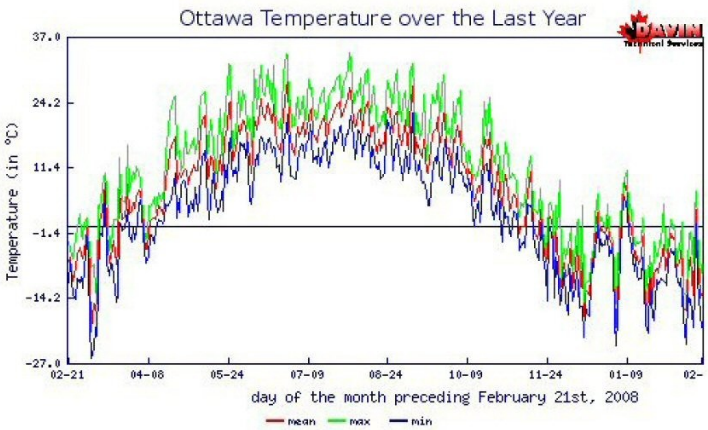
Meeting Peak Power Demands

The winter demand for home heating has a small number of very strong peaks that occur on days when the temperatures plunge to minus 15 degrees or lower. The strategy for meeting those peak demands determines the performance and economics of systems that draw heat from the ground.

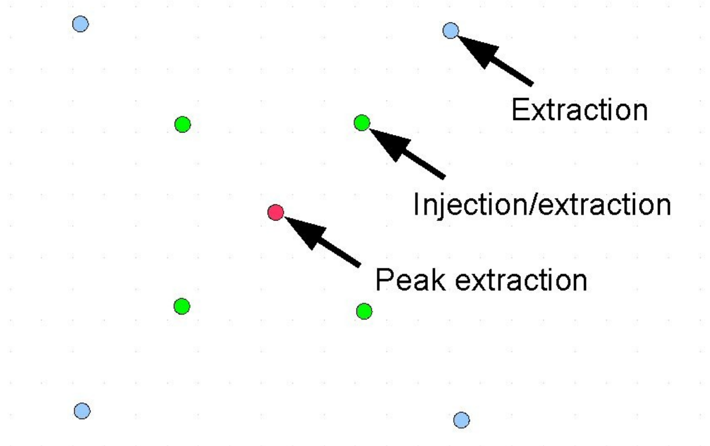


The above graph for Ottawa shows that there were about 10 nights when the temperature fell below -14 degrees, with the temperature ranging down to -27 degrees. Normally a furnace, such as natural gas furnace, is simply designed to meet the peak demand with a little to spare, but to take that approach with a ground source system would be very expensive because of the cost of the ground heat exchanger. This note explores a new approach.

Conventional ground source heat pumps commonly rely on backup heat sources like electrical or gas heaters that come on when the demand peaks. Since the peak demands occur in the middle of the winter when the heat around the boreholes has already been depleted the conventional systems perform very poorly during peak demand periods. Moreover, if such systems draw a lot of electric power at such times then they cancel out one of the primary objectives of using renewable energy – the reduction of peak power demands,

The AE systems described to date perform much better than conventional GSHP's. The pattern of heat flow in the ground ensures that there will be more heat reaching the outer boreholes and the mid-winter switchover from 4 to 8 boreholes creates a large boost in the capacity when it is needed. However, such a system still needs to be designed to be able to handle the small number of temperature spikes. By using the proposed method of dealing with those spikes the design objective is changed from needing to handle -27 degree spikes to only needing to handle -12 degree periods. The 15 degree reduction means that the boreholes can be substantially shorter, and thus less expensive, and there will be no need to depend on an external source of heat.

The new element is an extra borehole in the center of the array as shown below.



This extra borehole is connected in parallel with the four outer boreholes but normally a solenoid valve obstructs flow in this central heat exchanger. When the temperature drops below -12 degrees the solenoid valve opens injecting fluid that is typically about 12 degrees warmer into the heat pump and circulating that heat into all of the heat exchangers (whether there are 4 or 8 in use) to ensure that they are all working well within their operating range. The valve closes again when the outside air temperature rises above -12 degrees, and the heat that had been extracted will be replaced by the heat from the warm ground surrounding the central borehole, making the system ready for the next demand peak. A timing control increases the heat pump's capacity limit during this period.

Note that this peak demand protection is available throughout the winter, including fall and early winter when only the four outer heat exchangers are in use. This avoids a dilemma that can otherwise occur in the event of a cold snap that sometimes occurs early in the winter, requiring extra heat – and potentially forcing an early switchover from 4 to 8 holes.

Changing the number of heat exchangers in use also changes the power capacity of the ground system. With closed loop systems that can create instability if the ground loop's supply capacity is less than the heat pump's capacity to extract heat from the fluid. The heat pump needs to be set up to draw no more heat than the ground system can deliver with its current combination of number of holes and ground temperature.