Boosting AE System Capacity

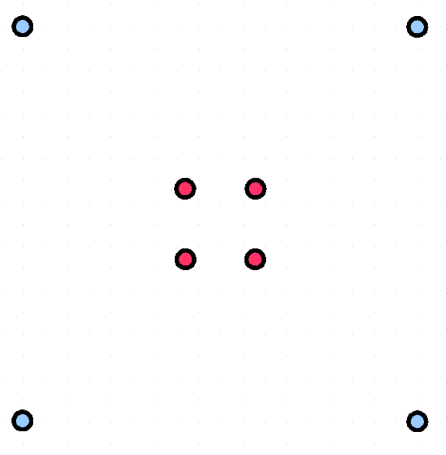
AE-Street systems are most attractive if the number of storage sites is minimized, particularly in downtown retrofits. That can be accomplished in two ways:

(1) make the boreholes deeper
(2) increase the number of injection points

With deeper boreholes the capacity can be increased in proportion to the increase in depth, with the added advantage that the end losses will be reduced.

There can be four or more injection points but in that case you need to take care that the heat extraction capabilities will be able to handle the greater capacity.

For example, a stub of an AE-Street system might use 80 metre boreholes and have two storage sites (to form a network), each with four injection holes. Such a stub should have sufficient capacity to heat, cool and provide DHW to about 30 homes of normal size and its performance would be readily predictable because it is physically not much different from the existing demonstration system (see the diagram below.).



The demonstration system uses two injection holes that are spaced 1.7 metres apart. That is enough to prevent them from interfering with each other during the summer injection period, so the process is like charging a set of rechargeable batteries, achieving a capacity that is the sum of their individual capacities.

Poor ground conductivity The use of multiple injection points is also useful to handle the situation where poor ground thermal conductivity limits the amount of heat that can be stored at each site. However, in that case the system should incorporate the DHW capability to ensure that the thermal wells around the outer boreholes will be big enough to trap the heat coming from the center.

Mechanisms The system's storage capacity and the rate at which heat can be injected into the store is simply proportional to the number of storage sites providing the air exchanger is scaled to suit. However, some of the other effects are not so obvious.

The heat extraction capacity is proportional to the length of the tubing, so an increase of two injection sites will double the storage capacity but only increases the tube length by one third. Adding the DHW capability adds to the annual load but since that heat is extracted throughout the year rather than just in the winter the 4-hole configuration achieves a better IN-OUT balance than the 2-hole design. Bear in mind that we are using an energy source that is free and that is very abundant, and that any excess or deficit will be handled during the next year's charging cycle, but in general it is desirable to err on the high side..

Power capacity Conventional ground source heat pumps suffer from a serious limitation in that their power capacity drops off at the very time when it is needed most, at midwinter, because the ground heat exchange tubes are physically a long way from their source of heat. That does not happen with AE systems.

By midwinter an AE system's isotherm pattern has adopted the pincushion shape that puts the central heat source close to the extraction tubes and maintains that pattern as the heat is extracted. Moreover the heat from the core is shared with the four outer extraction tubes even more directly.

At about the beginning of January the two valves that connect the central boreholes to the outer boreholes are opened. That starts a sharing process in which heat from the core area is transferred to the outer boreholes, a process that will continue through the balance of the winter because it takes time for the heat to travel back to the injection tubes. During warm winter days this steady heat transfer will result in heat building up around the outer tubes. On cold days that heat will be used for heating the homes. The outer holes thus serve as a means of short term heat storage and that stored heat is very close to the tubes so it is easily extracted.

An incidental consequence of that sequence is that an AE system will draw heat from the surrounding ground early in the winter, then allows the outer wells to recover during the midwinter period, after which that ground heat can be used again if the core heat runs out. This “pumping” of natural ground heat makes it possible to install AE systems relatively late in the summer.

The capacity of AE systems can be boosted by a factor of 2 or more by adding injection sites at relatively little added cost, and it can be boosted by an even larger factor by extending the borehole depth.