Task 45 Large Systems

Seasonal Borehole Thermal Energy Storage – Guidelines for design & construction

Subject:	Seasonal Borehole Thermal Energy Storage
Date:	4 February 2015
Description:	Guidelines for design of seasonal borehole thermal energy storages.
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Download possible at:	http://task45.iea-shc.org/fact-sheets

Intro

Borehole thermal energy storage (BTES), which is also referred to as duct storage, has been successfully used for seasonal heat storage in a number of large solar systems. Some of these systems utilize a heat pump to upgrade the stored energy to the load temperature while others use the stored heat directly without upgrading. Borehole thermal energy storages have also been used for storing cold.

BTES use the heat capacity in a large volume of native soil to store thermal energy underground. The soil itself is a very good medium for large heat storage systems since it is no-cost, already on-site, involves minimal excavation, is non-toxic and has a reasonable heat capacity. Much of the cost of a BTES is in the heat exchanger used to transfer heat to and from the soil, the drilling of boreholes in which to install the heat exchanger and in the insulation which is placed over the top of the store. For smaller storages (up to 5 000 m^3) typically an insulated steel tank is used but for large storages a BTES can be considerably cheaper per unit volume of water-equivalent storage.

Design of the storage

A borehole storage consists primarily of a large volume of earth that has a matrix of regularly spaced vertical holes drilled into it, each one usually containing one or two u-tubes that have been grouted in place. The top of the bore field is covered with insulation and earth which can be landscaped, covered with a playing field or a parking lot, etc. Water flow through the heat exchangers is used to charge and discharge the BTES, at different times. The BTES design can significantly affect the performance of the entire system so when deciding on the type of storage and its design, it is important to accurately model the storage within the system design model so that the whole system may be optimized.

Location of storage and geotechnical conditions

To avoid excessive heat loss from a BTES it is important that the storage is not implemented in an area where there is significant movement of groundwater at a depth near or above the bottom level of the boreholes.

A preliminary geotechnical investigation based on existing well records for the area of the planned storage can typically provide a reasonable idea of the expected stratigraphy including depths and types of soil and rock that are typical in that location, the likelihood of encountering moving water and the depth of the water table.

Calculation and optimization of borehol heat storages

To predict the behavior and performance of a BTES in an energy system it is necessary to account for performance of all of the subsystems and their interactions with each other and with the load and the weather. Mathematical models representing each of the components are connected together to simulate the whole system. Several different simulation tools are available, however, TRNSYS has probably been used most often for simulating large solar seasonal storage systems in many countries.

Costs of borehole heat storage

Only a limited amount of cost data is available for the implementation of borehole thermal energy storages. It is clear that like other large storages, the specific cost drops significantly as the size increases. In the TECH SHEET (figure 9) costs vary considerably - between 4 and 35 $/m3 ground storage volume.

Information on systems utilizing BTES

Eight large solar heating systems utilizing borehole thermal energy storages have been identified. Three are located in Germany (Attenkirchen, Crailsheim and Neckarsulm) one each in Sweden (Anneburg), Denmark (Braedstrup), Canada (Drake Landing), Finland (Kerava) and the Netherlands (Groningen).

The Crailsheim and Drake Landing projects are described in Project Example Fact Sheets, which are also available on the Task 45 site: http://task45.iea-shc.org/fact-sheets .

Information on 6 of the European systems listed above is also available through the Solar District Heating website: http://www.solar-district-heating.eu/tabid/575/Default.aspx and on the Canadian system at: http://www.dlsc.ca/.