Coefficient of Performance (COP)

A secondary objective of an Atmospheric Energy (AE) system is to reduce the amount of electricity needed to operate a heating system. Ground source heat pumps (GSHP's) typically have a COP of about 3.5 but some do not maintain that COP throughout the winter so their power demand increases and they may rely on backup heating when the intended capacity is not achieved during cold periods. This reduces their seasonal COP, commonly to a value of about 2.3. An AE system does not require such a backup, and moreover it is capable of delivering a higher COP with a given heat pump, so its seasonal COP is about 4.3. The COP is the ratio of the amount of energy delivered (heat) divided by the amount of energy (electricity) needed to drive the heat pump, so the AE system needs only little more than half as much electric energy as a conventional heat pump.

Reliance on a backup The degree to which a GSHP depends on a backup source of energy depends on the system design. You can increase the depth of the ground heat exchanger, which reduces the dependence but increases the capital cost. The Ontario Energy Ministry suggests that a reasonable objective is for the heat pump to provide two thirds of the heat. NRCan suggests that it should provide three quarters. Installers frequently recommend that the holes should be deep enough to improve on those figures. To put it in black and white terms, if the GSHP system delivered the heat for 80% of the time then during the remaining 20% of the time 3.5 times as much electricity will be required, in which case the average COP over the heating season would be 2.3.

If this were the only factor under consideration then a system that does not require a backup would operate with a COP of 3.5 throughout the heating season. The extra boost to 4.3 will be explained in a later section.

Power capacity Each of the ground heat exchangers has a maximum capacity, for example 2 kW, in which case the six boreholes would have a total power capacity of 12 kW. Most of the time the heat demand will be small compared to the total capacity so only the four outer boreholes are in use. When the demand exceeds 8 kW the two inner heat exchangers can also be used. That strategy conserves heat in the central area, both for use when heat is being extracted from the center and for preserving the reservoir of heat that flows out to the outer extraction holes.

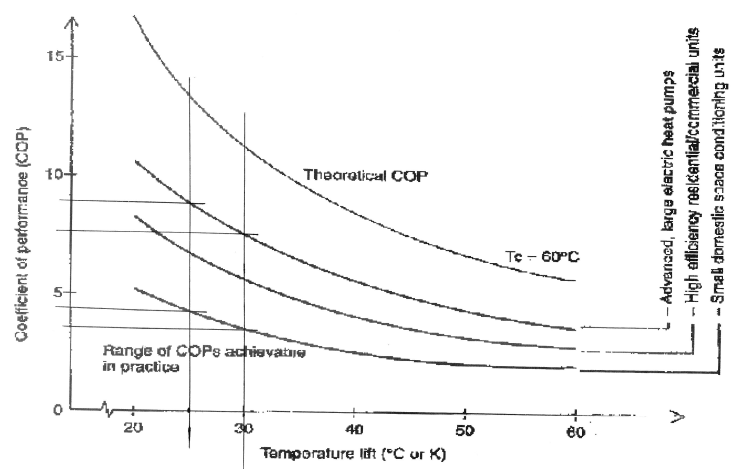
It is mandatory that the temperature around all six holes must never fall below the heat pump's acceptable operating range to meet the objective of eliminating the need for a backup source of energy. The primary means of doing that is to design the ground heat flow pattern so that there is always a substantial supply of heat flowing out from the central area via a short path.

A conventional GSHP creates a thermal well that grows in diameter as heat is extracted from the ground. That well eventually gets so big that the flow of heat from the warm ground surrounding the well is not adequate to meet the power demand of the heat exchanger, hence the need for a backup energy source.

In an AE system both the central storage area and each of the heat extraction wells have annular zones some distance out from the boreholes where there is a strong rate of heat flow. Those zones are initially close to the boreholes but they migrate outwards with time. By setting the spacing so that the zone around the central holes overlaps with those of the four extraction holes by January, they adopt a stable pincushion shape. The heat flows to the extraction holes which are only a short distance away, so the heat exchangers are never starved for sufficient heat to maintain their full power capacity.

Energy capacity Since there are only two injection boreholes and their injection power capacity is the same as that for heat extraction (4 kW in this example) their heat exchangers must operate at their full capacity and with a substantial duty factor during the summer to ensure that sufficient heat is collected.

COP value The actual value of the COP is enhanced in an AE system because the heat is extracted from relatively warm ground. The following graph shows the COP vs. temperature lift for an ordinary heat pump, a high efficiency heat pump, an advanced design suitable for large buildings, and the theoretical COP limits.



The intersections for a case where underfloor heating is employed are shown for a lift of 30 degrees vs. a lift of 25 degrees (for warmer ground).The COP for the latter is 4.34 at 25 degrees vs. 3.54 for 30 degrees. Note that the COP could be as much as 8.91 for the advanced heat pump.