# Heat storage for large buildings

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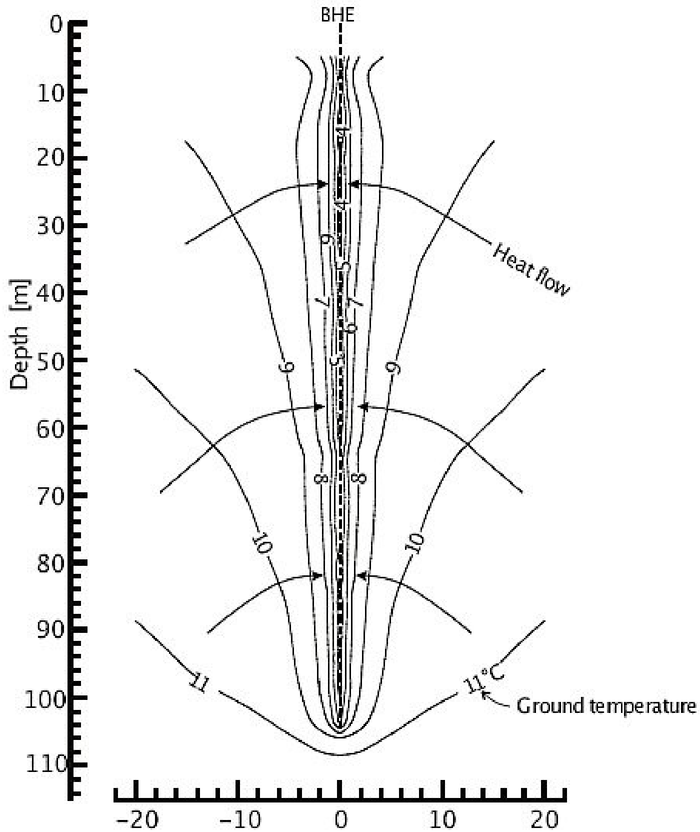


The above graph (Rybach & Mongillo, IEA-GIA) shows the isotherms around a borehole heat exchanger for the coldest period of a year (1997). Most of the heat has been extracted from the ground very close to the borehole. The pattern is similar for heat injection.

**Borehole spacing** In ground source heat pump (GSHP) systems the boreholes must be located far apart because over a period of years they progressively extract heat from an ever widening cylinder of ground (see the previous Sustainability Journal article). However, in AE systems the heat is replaced every year so the boreholes can be much closer together, typically occupying about 25 times less plan view area. That is particularly useful for the arrays of boreholes needed for large buildings, making it possible to locate the boreholes right under the buildings where they are protected from future ground excavations. That also puts the heat exchangers and their connecting tubes below the frostline so such ground systems are more energy efficient.

**Stability of the output** Over a period of decades the average ground temperature for a GSHP will decline significantly as the ground for the whole area loses its heat. Again, this problem is particularly acute for large buildings because they use multiple boreholes, the holes are typically deeper and space limitations usually dictate that they must be placed too close together in order to fit within the property. The usual "solution" is to make the boreholes deeper but that only delays the impact of the temperature depression. The results are substantially greater expense and declining outputs for GSHP's in comparison with AE systems.

**Impact on neighbouring buildings** It is not advisable to locate more than one large GSHP installation within a diameter of several hundred meters because they will interfere with each other and this effect could be crippling if there are several or more nearby systems. They will also interfere with the operation of home GSHP systems. The problem is that as the number of installations increases they are all sharing the same surface area via which the recovery heat is flowing from the surface so if there are 10 units in the area then the rate of recovery for each is reduced by nearly a factor of 10. The result is that they will all be competing for the limited amount of heat that was originally in the ground. That might be adequate to run the heat pumps for a few years but they will inevitably run out of energy.

**Capacity** The summer air contains an almost unlimited supply of energy. It can provide sufficient heat for large cities, large buildings and high population densities. In general the ground under the buildings has adequate heat storage capacity for large buildings but in the event that it does not the AE-Street network design can be used to distribute the storage over a wider area.

In Ottawa the energy consumption occurs almost entirely in just two sectors: buildings and transportation, with most of the energy for the buildings being used for space heating, cooling and domestic hot water, all of which can be supplied by AE systems. Although nearly half of all Canadian homes are heated electrically we lack sufficient hydro capacity to switch the remainder to that source, especially as the electricity could be better utilized for other applications (like transportation). We cannot use nuclear power either because of the strongly peaking winter demand. In principle we could use solar-thermal systems for heating (like the one in Okotoks) but such systems are much more expensive than AE systems and they impose limitations like requiring building orientation to catch the sun, etc. We cannot rebuild our housing stock to eliminate heat losses via insulation. AE systems may prove to be the most practical option for the future, for buildings of any size.

**Boosting the capacity** In general it is feasible to inject more heat to boost the ground temperature to increase the storage capacity and reduce the cost of the ground storage system. While that requires more efficient ground heat exchangers and a heat-trapping borehole array, such systems are extremely cost effective.