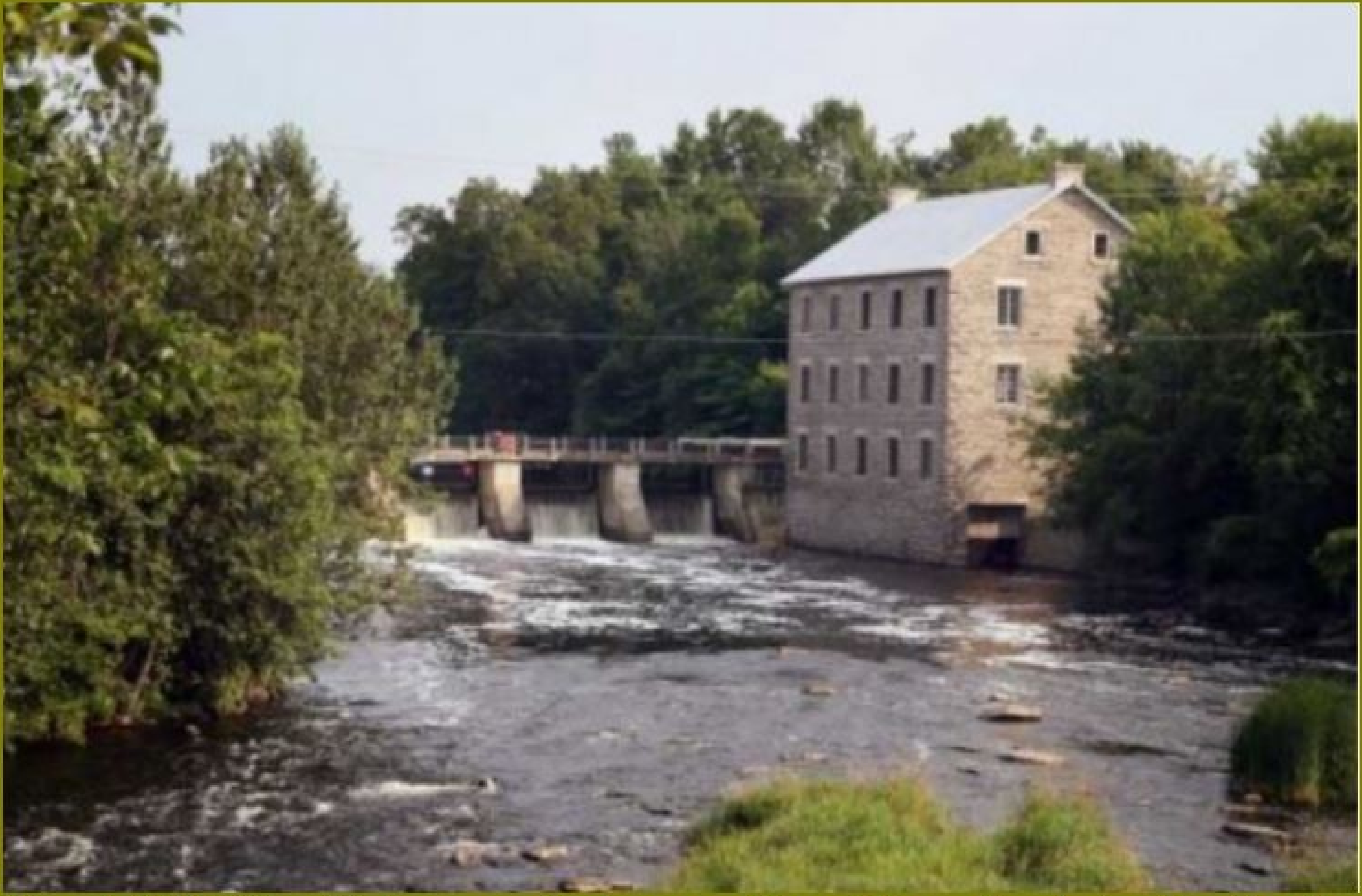
STORING EXERGY

For centuries waterwheels have been used to drive machinery but they extracted only a small part of the available energy.

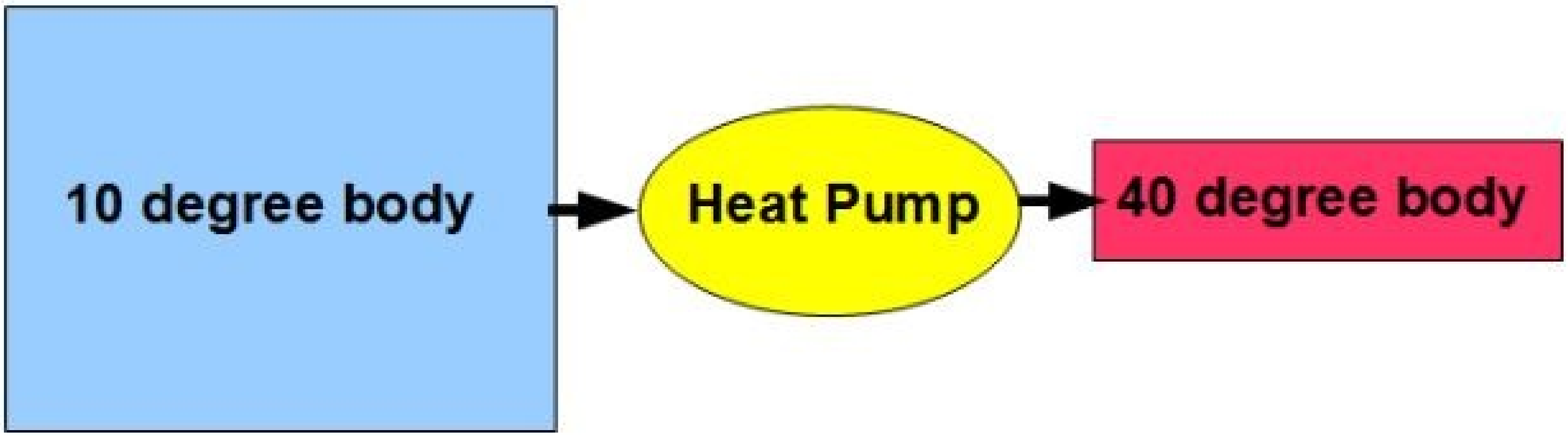


Watson's Mill. The efficiency can be improved by adding a dam but unless the dam is high most of the energy is still lost - a problem faced by most of the dams in eastern Ontario.

The Chaudiere Falls power station is a typical example of a generator that uses only a part of the available energy - providing about 43% of its potential electrical output in this particular case.

We need a means of storing the generator's output when its load is less than 100%

The solution: **Use the excess power to drive a heat pump that transfers heat from an insulated body to a smaller insulated body, and at a higher temperature.**

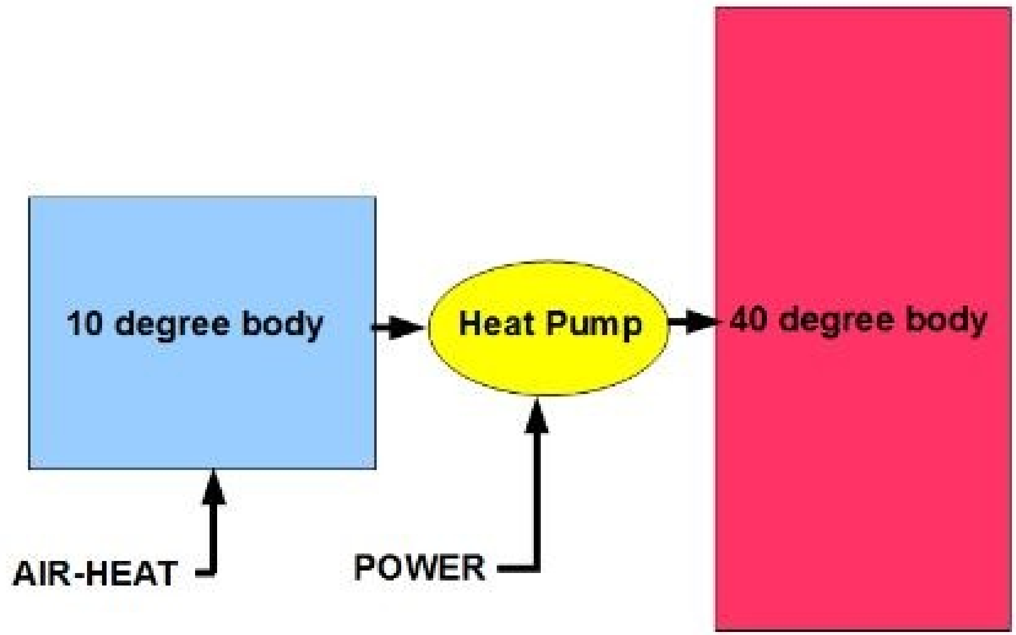


The result: **We can now store the energy in thermal form for later recovery.**
BUT : **Now the temperature is high enough to be used for space heating, so the energy can be recovered without the need of using more energy to adjust its temperature.**

We have used the heat pump to raise the exergy of the stored heat and that exergy is being stored. Exergy can be thought of as *the capacity to do work*, in this case to heat a building without any further help.

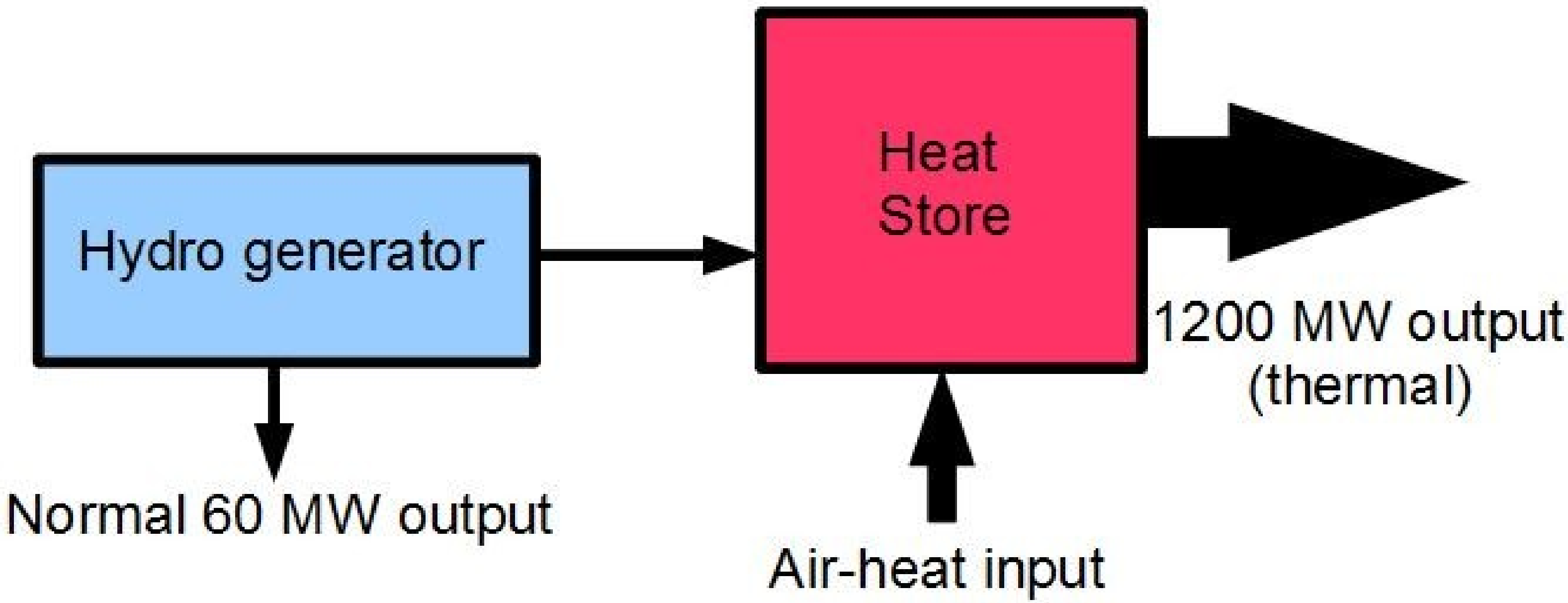
The process can be repeated:

At night the heat pump transfers heat into the hot body, which chills the cold body. During the day the cold body can be brought back to 10 degrees using heat from the air.



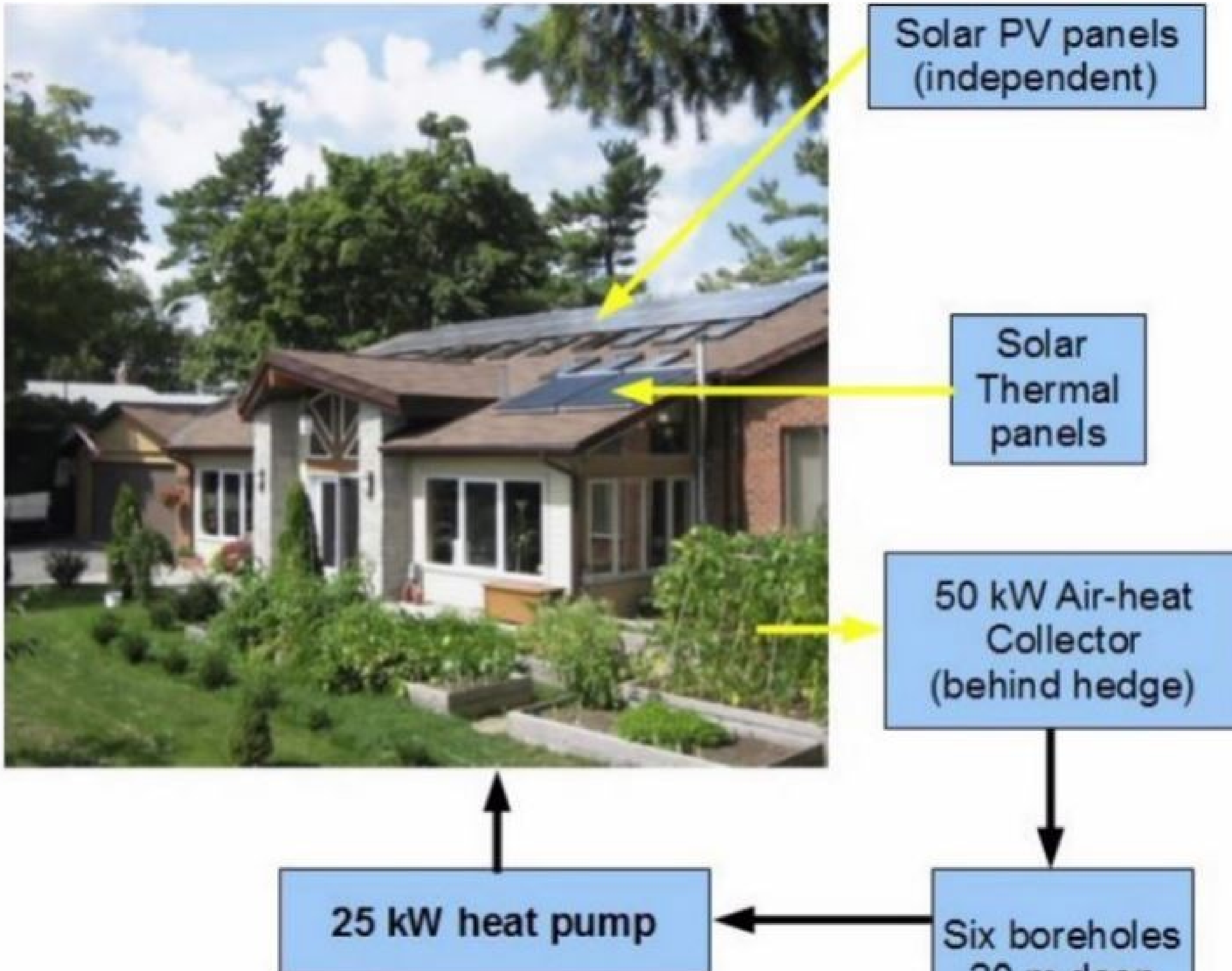
Result: **A large body of 40 degree heat can be built up. The source of the energy is the air but it is the exergy contributed by the heat pump that makes the stored heat useful.**

Magnifying the power output



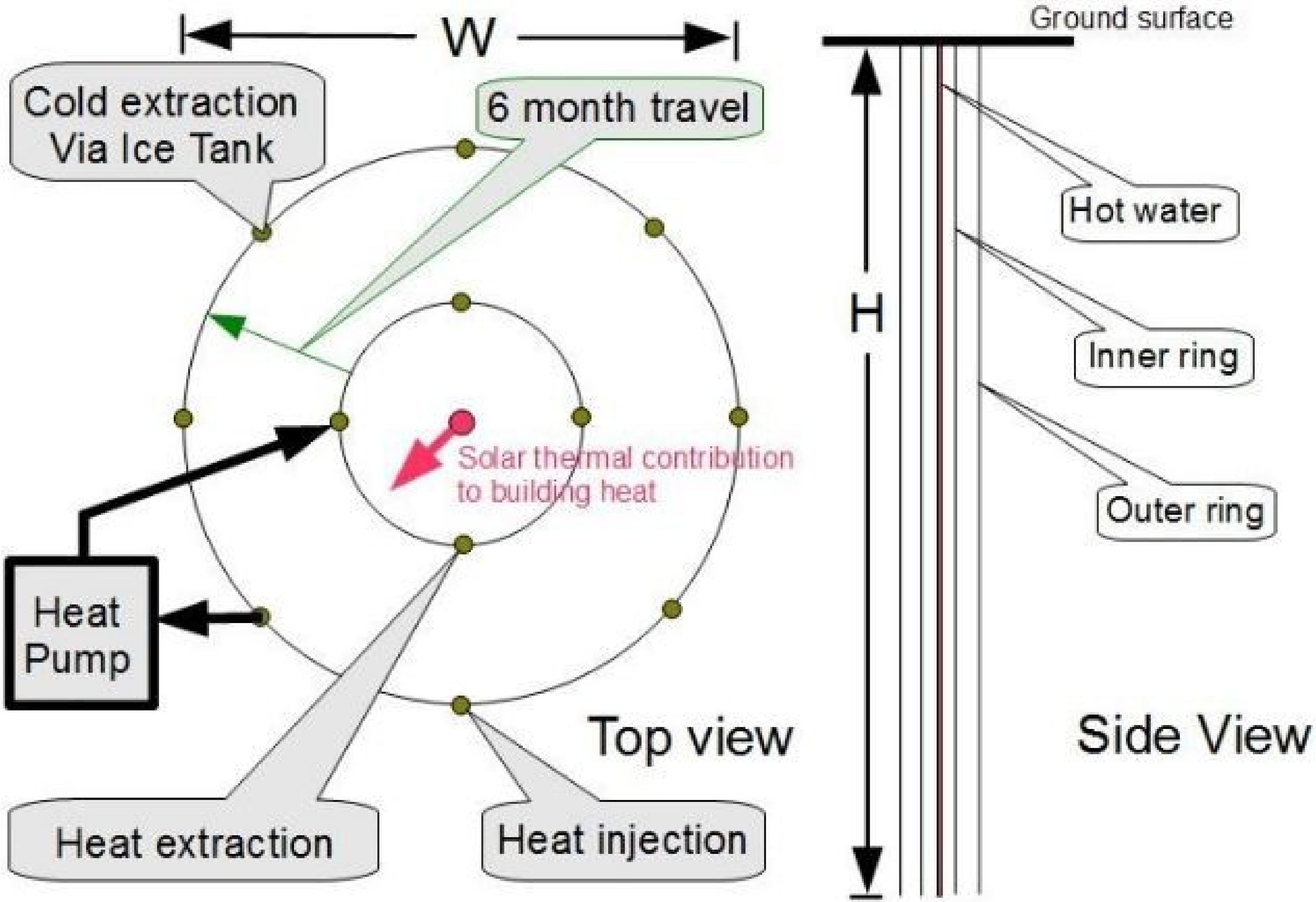
The air-heat input "magnifies" the energy output from the hydro generator. Because the heat store can be trickle charged at one rate but energy can be withdrawn at a much higher rate a modest 60 MW hydro power input can deliver as much as 1200 MW of thermal output power.

Note that all of the 1200 MW is coming from energy sources that are presently just going to waste.



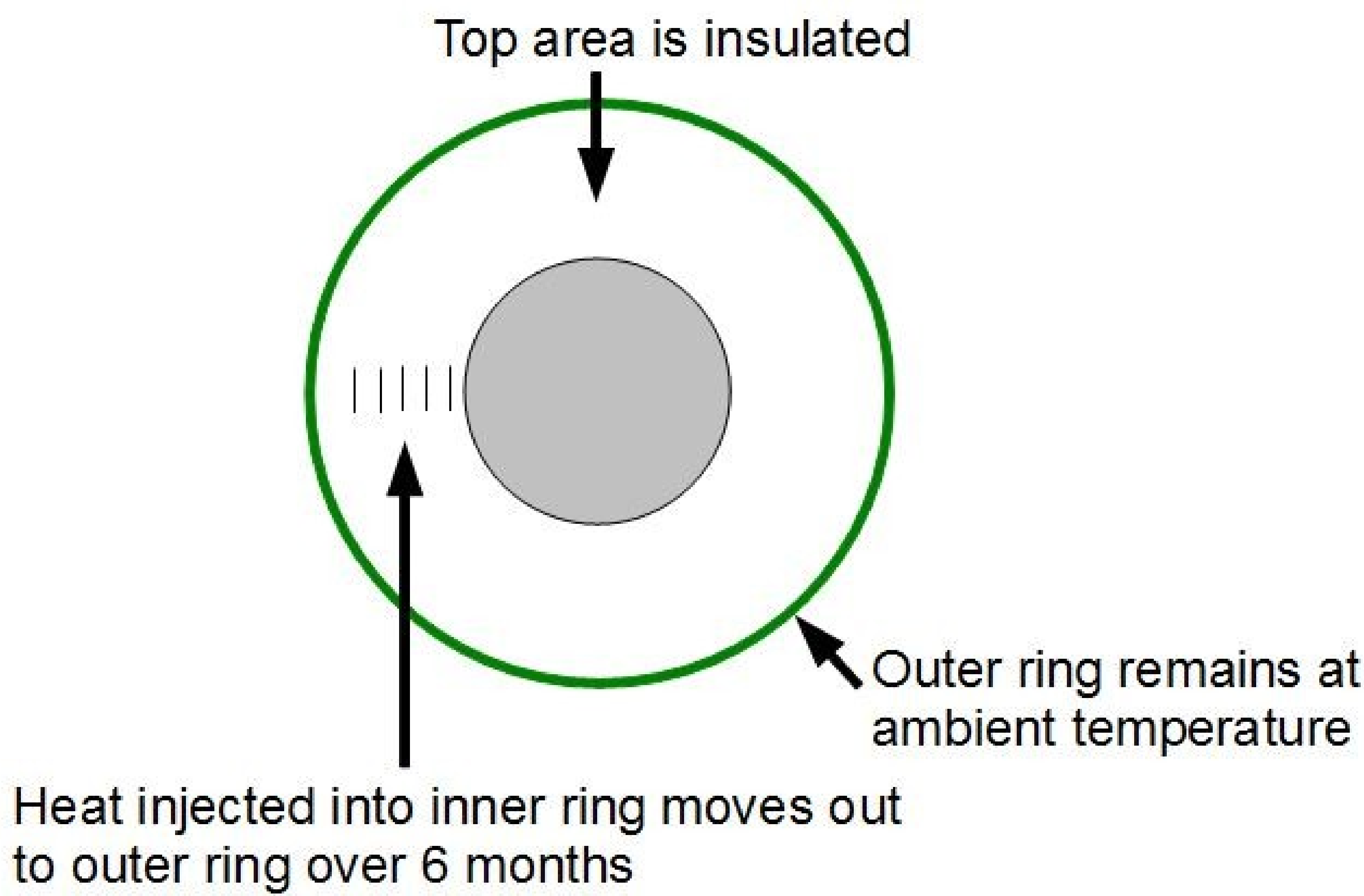
Test-bed installation in Kingston

50 kW air-heat exchanger

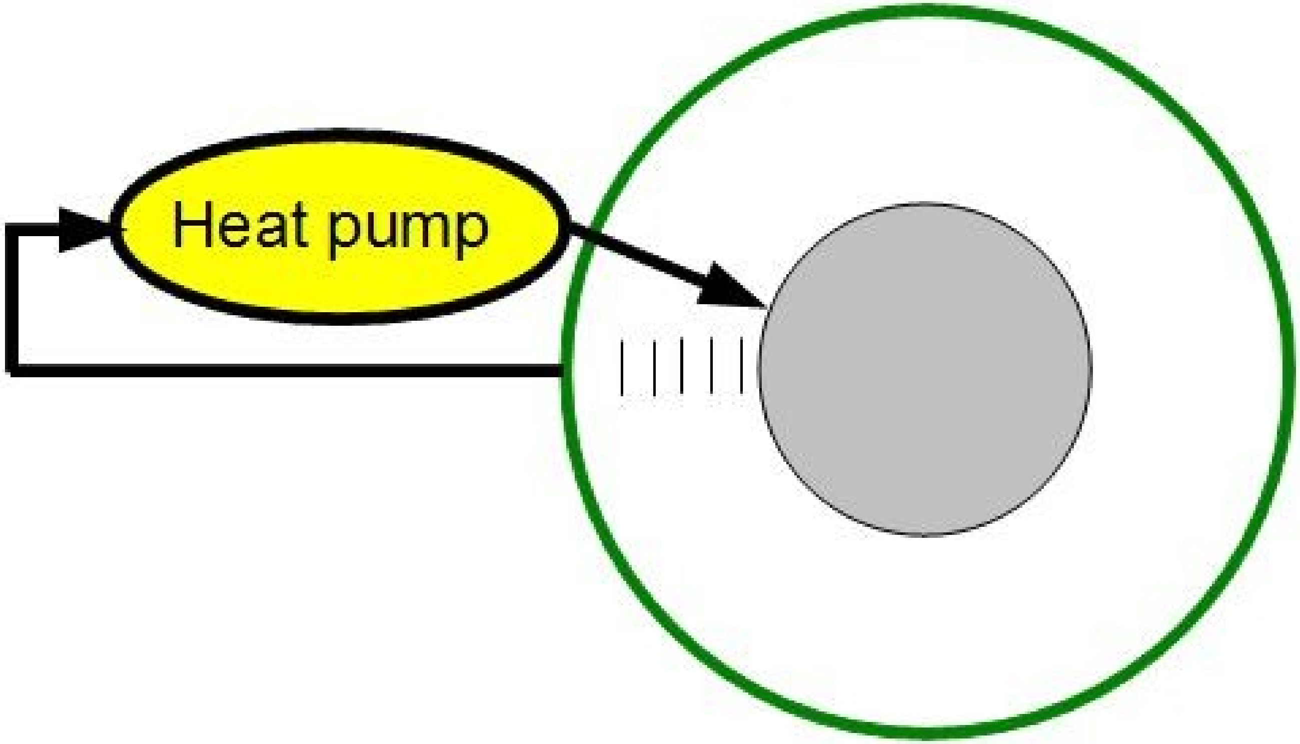


13 Borehole Concentric Heat Store

Heat trapping

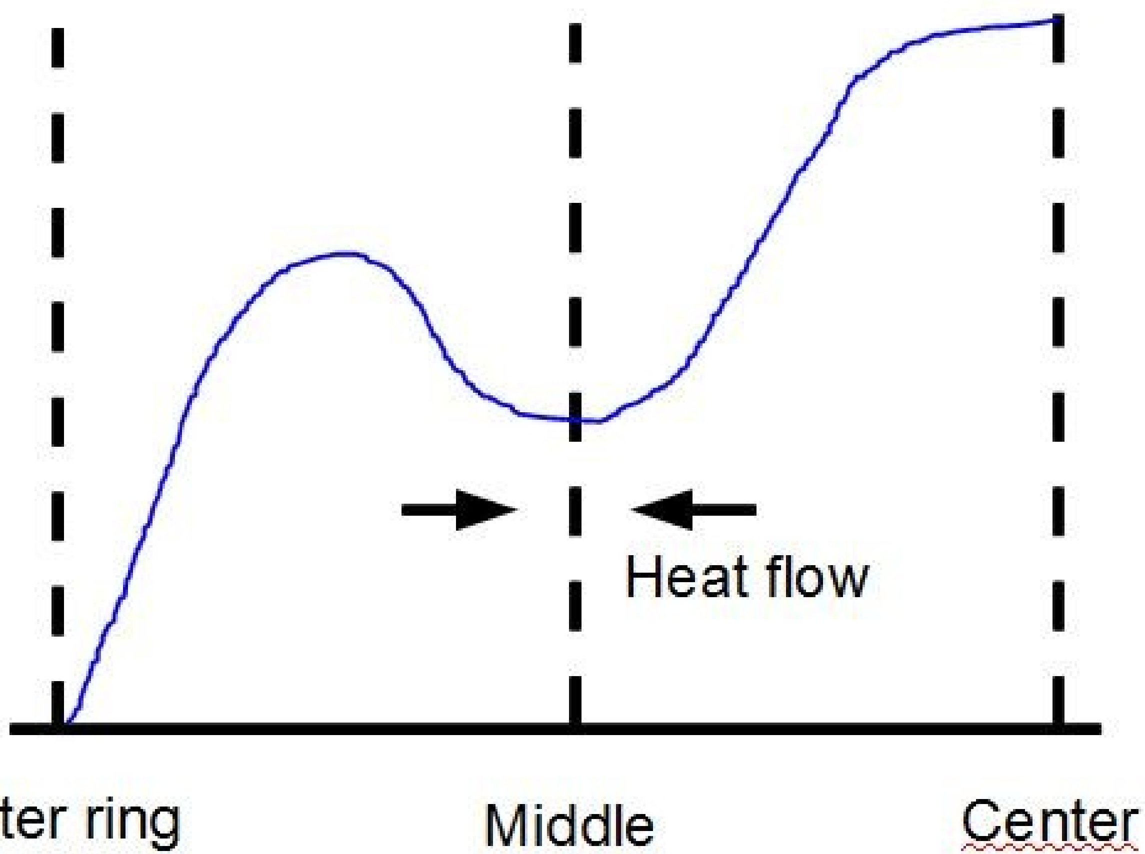


Heat recycling



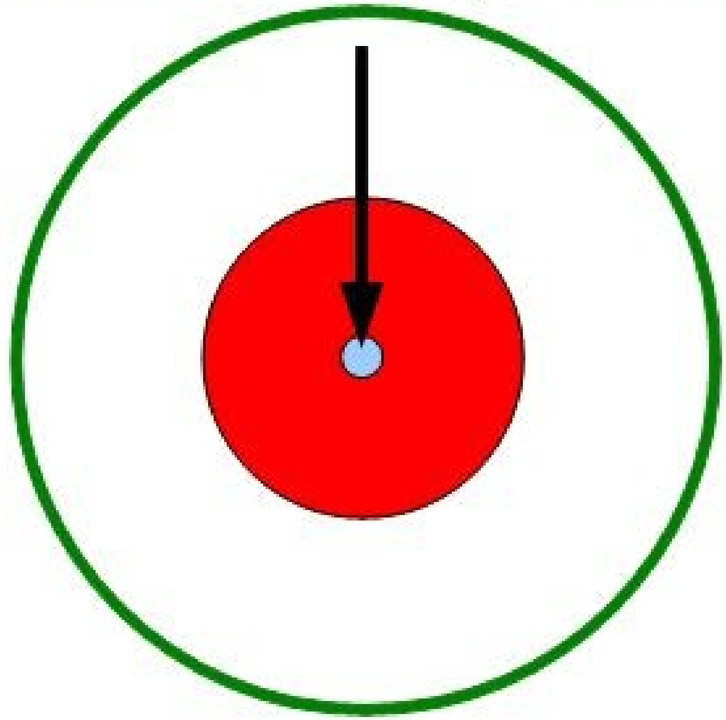
In the winter part of the heat is recycled back to the center to support the daily energy storage process

Winter heat trapping

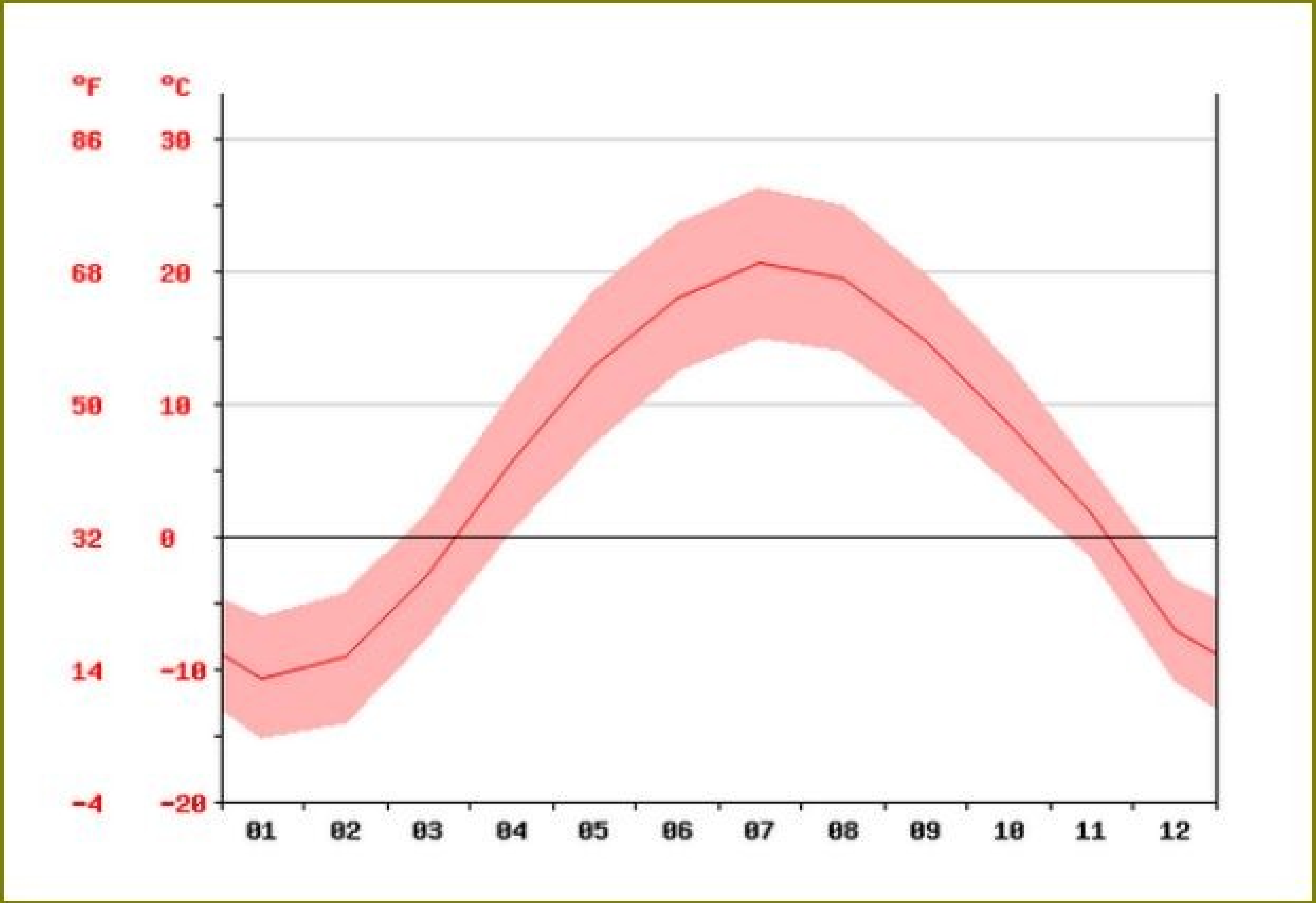


Heat injected into the middle ring by the heat pump cannot escape because of the surrounding temperature gradient. Because it is stored close to the boreholes it can be extracted at high power rates.

Solar heat injection



Solar input provides:
(1) High temperature for DHW
(2) Heat for peak heating demands
(3) Replenishment via ground flow
(*Can be replaced by a second heat pump in some cases*)



Temperatures in Ottawa. Most of the energy demand for buildings is for heating, cooling and DHW. Exergy storage could provide all three, and could at the same time reduce the power demand during the peak periods. In eastern Ontario the power needed to drive the exergy pumps could come from the extra power from the run-of-the-river stations. Peaking stations could be eliminated.

The alternative is to use natural gas, BUT:

* Ottawa will soon need to switch to shale gas
* 3.4% of the natural gas escapes before it reaches its destination
* the amount that is released but has not yet surfaced is unknown
* the GWP for natural gas is 72 (current IPCC value)

The consequence is that the GHG emissions of natural gas are about 2 times greater than the GHG emissions from coal even though the CO_2 from combustion is only 56% as much.

The City and the Province would have to abandon their GHG reduction targets if we were to continue to use natural gas.

Scope for ROR "free" energy in Eastern Ontario

* Current ROR hydro generation: 1819 MW
* Potential "free"electricity available: 8,000,000 MWh
* Potential thermal capacity available: 32,000,000 MWh(t)
* Potential rate of thermal heat delivery: 36,000 MW(t)

(note that this exceeds the total for electric power capacity for all of Ontario)

* Does not interfere with existing power applications
* Does not require an expansion of the grid lines
* Provides storage for wind and other intermittent sources
* Provides a domestic market for surplus power (e.g. nuclear)
* Provides heat when the grid is down
* Provides a means of importing electricity when the price is low
* Can be expanded using the existing sources of electricity

Building the exergy stores

* The primary cost is for the boreholes (including site assessment)
* Costs split between the LDC and building owners
* The two functions are managed independently
* One store per city block for homes

* At least 13 boreholes/store, 6 inch, 20 to 400 m deep
* Assessments: geology and hydrogeology
* Determine values for heat velocity, conductivity, specific heat
* Evaluate risk of pockets of natural gas
* Deal with aquifers
* Determine storage capacity

For more information:

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http://Sustainability-Journal.ca

You can search for "exergy storage" on the Internet

The principles are explained in "Exergy Storage in the Ground" by Ron Tolmie and Marc Rosen
3rd World Sustainability Forum, Nov. 2013
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