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Underground Thermal Energy Storage (UTES) consists in buried devices designed to exchange heat with the surrounding ground supposed to be colder than the heat source during the storage stage and warmer than the application site during the discharging stage. UTES is thus an attractive solution for solar thermal energy seasonal storage, where the heat collected in summer has to be stored to be recovered and used in winter. Several storage devices are available, the choice of which depends both on the conditions of changing and discharging energy and on the geological and hydrogeological local conditions (Schmidt et al., 2004). For instance, the storage can be done in dry rock by circulating a fluid through so-called Borehole Thermal Energy Store (BTES). Combined with Ground Source Heat Pump systems, many sites in Canada and central and northern Europe are already in operation for block and district heating (and more recently cooling) purposes (Dalenbäck, 2007).

Solargeotherm[1] is a 3-years French research project focused on the study of solar thermal energy storage into dry rock. Through a real-scale experimental device and heat transfer models which allow exploring scenarios of storage and recovery, the project aims at evaluating the energetic potential of such a system.

The experimental site is located in a Paleozoic schist quarry in the Eastern Pyrenees (France). The geological characterization and fracturing of the bedrock were determined thanks to borehole cuttings analysis and geophysics. Thermal properties of the bedrock were evaluated through an in-situ distributed thermal response test (Lanini & Nguyen, 2011). The experimental device includes 42 m² of thermal solar panels, three subvertical boreholes, drilled to 180 m deep and equipped with double-U geothermal probes, and a 6 kW dry cooler simulating the thermal load of a representative house. The probes are instrumented with an optical fiber that enables temperature monitoring all along the boreholes through distributed temperature sensing (DTS) system.

The energy injection has begun in March 2010. Entirely automatized, it takes place with a constant flow of 56 l/min as soon as the temperature at the outlet of the solar panels exceeds 30°C. During the first year, no energy recovery was experimented, as the ground store needs to be heated up to reach a yearly quasi steady state (Nussbicker et al., 2005). As a first result, temperature pattern in the ground after three months of energy injection in probe B is shown on figure 1. The temperature in probe B appears to be 10°C higher than in witness probes A and C (filled with static water). Observations show that hardly 5% of the energy injected during the day is stored in the BTES, the major part being dissipated during the night. A detailed energy balance is being calculated. Relying on this analysis, best practices

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guidelines will be edited at the end of the project for a better design and optimum uses of system coupling BTES and solar panels.

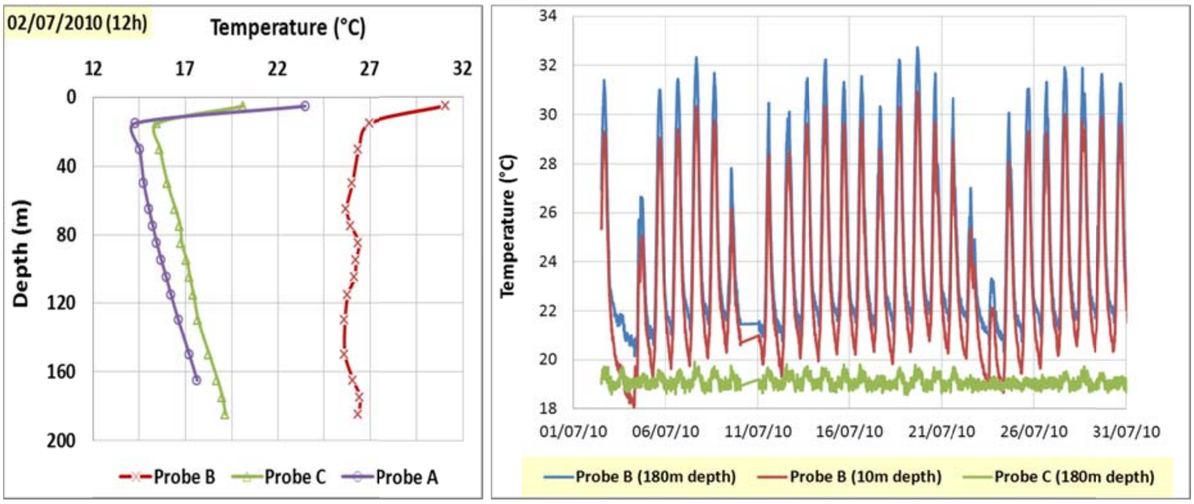

Figure 1: Temperature vertical distribution and temporal evolution in the schist rock after 3 months of solar thermal energy injection

For a better understanding of the thermal functioning of the system, different modeling efforts were performed. A detailed model of the double-U geothermal probe was developed under Comsol Multiphysics. It accounts for the heat transfers between the different materials involved in the exchange device (i.e. bedrock, sealing grout, polyethylene probe tube, heat transfer fluid, surface insulator). Validated against the experimental data collected during the distributed thermal response test, it shows that, due to the thermal resistivity of the sealing grout, the rock thermal conductivity plays a minor role in the heat transfers between the hot circulating water and the surrounding bedrock (Iris technologies, 2011). The development of a 3D-multilayer model is also in progress under the Finite Volumes hydrogeological code MARTHE. Simulating the system at a larger scale and pluri-annual periods of time, it will be used to explore different scenarios of energy storage/recovery cycles. Modeling results are expected to complete experimental data analysis in order to evaluate, and propose solutions to improve the efficiency of solar thermal energy storage in dry rock through boreholes.

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