The light at the end of the tunnel

We need to start with a roadmap that shows us how we can reach the promised land, where energy is cheap and the systems that deliver it are clean, reliable and unobtrusive. For the buildings sector, and the power industry that serves it, exergy storage offers a potential solution but is it a complete solution or just one of a thousand partial solutions?

Let us start with the challenges in Ontario, using the Buildings Sector statistics from NRCan.

1) We know how much electricity is being used for thermal applications (heating, cooling, DHW) in Ontario (110.2 PJ/y, see Table 1). The objective is to displace that demand (i.e. shift it from high demand periods to low demand periods).

2) If you think of the collection of exergy stores as a battery then the input energy being fed to the "battery" will also be 110.2 PJ/y.

3) We know how much energy (electrical + thermal) is being used by buildings in Ontario (657.1 PJ/y, see Table 2). Part of that energy will be supplied by the solar thermal collectors, which need to deliver at least 148.5 PJ/y (110.2+38.3 from Table 2) for the DHW but their total contribution is a design choice. 300 PJ/y would be a reasonable choice, leaving 357.1 PJ/y to come from the heat pump concentrators.

4) If the heat pump output is to be 357.1 PJ/y and the input is 110.2 PJ/y then ideally we would like the COP of the heat pumps to be 357.1/110.2 = 3.2, which is an achievable objective.

5) The availability of storage would make the existing generation facilities more productive by at least 72.3 PJ/y (see Table 3) so such a system would meet 100% of the buildings' thermal energy demands without interfering with the other electricity applications and would still leave at least 72.3 PJ/y of new power left over for other electricity applications.

6) As the population (and the number of buildings) grows the four sources of energy needed for exergy stores will grow in proportion so such a system is inherently very stable.

7) The cost per MW of capacity of exergy stores is much less than the cost per MW of electricity generation and the four sources of energy are all free so as the storage system is deployed the reduction in capital costs and operating costs should result in a steady decline in the costs of both electricity and thermal energy, especially as the power is all drawn at night when electricity is cheap.

8) The need for gas fired peaking power stations is eliminated, along with the need to use fossil fuels for heating buildings and DHW.

9) The GHG emissions attributable to the buildings and to power generation would be eliminated.

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Table 1 The power consumption in Ontario in 2011 for the Residential and Commercial/Institutional Sectors (ref. NRCAN OEE energy database). The total electricity consumption is 326.6 PJ/y.

Use	PJ/year
Electricity used for heating in residences	36.4
Electricity used for heating in commercial/institutional	14.5
Electricity used for cooling in residences	16.1
Electricity used for cooling in commercial/institutional	31.9
Electricity used for water heating in residences	9
Electricity used for water heating in commercial/inst.	2.3
Total electricity used in for thermal apps in 2011	**110.2**

Table 2 The total energy consumption (including natural gas) in 2011 for the building sectors

Use	PJ/year
Total energy used for heating in residences	339.6
Total energy used for heating in commercial/institutional	119
Total energy used for cooling in residences	16.1
Total energy used for cooling in commercial/institutional	33.9
Total energy used for water heating in residences	110.2
Total energy used for water heating in commercial/inst.	38.3
Total energy used for thermal apps in 2011	**657.1**

Table 3 Extra power that would be available if surplus energy is stored. Units are PJ/year

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Surplus baseload hydro (OPG data)	4
Surplus baseload hydro from other hydro sites (projected)	2.7
Surplus power dumped via exports (IESO data)	65.6
Surplus wind power	not available
Unused nuclear capacity[1]	not available[1]
Total	**72.3**

1. Ontario's nuclear generation capacity is 12,947 MW (IESO data) but during periods of low demand the generation falls to the 8000's, and on a daily basis the nighttime generation is usually substantially less than the daytime generation, indicating that the nuclear stations are being throttled back. This is likely to be the largest factor but the data is not available.