# Power generated in Eastern Ontario

Exergy stores could radically improve the efficiency of the hydro power generation stations in Eastern Ontario.

According to OPG the capacity of the hydro power generating stations in Eastern Ontario is 1819 MW. Almost all of this power is being generated in run of the river facilities that have little or no storage capacity so at times when there is little or no demand for electricity the potential energy of the flowing water is lost.

At night Ontario has three sources of energy for generation:
1) nuclear
2) hydro
3) wind

The nuclear stations work at a fixed power level so at night they provide nearly all of the power that is needed. The contribution of wind power is small but is growing rapidly. Because of the high capital costs of the wind turbines and of the high capacity distribution grid they need it is not desirable to curtail their production at night. The end result is that when the demand is low it is the hydro stations that produce relatively little power. For hydro stations that incorporate water storage the potential energy is stored for later use but for run of the river stations the ability to extract much of the water power is permanently lost. During the day the demand is normally well below the supply capability so even then for most of the time the hydro stations will still be operating at well below their capacity.

For Canada as a whole NRCan's estimate is that run of the river stations operate at 40 to 80% of their capacity. Unfortunately, their report (below) is no longer available and a search did not locate a substitute. It is likely that the hydro stations in Eastern Ontario are at the low end of this range, perhaps 40 to 60%, so for the purposes of this review a value of 50% will be temporarily assumed.

http://canmetenergy-canmetenergie.nrcan-rncan.gc.ca/fichier.php/codectec/Fr/H327842.201.01

***Update - 2 Jan/14*** ***The figure for the Chaudiere Falls generating stations in Ottawa is 42.6%. If that is typical (as appears to be likely) then the potential benefits of using thermal storage will be about 17% greater than the following calculations indicate. Note however that in some cases the capacity factor may be low because of diminished river water flow, in which case storage will not make up for that part of the lost output.***

**Boosting the capacity**
Given any means of storing electricity the way is open to double the energy output of the Eastern Ontario hydro stations. If they are operating at 50% of their capacity then their average daily output will be: 1819x0.5x24 = 21, 828 MWh/day, or 7,967,220 MWh/year. If sufficient storage is available then the run of the river stations could operate at nearly 100% of their capacity. They will still have the same 1819 MW power capacity but now they will be capable of delivering an extra 8 million MWh/year without interfering with their normal functions.

If the power is used to boost the exergy in exergy stores (ExS for short) and the COP of the heat pumps is 4 then the total amount of thermal energy that is produced will be 21828x4 = 87,312 MWh/day (31,868,880 MWh/year). The extra energy is coming from the air, from AC heat that is recovered, and from solar thermal panels as explained in Exergy Storage in the Ground. If the homes are each using 15,000 kWh of thermal energy per year the thermal supply would be sufficient for 2.1 million homes. That is more than the number of homes that exist in Eastern Ontario but the heating demand for commercial and institutional buildings should absorb the balance of the energy being supplied. The upshot is that it would be possible to store nearly all of the electricity that would be generated if the generators worked constantly at their rated capacity.

At the present time the power grid supplies the energy for heating, cooling and hot water in a great many Eastern Ontario homes. The ExS storage systems would take over those functions, freeing up much of the existing supply for other applications - running our vehicles for example. That is over and above the extra 8 million MWh/yr in electricity production.

**Cutting the price of electricity**
From an economic point of view doubling the productivity of the power stations would provide 32 million MWh of power virtually free of cost, which could nominally cut the price of electricity in half. There would be no increase in the cost of distributing the power because the present distribution facilities would all be functioning within their capacities. We would simply by using 32 million MWh of energy that is presently going to waste. Cutting the price in half would not reduce the income of the power distributors because they would be delivering twice as much energy to their clients via the existing grid facilities.

For the thermal applications cutting the power price in half but doubling the consumption would leave the homeowner at square one for heat costs but most of a home's electricity consumption is for other applications - cooking, lighting, TV's, computers, etc., so for those applications the power costs would be reduced.

**Adding new sources of energy (that are clean, silent and invisible!) + retrofitting**
Note that only 8 million MWh of that 32 million MWh of extra energy is actually coming from the hydro stations. The balance is provided by the recovery of AC heat, air-source heat and solar heat, the primary energy sources for ExS systems. At the present time none of those energy sources are being utilized on a significant scale, so nearly all of the 32 million MWh is new energy that is clean, permanently sustainable and locally available. Note also that modifying the system so that it provides both power and heat to the clients can be done for both new buildings and for the existing building stock. There is no need to add insulation to the buildings or to spend money on energy conserving equipment. This ability to retrofit the existing building stock is essential if Ontario is to meet its GHG reduction targets.

**Peak thermal demands**
Such a system must also be capable of meeting the peak thermal power demands. If the buildings were heated electrically those demands would require a huge increase in the grid's capacity. That is the basic reason why we have clung to the use of natural gas for heating. 32 million MWh would be enough energy to meet the average demand of the buildings but it is also necessary to ensure that the rate of delivery (i.e the thermal power) will be adequate to handle the peak demands, such as the coldest winter nights or the hottest summer days.

Heat can be injected into the ground at one rate but can subsequently be extracted at a very different rate. For example, in the spring and fall the home heating loads will be small so the rate of heat extraction from the ground will be low. The crucial factor is that the rate of supply must be adequate to handle the heating load on the coldest night of the year, even if there has been a succession of cold nights. If the homes were heated electrically the 1819 MW of power from the hydro stations would be grossly inadequate to provide the thermal power rate that is needed. However, the ExS systems multiply the energy collection rate by a factor of about 4 and they can further temporarily increase the delivery of heat extracted from the ground so on those extra cold nights the thermal delivery rate could be up to 36,000 MW. For one million homes that would work out to 36 kW per home. That is more than double the demand of the homes so the thermal supply rate based on the existing power generators should be able to handle the most extreme cold snaps for all of the buildings in Eastern Ontario.

**Costs**

The result would be that Ontario would no longer need to use fossil fuels for heating, and the power to run the heating/cooling/DHW systems would all be coming from potential energy sources that are presently going to waste. Exergy boosting pumps work at night, when the power loads are small, and they would never run during the day when the electricity is needed for other purposes. No additions are needed for the power generation or the power distribution facilities. The major new element would be the cost of drilling the holes for the ExS storage systems (very roughly 75m x$100/m = $7500 per house). Such homes do not need furnaces, chimneys, extra insulation, etc, so for new homes there is little or no net extra capital cost. The cost of the energy for heating and cooling will be lower, and the cost of electricity should be much lower.

ExS systems simultaneously serve two almost independent functions:
1) they increase the capacity of the existing generation facilities without increasing the capital or operating costs, and
2) they provide clean, inexpensive, reliable and resilient heating, cooling and DHW for buildings

**Cost/Benefit analysis**

From the above we can make an initial stab at a cost/benefit analysis. Suppose that we have a block of 50 homes that are sharing an exergy store and that are each using 15,000 kWh of energy per year and that require 18 kW of power to meet their peak heating load. At $7500 per home the capital cost would be about $375,000 per block. If the conventional capital cost of power is $5000 per kW the capital value would amount to $4,500,000 per block, so the capital cost of a conventional energy system would be 12 times greater than the cost of the exergy option. If the conventional energy cost is 6 cents per kWh the annual value of the heat would be $45,000 per block but the cost of the electricity to run the exergy store is only $5,625 so the primary operating cost of the exergy option is only one eighth of the conventional cost. These are very crude values but they point to the potential of exergy storage systems having very attractive cost/benefit ratios even before you consider factors like the elimination of GHG's and the very long lifetime of the ground storage facilities. Note that since most of the energy is collected locally the energy transmission costs are greatly reduced and that the incremental energy production does not take up any space.

**A new policy is needed**

The outstanding need is for policy makers to establish the means for splitting the conversion costs between the power-supplying organizations and the building owners. They would be sharing the heat stores and would be using them for two almost independent functions so it would be mandatory to find a way for the two parties to establish a means for splitting the costs. In the absence of such a policy the consequence would be a slow adoption of a reform that is urgently needed. The Ontario government's LTEP continues to ignore the significance of thermal energy even though it is a bigger part of the energy consumption pattern than electricity and is a far larger contributor to GHG emissions and pollution. The LTEP also ignores the potential to cut electricity costs as outlined above. Both issues were raised in the submissions made to the Ministry and many organizations emphasized the importance of creating policies for energy forms other than electricity, but to no avail.

The concept of jointly storing both electricity (in the form of exergy) and heat can be implemented on any scale, from a single house to the whole of Eastern Ontario. Because it can be implemented progressively it does not require that Ontario gamble on a new technology but it does require a cost-splitting formula so the critical path is to make a start in getting power companies and building owners to work together.