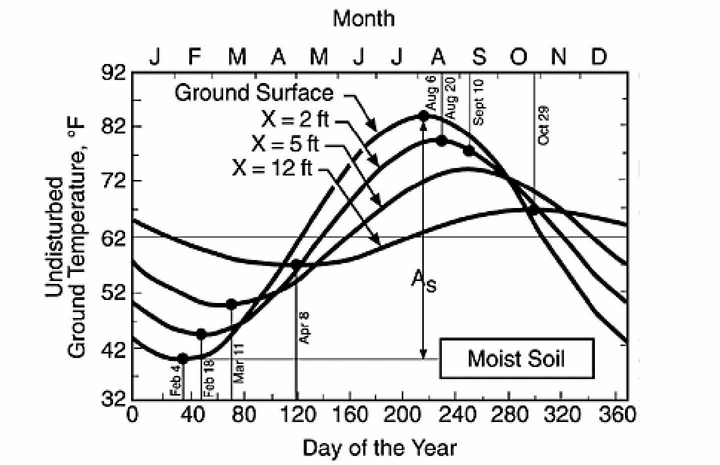

Feasibility of Seasonal Storage

Seasonal storage of heat and cold is not new. It has been used for thousands of years in the form of ice houses for storing ice, and for decades in the form of ground source heat pumps (GSHP's). It is sometimes mistakenly believed that the latter employ heat that comes from deep underground but that is not true. Rock is a good insulator and there are many kilometres of rock between the surface and deep sources of heat, so the heat that is extracted by GSHP's is solar heat that has been absorbed in the summer and stored until it is extracted in the winter. As a starting point then, we know that seasonal storage is a feasible and well proven concept, and there are over a million examples of heat exchangers that have been used to extract the required quantities of heat from the ground (and to inject heat, since the heat exchangers can work in both directions).

It is commonly assumed that if you want to store heat then you will need some sort of insulated box. However, if you store the heat in the ground then the ground itself is such a good insulator that very little heat will be lost if the storage volume is sufficiently large. Moreover, the heat flows through the ground at such a gradual rate that you can inject heat at one point and extract it just at it reaches a second point six months later, so the heat can be recovered right at the time that it is needed. These points are both illustrated in the above graph, which shows that the ground surface temperature swings are greatly reduced by the insulating effect of 12 feet of soil, and that it takes three months for the temperature swings to be reflected at that depth. Solid rock is an even better insulator than moist soil.

A modular ***HEAT network*** storage field is relatively compact, being about 30 metres in diameter and 200 metres deep. The mass, if the rock is granite, is 380 million kg (sandstone is 14% lighter). The amount of energy that is stored if the delta T is 10 degrees is 838,000 kWh, or enough to heat and cool 56 homes or a large office building. The innermost boreholes are reserved for injecting heat or cold, and the outermost ones are reserved for extracting the heat or cold. It takes about six months for the heat to move from the center to the periphery so no heat is lost in the intervening period. By the time it reaches the outermost area the extraction demand is high so the heat is efficiently recovered. If the loads for heat and cold are approximately balanced a single storage field can serve both purposes, simultaneously storing winter cold in the center while the previous summer's heat is extracted from the peripheral area. Where the loads are not balanced, all but one of the modular storage fields serving a area will store only heat or cold, in which case the capital cost will be slightly higher because the injection boreholes are used for only one season. In any case, the heat loss is negligible or there may actually be a heat gain from the surrounding ground with an optimum design.

We can accurately calculate how much heat or cold is stored in the ground (see left) and we know that it will not be lost in the intervening season. In the winter the storage temperature will be about 10 degrees higher than the temperature of the ground for a GSHP so the efficiency of the heat pumps in the homes will be much higher. That results in a relatively low consumption of electricity, which can further be lowered by integrating functions like refrigeration and food freezing into the home's system, since the capacity is there and it's free. If an efficient heat pump is used the winter electricity bill of a home heated by a ***HEAT network*** will be comparable to that of a home heated with natural gas. During the summer very little electrical power is needed, especially to cool large buildings, because the storage temperature is so low that a heat pump is not needed for air conditioning.

At the end of a heating or cooling season the storage temperature will be close to the normal temperature of the surrounding ground. If the season has been particularly severe the system could continue to operate, and the excess demand would be made up in the following seasons. It is like having a gas tank that is always at least half full. The system is also flexible in coping with demand and supply variations. Boreholes located inside of the outer ring can increase the heat output as required, and these intermediate boreholes can also be used as injection sites at the appropriate times. Note that the borehole heat exchangers and the heat pumps can be completely conventional. A ***HEAT network's*** performance can be reliably predicted right now. It is really the means of deployment that is new.