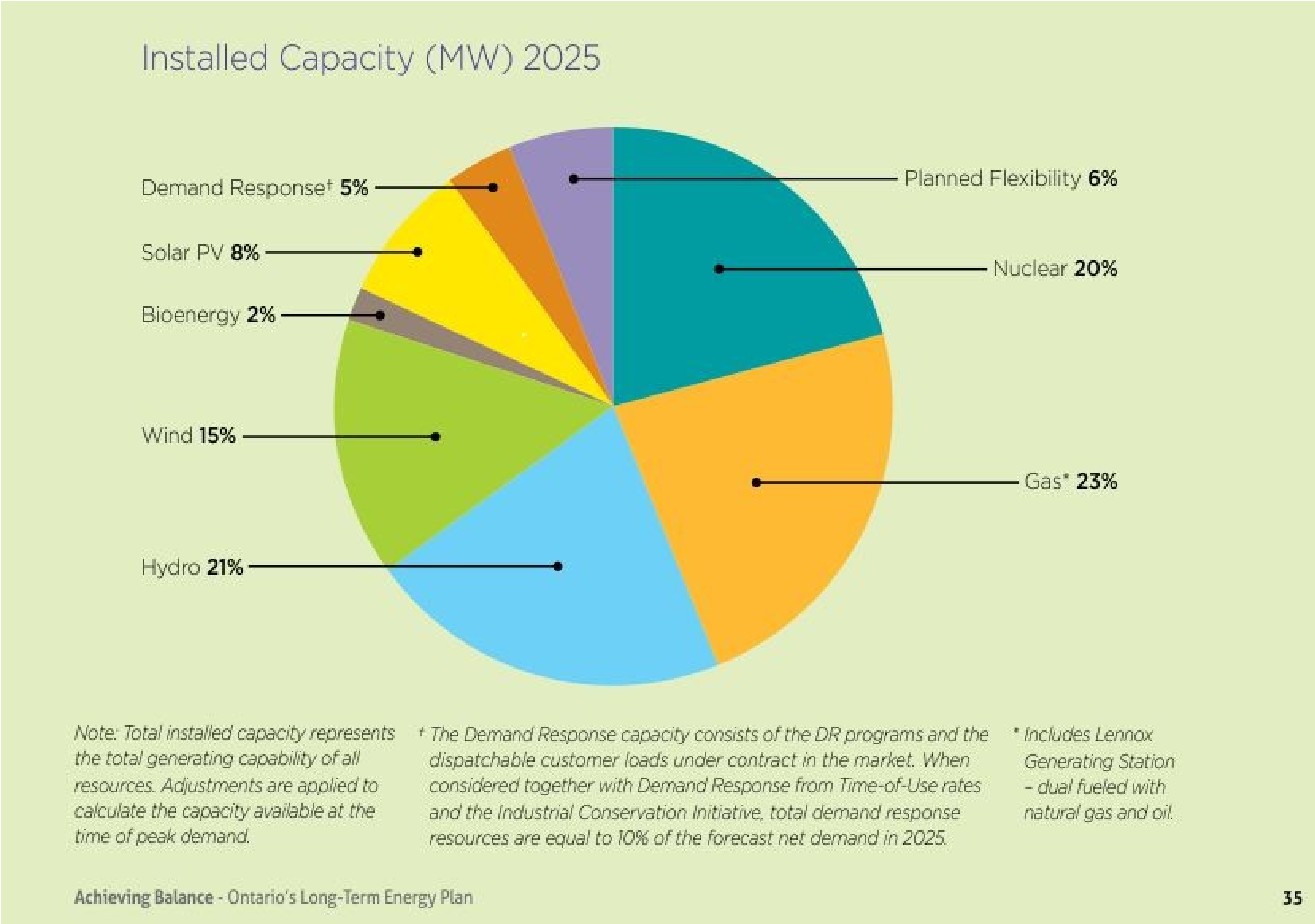
Issue 5.1 - Is the proposed regulated hydroelectric production forecast appropriate?

Issue 5.1(a) - Could the storage of energy improve the efficiency of hydroelectric generating stations?

OPG have stated that apart from some pumped hydro storage (174 MW at the Adam Beck site) they do not employ storage or plan to use it in the near future. The OPG documents consequently provide almost no evidence on the merits of employing energy storage even though it is widely used by other organizations in Ontario and elsewhere (examples are Enwave, the UOIT store and the Drake Landing installation). The ground under just the city of Ottawa is capable of storing over 5,000 petajoules of thermal energy (that compares to a total electricity production of 1,237 petajoules in all of Canada), illustrating that there is no problem in providing sufficient storage capacity. The daily IESO data shows that if we used storage to flatten the power demand then we could store about 3,000 MW over a 5 hour period on most nights in Ontario, resulting in electric storage capacity of 3,000 x 5 = 15,000 MWh per day, or 5,475,000 MWh over the course of a year, or 19.7 petajoules/year. That comparatively small amount of storage would make dramatic changes in the outcomes of all four of the general questions listed below, and at minuscule financial risk inasmuch as OPG could start with very small installations to evaluate the performance.

Correspondence, Sustainability-Journal.ca re. eb-2013-0321, Nov 21, Dec 16, Mar 31, Apr 4, 14, 16, 28 (4 reports), May 7
OPG letters to OEB, Apr 3, 10
Wikipedia, "Sir Adam Beck Hydroelectric Generating Stations", accessed Jun 9/14
Appendix A
IESO site, ieso-public.sharepoint.com
Appendix B
Wikipedia, "Energy Storage", accessed June 9/14
KT 2_2 "Long Term Energy Plan"

Why is storage not utilized (other than for the pumped hydro at Sir Adam Beck station)**?**



Source: Achieving Balance - Ontario's Long Term Energy Plan, pg. 35
OEB Exhibit KT 2_2

Questions for the Hydro panel:

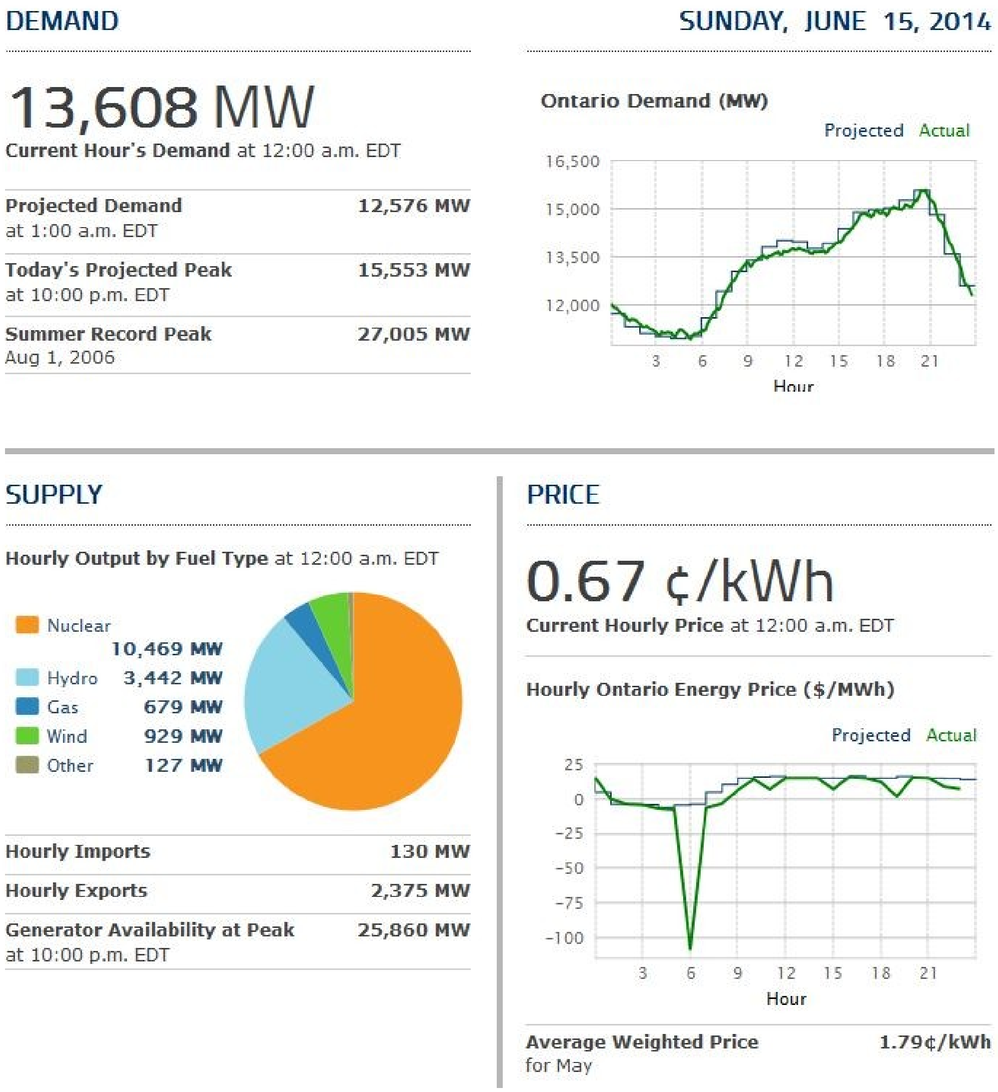
1) Is this the energy mix used for the plan described in EB-2013-0543?

2) Will the increases in Wind power and Solar PV generation require a corresponding increase in natural gas generation capacity? Will OPG be involved in any of those three sources?

3) What will OPG's contributions to the Demand Response and Flexibility segments be?

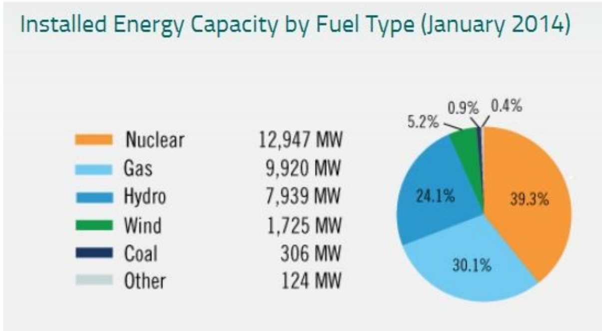
During the delay that has preceded the Hydro Panel we have been monitoring the hourly reports on power demand and the supply mix via the ieso-public.sharepoint.com site (reported in Appendix G). The reports show that Ontario has continuously exported power during this period, typically ranging from 1,400 to 3,400 MW. The IESO price for that power has often been negative (for 7 hours on Saturday night, for example) and has rarely exceeded 1.5 cents per kWh. Moreover the power generation from the hydro and nuclear stations has been throttled back when the demand is low, reducing their productivity with no significant reduction in their operating costs. The total lost power capacity at this time of year thus amounts to about 1,500 MW (hydro cut-backs) plus 1,800 MW (nuclear cut-backs) plus an estimated 2,000 MW (exports) for an overall total of 5,300 MW. <u>That is roughly 40% of the actual production</u>, and it does not include any of the seasonal cut-backs

that appear to have been made! Clearly the use of storage could dramatically reduce such losses.



An example of one of the IESO reports

4) How much money is OPG losing because of these exports and how much domestic income is lost because of the price being lower than the cost?



IESO graphic showing current energy source contributions

5) The total hydro capacity is shown as 7,939 MW but in this period the supply has ranged from only about 2,700 to 4,400 MW. Since most of the hydro power employs run-of-the-river technology does that imply that the capacity factor is only about 50%?

6) During high demand periods the IESO price sometimes skyrockets, creating a loss situation for the LDC's that distribute the power. What is the approximate magnitude of this consequence?

7) If the power produced during low demand periods can be stored what would the capacity factor be?

8) If storage were used for hydro, nuclear and wind power how much of an improvement could be realized in the gross revenues from those sources?

One of the means of storing energy is to store it in the ground in thermal form. The storage capacity can be very large (Appendix A shows how 5000 PJ of thermal energy could be stored in the ground under the City of Ottawa). Such storage can handle electrical storage as well, using a Power IN / Demand Reduction OUT procedure for electricity as outlined in Appendix B.

Four general questions need to be addressed:
1) Could the existing hydro stations be more productive?
2) Could the planned OPG capital expenditures be reduced?
3) Could the system reliability be improved?
4) Could Ontario's GHG emissions be reduced?

The appendices briefly explain how storage could contribute to all of these objectives.

Appendix A

How much thermal energy can we store in the ground?

Let us take the City of Ottawa as an example:

The City of Ottawa has an area of 2,778square kilometres

If the boreholes are drilled 200 m deep the volume is 5.6×10^{11} cubic metres

If the rock type is granite (one of several types in Ottawa) the mass is 15×10^{14} kilograms

If the average temperature swing is 5 degrees C the heat capacity is 5.93×10^{18} watt-sec

Converted to kWh = 1.65×10^{12} (or 1.65×10^{9} MWh, or 5,940 petajoules)
(for limestone the storage would be 1.79×10^{12} kWh or 6,415 petajoules)

That compares to an annual production of 1,237 petajoules of energy from all of Canada's hydro power stations.

If the heat is being stored from summer to winter (or vice versa) the energy storage capacity of the ground under Ottawa would be sufficient to store all of the hydro energy produced in all of Canada, regardless of what mix of rock types is encountered.

Actually, some of the storage capacity will be repeatedly used 365 days per year because we would be running the heat pump concentrator at night (when surplus power is available) and recovering the energy throughout the day. No power is consumed during the recovery stage. That ensures that no power is drawn during the peak (daytime) demand period. The consequence is that we really only need a small storage capacity for the diurnal portion of the storage cycle so the storage volume needed for a building is much smaller than the storage volume that would have been needed by a ground source heat pump system of comparable annual capacity. That means that exergy storage systems are much less expensive to build than GSHP's of similar capacity.

Similar simple calculations demonstrate that the amount of available energy that can be extracted from local energy sources like the air, from the ground, from the buildings themselves and from relatively small solar thermal collectors, is also much larger than the amounts of energy needed for the thermal demands of the buildings. The stores (called exergy stores) can thus concurrently achieve two objectives - storing heat (and cold) for the thermal needs of the buildings, and at the same time storing electricity to improve the efficiency of the power generation system.

The limiting factor for the amount of electricity that can be "stored" (i.e., have its demand shifted in time) is the amount of electrical energy needed to run the heat pumps. That implies that exergy storage is most attractive in places where the winter and summer thermal demands are high, resulting in a substantial electrical input for the heat pumps. Some countries make very little use of air conditioning because their cool summer air can cool even large buildings, and some of them have relatively moderate winters as well, so exergy stores will be less attractive in those countries as compared to

Canada.

General - Question 1 - productivity
The output from run-of-the-river hydro stations can be cut back to meet diminished demand (unlike nuclear stations) so in practice they tend to operate with low capacity factors. Adding storage enables such stations to continuously operate at full power.

a) Run-of-the-river vs. high dams in Ontario

    OPG Application

b) Current capacity factors for the OPG hydro stations

    Not provided in the OPG application

c) Potential capacity factors for stations that always operate at full power

    Not provided in the OPG application

d) Generates thermal outputs in addition to storing power

    3rd World Sustainability Forum, "Exergy Storage", Tolmie and Rosen

e) Utilization of energy sources that are normally wasted (air-heat and cold, AC heat)

    S-J letter, "Storage", S-J.ca, Mar/14

e) Integrating intermittent energy sources like wind without impacting hydro generation

    S-J.ca, Mar/14

f) Potential for uses in northern communities

    S-J.ca, Mar/14

General - Question 2 - capital costs
Instead of needing to generate power to meet peak loads (with a contingency margin) storage can be used to collect power, particularly at night, and meets the peak demands from storage instead of via generation. Our estimate is a reduction of about 11,000 MW in the required generation from all sources, with a commensurate reduction in the cost of the facilities that would have been needed to generate that amount of power.

a) Target cost per MWh of storage capacity

    Appendix C

b) Target cost per MW of power capacity

    Appendix C

c) Lifetime

    Appendix C

d) Labour cost

    Appendix C

e) Approvals plus construction times

    Appendix C

f) Space occupied, noise, visual or real pollution, etc.

    Appendix C

g) Avoidance of future "carbon tax"

    Pembina Institute, "Putting a Price on Carbon Pollution"

h) Avoidance of peaking power import costs

    Appendix C

i) Levels seasonal and diurnal price fluctuations for power

    Appendix C

j) Adaptable to differing regional energy supply (nuclear, wind, hydro or solar)

S-J.ca, "Storage", Mar/14

k) No decommissioning cost

Appendix C

l) No drowned land, destruction of waterfalls

Appendix C

m) No nuclear, fire or explosion hazards (or related costs)

Appendix C

General - Question 3 - reliability

Exergy stores provide energy on a continuous basis even if the grid, or the generation stations, or the transmission lines or the local switching stations and distribution lines should fail.

a) Energy is stored at the point of consumption

S-J.ca, Jun/14

b) Accumulation timing is controlled by grid operator

S-J.ca, Jun/14

c) Requires very little backup power

S-J.ca, Jun/14

d) Generators can shed demand to match ramping

S-J.ca, Jun/14

e) Generation and transmission line operators can directly control location and amounts of electricity storage

S-J.ca, Jun/14

f) Repairs to generators or lines can be carried out without loss of service (or loss of revenue)

Appendix D

g) Consumers can run on local energy supply for many days

Appendix D

General - Question 4 - emissions

Ontario is emitting about 105 million tonnes of GHG from natural gas that is used for both electrical and thermal energy supplies for buildings. That could progressively be reduced to zero via the use of exergy storage systems, which provide a solution for GHG emissions from both power generation and from thermal energy supply.

a) Although they do not themselves emit GHG's, both RoR hydro and nuclear require large scale backup from natural gas fired stations

Appendix E

b) A "carbon tax" of $50 to $200/tonne can be permanently avoided if natural gas is eliminated

Pembina Institute, "Putting a Price on Carbon Pollution"

c) The pending switch from domestic to imported natural gas is avoided

NEB annual Report, 2013, "Natural Gas"

d) Storage makes it feasible and economical to employ clean but intermittent energy sources like wind

S-J.ca, Jan/14 "Wind powered energy stores"

e) Cheap, clean electricity will be needed to implement GHG reductions for transportation

Appendix E

Many of the above references are statements of facts, logical conclusions or straightforward calculations based on elementary principles and widely available data so they do not rely on expert opinions. Where possible these are covered in the following appendices.

Appendix A

How much thermal energy can we store in the ground?

Let us take the City of Ottawa as an example:

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If the boreholes are drilled 200 m deep the volume is 5.6 x 10^{11} cubic metres

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Actually, the storage will be repeatedly used 365 days per year because we would be running the heat pump at night (when surplus power is available) and recovering the energy throughout the day, thus ensuring that no power is drawn during the peak (daytime) demand period. The consequence is that we really only need a small storage capacity for the diurnal portion of the storage cycle so the storage volume needed for a building is much smaller than the storage volume that would have been needed by a ground source heat pump system. That means that exergy storage systems are much less expensive to build than GSHP's.

Similar simple calculations demonstrate that the amount of available energy that can be extracted from the air, from the ground, from the buildings themselves and from relatively small solar thermal collectors is much greater than the amounts of energy needed for the thermal demands of the buildings.

The limiting factor for the amount of electricity that can be "stored" (i.e., have its demand shifted) is the amount of electrical energy needed to run the heat pumps. The process boosts the exergy of the stored heat without substantially changing the amount of stored energy. That implies that exergy storage is most attractive in places where the winter and summer thermal demands are high, requiring a substantial electrical input for the heat pumps. Some countries make very little use of air conditioning because their cool summer air can cool even large buildings, and some of them have relatively moderate winters as well, so exergy stores will be less attractive in those countries as compared to Canada.

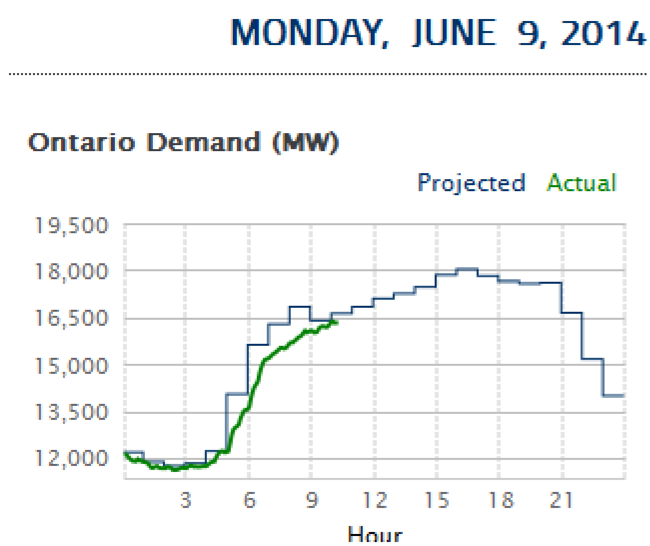
Appendix B

Daily storage of electricity (in the form of exergy)

To store exergy a heat pump is used to boost the temperature and store the heat in a smaller volume at the center of a concentric heat store. The heat pump is operated only when there is a surplus of power available (defined by the grid operator) but the duration of the heat pump's operation is determined by a HUB operator who ensures that sufficient heat is stored to meet the needs for space heating, cooling and hot water for the buildings being served.

The heat pump can be used to either boost the core temperature or to chill the core, thus saving cold in the latter case for use in the summer for air conditioning. (There is an alternative approach available for storing cold that is useful for smaller buildings.) In either case power is used only when there is surplus power available and it is effectively recovered when the stored heat or cold is used for one of the thermal applications. The primary demand occurs during the summer cooling period and the winter heating period, which nearly always correspond to peak power demand periods, but to cover all eventualities the HUB also limits the power consumption during the peak periods (a backup supply capability is also incorporated).

Throughout the year the daily pattern of power consumption is similar to the following graph. There is a period of 5 hours in the middle of the night when the consumption is very low, often giving rise to a need to dispose of some of the excess power, so this is the time when the heat pump is operated, raising the consumption at that time and reducing the high consumption value during the day, so the store acts like a giant electric battery.



Three of the four energy sources used for power generation lack the ability to store the source energy energy if they are not always operated at their full output. In some countries hydro power incorporates storage via the use of dams that accumulate water when power demand is low but in Ontario the hydro stations are nearly all run-of-the river stations that operate with a fixed head so they cannot store potential energy. Consequently the Ontario system depends heavily on the use of natural gas powered generators, which tend to be expensive to run (because they are nearly always running at part load) and that generate GHG's. Exergy stores provide a means of storing energy on a large scale that makes it much easier to handle nuclear, water and wind power. Exergy stores also make it possible to utilize low grade energy recovered for the cooling systems in the buildings and from air around the buildings. Potentially these low grade energy sources could become Ontario's primary sources of energy.

Appendix C

The capital cost of storing energy (MWh) with exergy stores is two to three orders of magnitude lower than the cost of alternatives like batteries. Moreover, the storage facilities have a very long lifetime (up to a century) and very low operating costs, and offer many additional advantages outlined below.

The capital cost per MW of thermal power capacity is also attractive (roughly $1/watt) but the electricity storage capacity is lower than the thermal storage capacity so the economic advantage for power is not so large, although the lifetime, low operating costs, good space utilization, lack of hazards, etc. mitigate that effect. Such systems operate unattended so the labour costs are very low. There are no drowned lands or destruction of natural sights like waterfalls, and the decommissioning costs are nearly zero.

There are no major hazards involved in building and using exergy stores so the approval processes are much faster and simpler than those for nuclear, fossil-fuelled or hydro stations, and a new exergy storage facility can be built in a few weeks. They can be installed under buildings or streets, they are invisible, create no noise, and once the ground loops have been installed they are permanently sealed so they do not require subsequent access. At some point in the future it is likely that some form of "carbon tax" will be implemented in Ontario but exergy stores will be exempt from such "taxes".

Ontario presently needs to import power during peak demand periods and also to export power to get rid if it when the fixed output sources are generating too much power. Both operations are sometimes very expensive, and they can be eliminated if sufficient storage is incorporated into the system. The cost of a Smart Grid to handle the power balance is likewise greatly reduced.

The concept can be optimized for areas that predominantly use hydro power (boosting the generator efficiency), wind power (handling the seasonal and weather related fluctuations), nuclear power (making the stations load following) and for solar thermal power, which is particularly attractive for northern applications.

Appendix D

During peak demand periods exergy stores do not consume power except for a small amount needed to operate the circulation pumps, but that is small enough to make it possible to use batteries for that power, recharging the batteries at night. Since most of the buildings' energy demands are for thermal energy, with only about one quarter being used for the electrical functions, the backup supply can optionally be made large enough to provide backup for the electrical functions as well. That type of backup will be particularly attractive once primary (air-Al) plus secondary (Li-ion) battery combinations become commercially available. In the meantime motor generators are suitable, and since they can be controlled as a part of the grid control the strategies can virtually eliminate even brief power interruptions.

If the grid supply is not functioning for any reason the exergy stores can be run for a matter of weeks without using the relatively power-hungry heat pumps.

Appendix E

Exergy stores both reduce the summer and winter demand peaks and at the same time provide power storage to flatten the power load even more, so as they are deployed the load fluctuation problem rapidly diminishes. Such stores can cover a single residence (at a cost penalty) or they can be used for multi-megawatt facilities, again with a practical limit that is determined by the velocity of the heat flow in the ground.

Developing the means for limiting the cost of electricity is fundamental to the potential for dealing with the other primary source of GHG's - the transportation sector.

Appendix F

The concept requires that the thermal storage capacity of the ground must be adequate to store the amount of energy that the buildings will need. The following tables (from the NRCAN OEE energy database) show that the thermal storage capacity will be adequate (shown for the residential and commercial sectors).

Residential Sector

Ontario[1]

Table 2: Secondary Energy Use and GHG Emissions by End-Use

	1990	2006	2007	2008	2009	2010	2011
Total Energy Use (PJ)	**489.0**	**527.8**	**566.2**	**582.0**	**502.5**	**492.4**	**527.6**
Energy Use by End-Use (PJ)							
Space Heating	306.1	312.8	351.0	365.1	330.9	311.0	339.6
Water Heating	89.8	114.0	117.5	116.3	103.0	103.1	110.2
Appliances	65.8	62.4	59.9	65.8	46.9	47.3	47.5
Lighting	19.6	20.1	18.7	20.6	14.4	14.6	14.2
Space Cooling	7.8	18.5	19.1	14.2	7.4	16.5	16.1
Shares (%)							
Space Heating	62.6	59.3	62.0	62.7	65.9	63.2	64.4
Water Heating	18.4	21.6	20.8	20.0	20.5	20.9	20.9
Appliances	13.5	11.8	10.6	11.3	9.3	9.6	9.0
Lighting	4.0	3.8	3.3	3.5	2.9	3.0	2.7
Space Cooling	1.6	3.5	3.4	2.4	1.5	3.3	3.1

Commercial/Institutional Sector

Ontario[1]

Table 2: Secondary Energy Use and GHG Emissions by End-Use

	1990	2006	2007	2008	2009	2010	2011
Total Energy Use (PJ)	**319.4**	**407.4**	**442.5**	**470.5**	**415.7**	**409.4**	**437.1**
Energy Use by End-Use (PJ)							
Space Heating	164.6	191.1	207.7	223.0	208.9	184.5	199.0
Water Heating	26.2	38.1	38.8	39.9	38.0	35.9	38.3
Auxiliary Equipment	34.7	67.6	80.2	97.1	85.1	87.2	92.4
Auxiliary Motors	32.7	28.1	28.8	31.7	29.7	30.2	31.3
Lighting	40.9	33.4	34.3	38.0	35.7	36.4	40.1
Space Cooling	17.4	45.9	49.6	37.5	16.4	33.1	33.9
Street Lighting	2.8	3.1	3.2	3.3	1.8	2.1	2.0
Shares (%)							
Space Heating	51.5	46.9	46.9	47.4	50.2	45.1	45.5
Water Heating	8.2	9.3	8.8	8.5	9.1	8.8	8.8
Auxiliary Equipment	10.9	16.6	18.1	20.6	20.5	21.3	21.1
Auxiliary Motors	10.3	6.9	6.5	6.7	7.2	7.4	7.2
Lighting	12.8	8.2	7.8	8.1	8.6	8.9	9.2
Space Cooling	5.4	11.3	11.2	8.0	3.9	8.1	7.8
Street Lighting	0.9	0.8	0.7	0.7	0.4	0.5	0.5

The electrical storage capacity is equal to the thermal storage capacity divided by the seasonal COP for the concentrating heat pump. That COP will depend on the application, but will typically range from 2 to 5. The following NRCan tables show that this requirement can also be met.

Residential Sector

Ontario[1]

Table 1: Secondary Energy Use and GHG Emissions by Energy Source

	1990	2006	2007	2008	2009	2010	2011
Total Energy Use (PJ)	**489.0**	**527.8**	**566.2**	**582.0**	**502.5**	**492.4**	**527.6**
Energy Use by Energy Source (PJ)							
Electricity	163.0	153.6	151.3	163.1	111.9	119.9	119.6
Natural Gas	252.3	315.4	353.3	359.2	329.3	312.6	349.9
Heating Oil	51.2	31.4	30.5	26.7	28.5	28.1	23.3
Other[2]	6.4	7.7	8.7	9.4	8.4	9.0	10.7
Wood	16.2	19.8	22.3	23.6	24.4	22.8	24.1
Shares (%)							
Electricity	33.3	29.1	26.7	28.0	22.3	24.4	22.7
Natural Gas	51.6	59.8	62.4	61.7	65.5	63.5	66.3
Heating Oil	10.5	5.9	5.4	4.6	5.7	5.7	4.4
Other[2]	1.3	1.5	1.5	1.6	1.7	1.8	2.0
Wood	3.3	3.7	3.9	4.0	4.9	4.6	4.6

Commercial/Institutional Sector

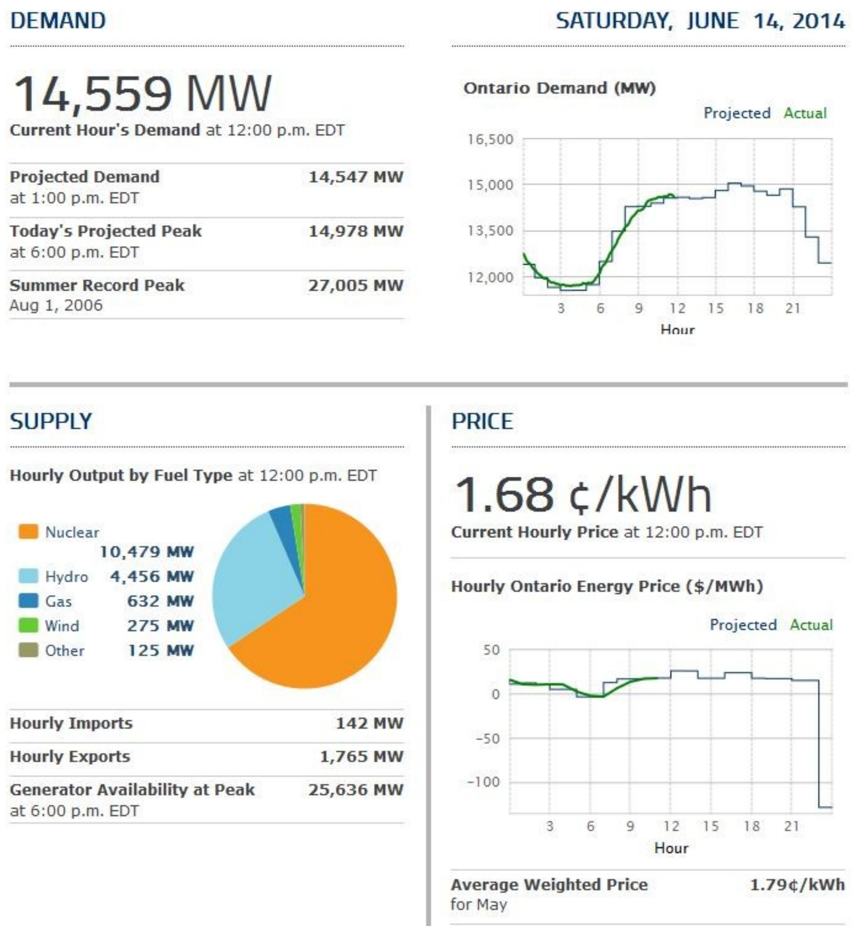
Ontario[1]

Table 1: Secondary Energy Use and GHG Emissions by Energy Source

	1990	2006	2007	2008	2009	2010	2011
Total Energy Use (PJ)	**319.4**	**407.4**	**442.5**	**470.5**	**415.7**	**409.4**	**437.1**
Energy Use by Energy Source (PJ)							
Electricity	146.6	185.9	205.8	234.6	192.3	195.6	207.0
Natural Gas	148.9	199.9	213.2	214.8	207.3	197.3	210.9
Light Fuel Oil and Kerosene	15.6	7.4	8.5	5.7	2.9	3.3	3.2
Heavy Fuel Oil	2.5	2.8	2.0	1.5	1.1	0.4	0.7
Steam	0.0	0.3	0.5	0.5	0.0	0.0	0.0
Other[2]	5.8	11.0	12.5	13.4	12.1	12.8	15.3
Shares (%)							
Electricity	45.9	45.6	46.5	49.9	46.3	47.8	47.4
Natural Gas	46.6	49.1	48.2	45.7	49.9	48.2	48.2
Light Fuel Oil and Kerosene	4.9	1.8	1.9	1.2	0.7	0.8	0.7
Heavy Fuel Oil	0.8	0.7	0.5	0.3	0.3	0.1	0.2
Steam	0.0	0.1	0.1	0.1	0.0	0.0	0.0
Other[2]	1.8	2.7	2.8	2.9	2.9	3.1	3.5

Appendix G

The IESO reports were accumulated hourly but only every sixth report is shown here.



DEMAND

SATURDAY, JUNE 14, 2014

14,704 MW

Current Hour's Demand at 10:00 p.m. EDT

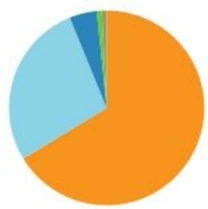
Projected Demand at 11:00 p.m. EDT	**14,197 MW**
Today's Projected Peak at 6:00 p.m. EDT	**14,844 MW**
Summer Record Peak Aug 1, 2006	**27,005 MW**

Ontario Demand (MW)

SUPPLY

Hourly Output by Fuel Type at 9:00 p.m. EDT

Nuclear	**10,477 MW**
Hydro	**4,351 MW**
Gas	**726 MW**
Wind	**122 MW**
Other	**128 MW**



Hourly Imports	**69 MW**
Hourly Exports	**1,283 MW**
Generator Availability at Peak at 6:00 p.m. EDT	**25,636 MW**

PRICE

1.62 ¢/kWh

Current Hourly Price at 10:00 p.m. EDT

Hourly Ontario Energy Price ($/MWh)

Average Weighted Price for May	**1.79¢/kWh**

DEMAND

SUNDAY, JUNE 15, 2014

11,053 MW

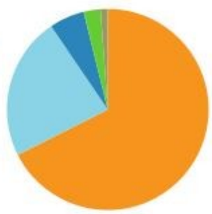
Current Hour's Demand at 7:00 a.m. EDT

Projected Demand at 8:00 a.m. EDT	**11,571 MW**
Today's Projected Peak at 10:00 p.m. EDT	**15,553 MW**
Summer Record Peak Aug 1, 2006	**27,005 MW**

SUPPLY

Hourly Output by Fuel Type at 7:00 a.m. EDT

Nuclear	**8,736 MW**
Hydro	**2,968 MW**
Gas	**732 MW**
Wind	**347 MW**
Other	**149 MW**



Hourly Imports	**MW**
Hourly Exports	**1,733 MW**
Generator Availability at Peak at 10:00 p.m. EDT	**25,728 MW**

PRICE

-10.97 ¢/kWh

Current Hourly Price at 7:00 a.m. EDT

Hourly Ontario Energy Price ($/MWh)

Average Weighted Price for May	**1.79¢/kWh**

DEMAND

SUNDAY, JUNE 15, 2014

14,933 MW

Current Hour's Demand at 8:00 p.m. EDT

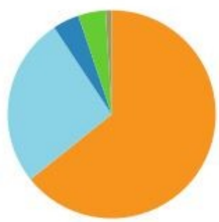
Projected Demand at 9:00 p.m. EDT	**15,237 MW**
Today's Projected Peak at 10:00 p.m. EDT	**15,553 MW**
Summer Record Peak Aug 1, 2006	**27,005 MW**

Ontario Demand (MW)

SUPPLY

Hourly Output by Fuel Type at 8:00 p.m. EDT

Nuclear	**10,472 MW**
Hydro	**4,305 MW**
Gas	**676 MW**
Wind	**692 MW**
Other	**151 MW**



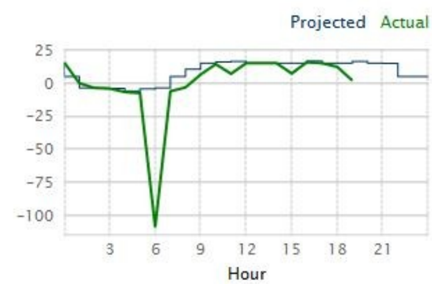
Hourly Imports	**95 MW**
Hourly Exports	**1,619 MW**
Generator Availability at Peak at 10:00 p.m. EDT	**25,860 MW**

PRICE

0.12 ¢/kWh

Current Hourly Price at 8:00 p.m. EDT

Hourly Ontario Energy Price ($/MWh)



Average Weighted Price for May	**1.79¢/kWh**

DEMAND

MONDAY, JUNE 16, 2014

11,772 MW

Current Hour's Demand at 5:00 a.m. EDT

Projected Demand at 6:00 a.m. EDT	**12,125 MW**
Today's Projected Peak at 6:00 p.m. EDT	**18,000 MW**
Summer Record Peak Aug 1, 2006	**27,005 MW**

Ontario Demand (MW)

SUPPLY

Hourly Output by Fuel Type at 5:00 a.m. EDT

Nuclear	**9,928 MW**
Hydro	**3,058 MW**
Gas	**699 MW**
Wind	**886 MW**
Other	**137 MW**

Hourly Imports	**85 MW**
Hourly Exports	**3,417 MW**
Generator Availability at Peak at 6:00 p.m. EDT	**26,443 MW**

PRICE

-0.04 ¢/kWh

Current Hourly Price at 5:00 a.m. EDT

Hourly Ontario Energy Price ($/MWh)

Average Weighted Price for May	**1.79¢/kWh**

DEMAND

MONDAY, JUNE 16, 2014

12,203 MW

Current Hour's Demand at 6:00 a.m. EDT

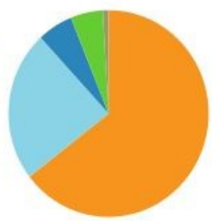
Projected Demand at 7:00 a.m. EDT	**13,213 MW**
Today's Projected Peak at 6:00 p.m. EDT	**18,000 MW**
Summer Record Peak Aug 1, 2006	**27,005 MW**

Ontario Demand (MW)

SUPPLY

Hourly Output by Fuel Type at 6:00 a.m. EDT

Nuclear	**9,917 MW**
Hydro	**3,619 MW**
Gas	**883 MW**
Wind	**800 MW**
Other	**143 MW**



Hourly Imports	**85 MW**
Hourly Exports	**3,438 MW**
Generator Availability at Peak at 6:00 p.m. EDT	**26,443 MW**

PRICE

0.79 ¢/kWh

Current Hourly Price at 6:00 a.m. EDT

Hourly Ontario Energy Price ($/MWh)

Average Weighted Price for May	**1.79¢/kWh**