Ground Heat Storage Systems: perspective in Mediterranean environment

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# Ground Heat Storage Systems: perspective in Mediterranean environments

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## 1. Introduction and state of the art

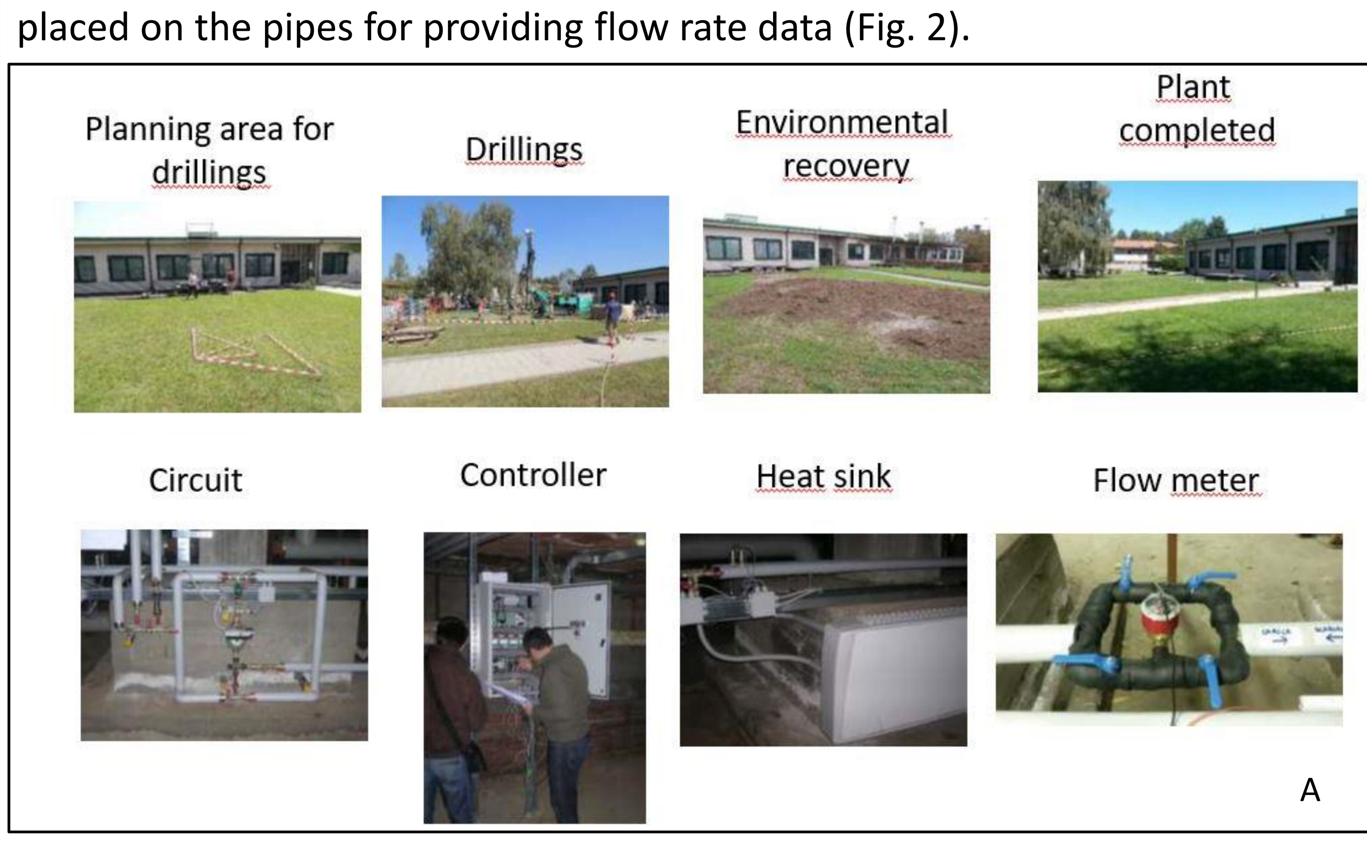
Geothermal energy is one of the more environmentally friendly energy source, continuously expanding between the renewable energies, and is expected to more than triple until 2050 (International Energy Agency, 2018). In particular, cooling down is catching on. As a result of populations and incomes growth the use of air conditioners is becoming increasingly common, especially in commercial buildings and high-density residences of the hottest world regions, like Mediterranean areas. A new frontier is covered by ground heat storage systems such as Underground Thermal Energy Storage (UTES). These systems contribute to a large-scale energy efficiency and a long-term storage of thermal energy, significantly reducing environmental impacts, increasing the potential uptake and recovering heat flows that are otherwise lost. They are commonly used in Northern Europe (e.g. Norway, The Netherlands, Germany, Sweden) and in Northern America (e.g. Canada). Focusing on Mediterranean Countries, cooling demand is especially higher than the heating one. It is usually covered through refrigeration systems such as vapor compression devices, which employs electrically driven compressors to transfer energy (Jakubcionis and Carlsson 2018). One of the objective of this project, is then to implement the current studies, such as monitoring thermal underground thermal behavior and modelling of potential UTES resources, transferring this model to other hydro-geological contexts as well. This could be possible by taking advantage of real cases like a field scale living lab, available nearby Torino (NW Italy), within unsaturated alluvial deposits.

## 2. Methods

A multidisciplinary approach should be followed. It comprises field and laboratory tests, as well as final numerical simulations. As a consequence of the field, laboratory and numerical simulations data, a living lab in Grugliasco (Torino, NW Italy) is available (Fig. 1). It is designed as a BTES (Borehole Thermal Energy Storage) technology (Fig.2; 3), to test the ability of the alluvial deposits of the North-Western Po Plain in collecting thermal energy, produced by solar panels (Fig. 3) with defined climatic conditions (Giordano et al., 2016).


**Figure 1. Geographical location of the BTES plant NW Torino (Italy), on the right. BTES plant configuration, on the left: red circles = inner probe; blue circles = outer probe; green circles = equipped with Pt100; pink circles = piezometer.**

A total of 20 RTD 4wire Pt100 (measurement range -50÷180°C, accuracy 5%) were placed every 5m down-hole in three of the four BHEs and in the monitoring hole (Fig. 2). In addition, 10 temperature sensors of the same type were placed throughout the circuit and on the thermal panels. An ultrasonic flow meter was placed on the pipes for providing flow rate data (Fig. 2).



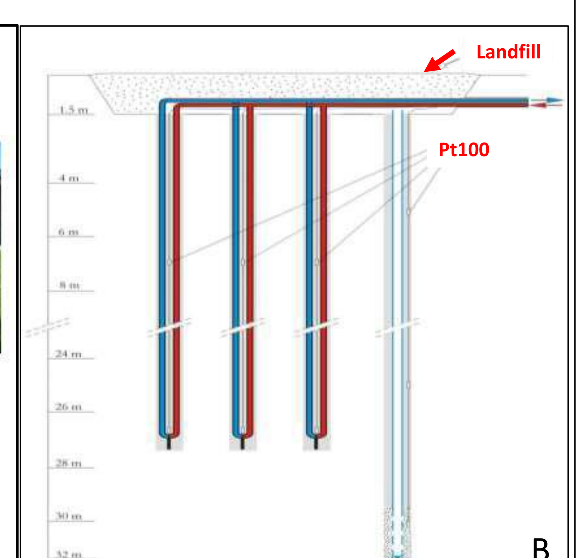
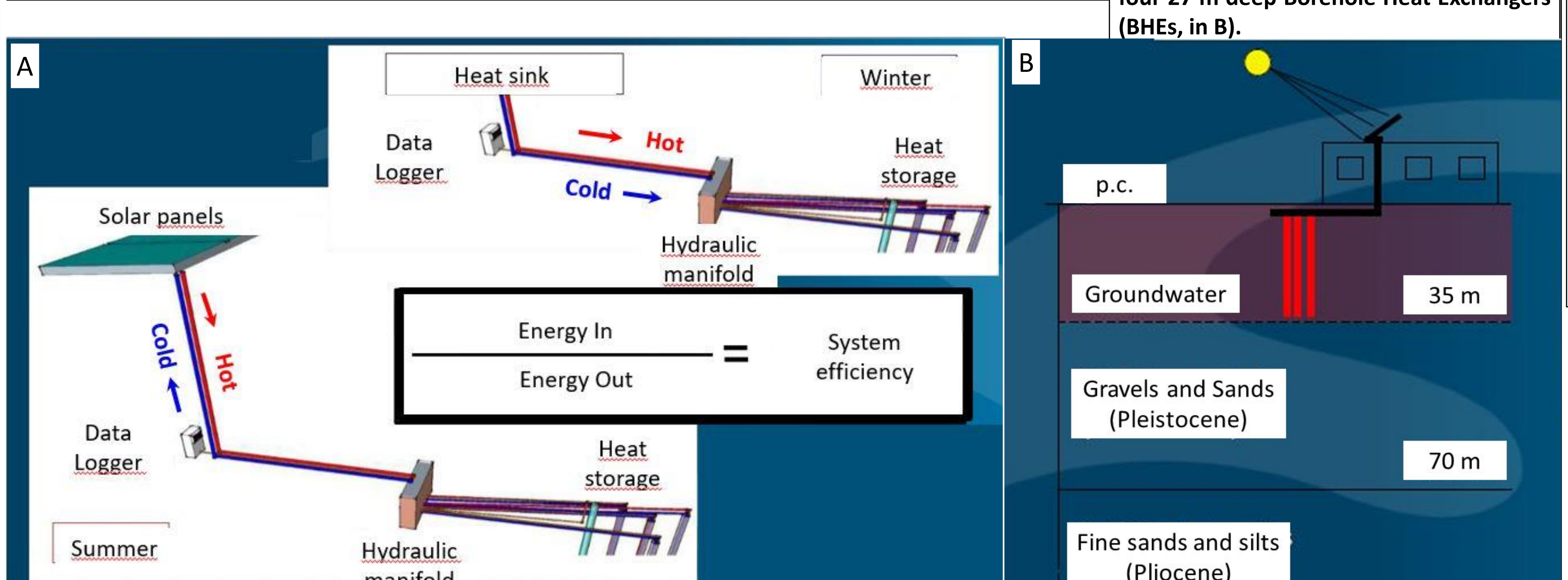




**Figure 2. Operational phases from drilling activity to the hydraulic circuit of the plant, and the employment of the remote control system (A). The system allows the storage of heat in the ground, through four 27 m deep Borehole Heat Exchangers (BHEs, in B).**



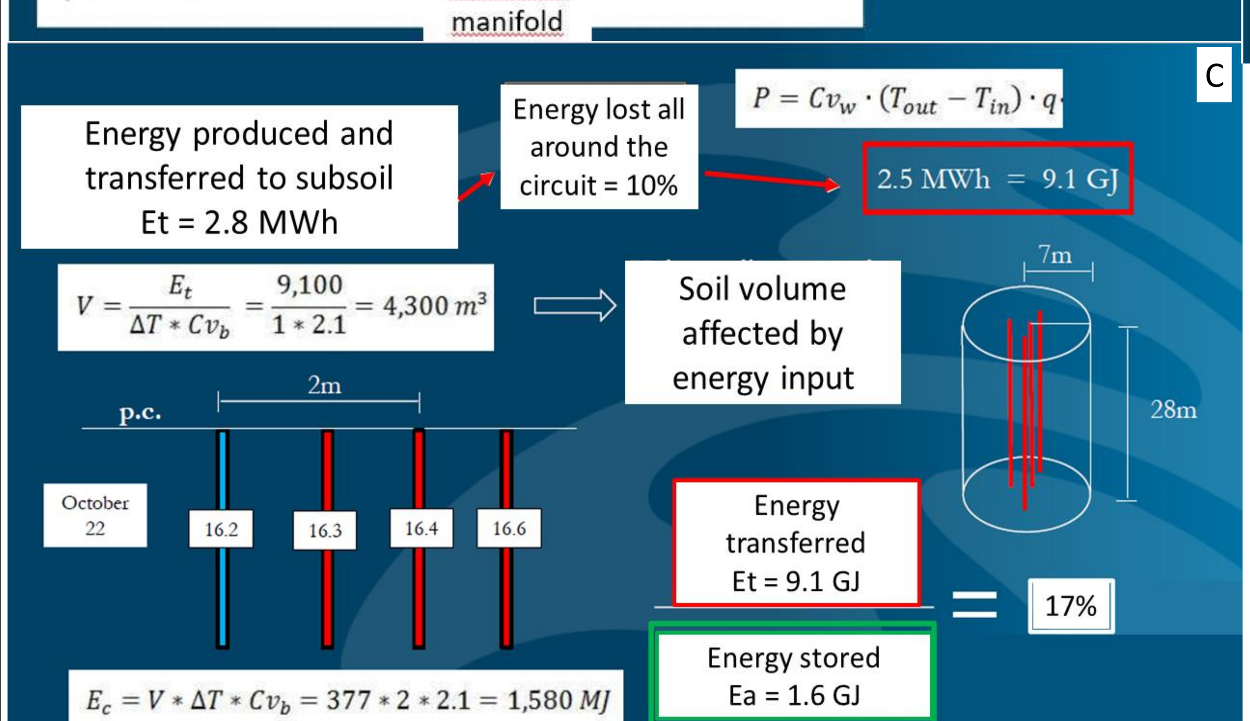




**Figure 3.**
**Plant functionality during Winter and Summer seasons (A) with a detailed perspective along Z-axis (B).**
**Energy transferred Vs. Energy stored balance (C)**

**The circuit is governed by a 59 W electric hydraulic pump, providing the carrier fluid circulation (flow rate of 210 l/h and a constant pressure of 2.2 bar). A management system is controlled at the Department of Earth Sciences, University of Torino.**

## 3. Results

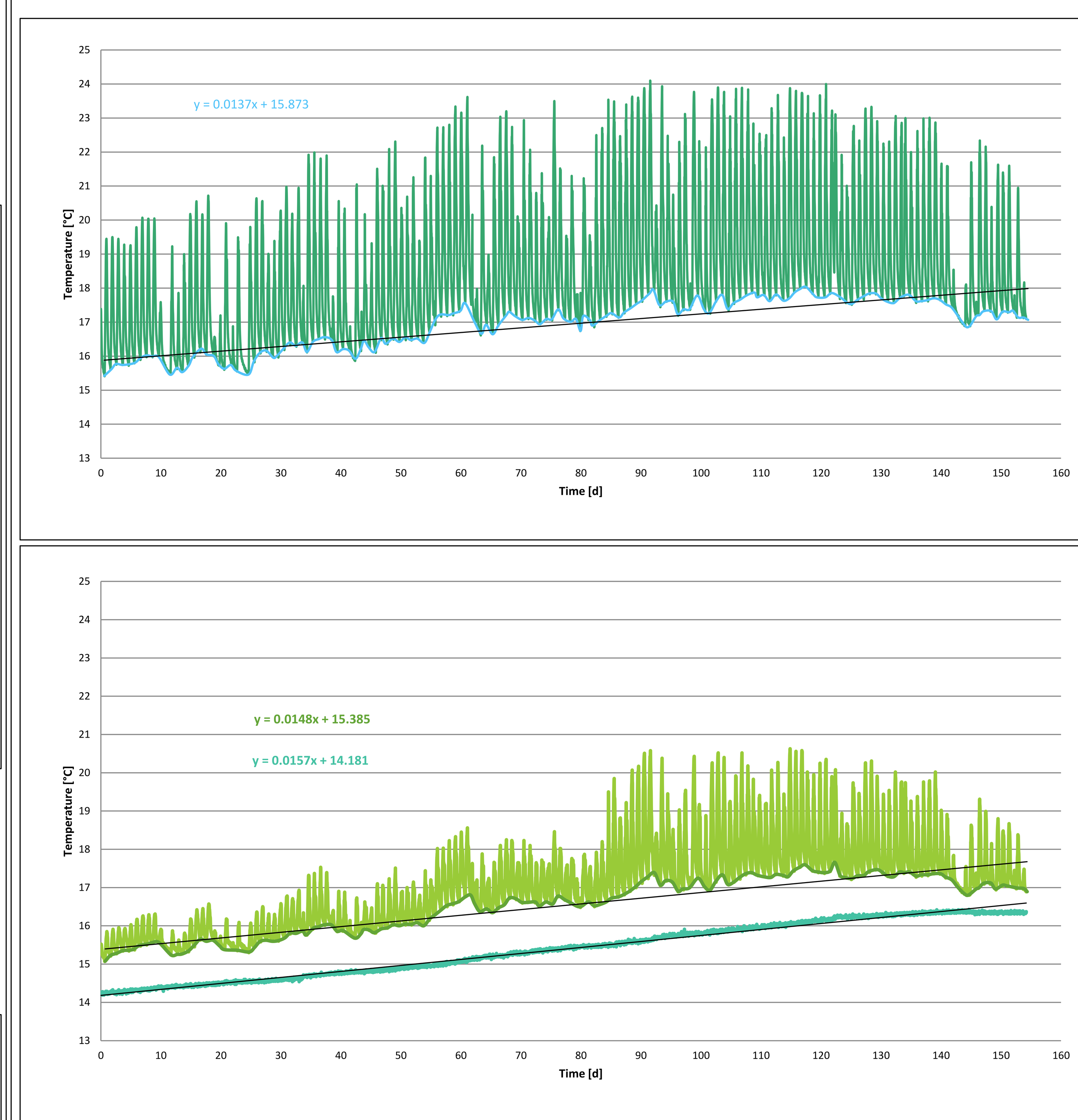



**Fig. 4**
**Registration period (April 8–October 20, corresponding to 160 days).**
**From Giordano et al., 2016.**

**Uppermost graph: temperature data (green line) from the central borehole with double U configuration (Fig.1).**
**The regression curve corresponds to the daily minimum (light blue line).**

**Lowermost graph: temperature data (light green line) from the external boreholes with a single U configuration (Fig.1).**
**Its regression curve referred to the daily minimum (dark green) ; temperature values (sea-green line) from the monitoring BHE (green circle in Fig.1), with its relative regression curve.**

**During the first part of the injection period the plant was set to provide the highest possible temperature to the working fluid. The system was therefore set to have a maximum flow rate of 80-90 l/h, which is approximately the 40% of the nominal rate of the pump**

**Reported temperatures record an increase of values for the considered period, sometimes influenced by the temperature of the carrier fluid as well as to the colder or warmer weather.**

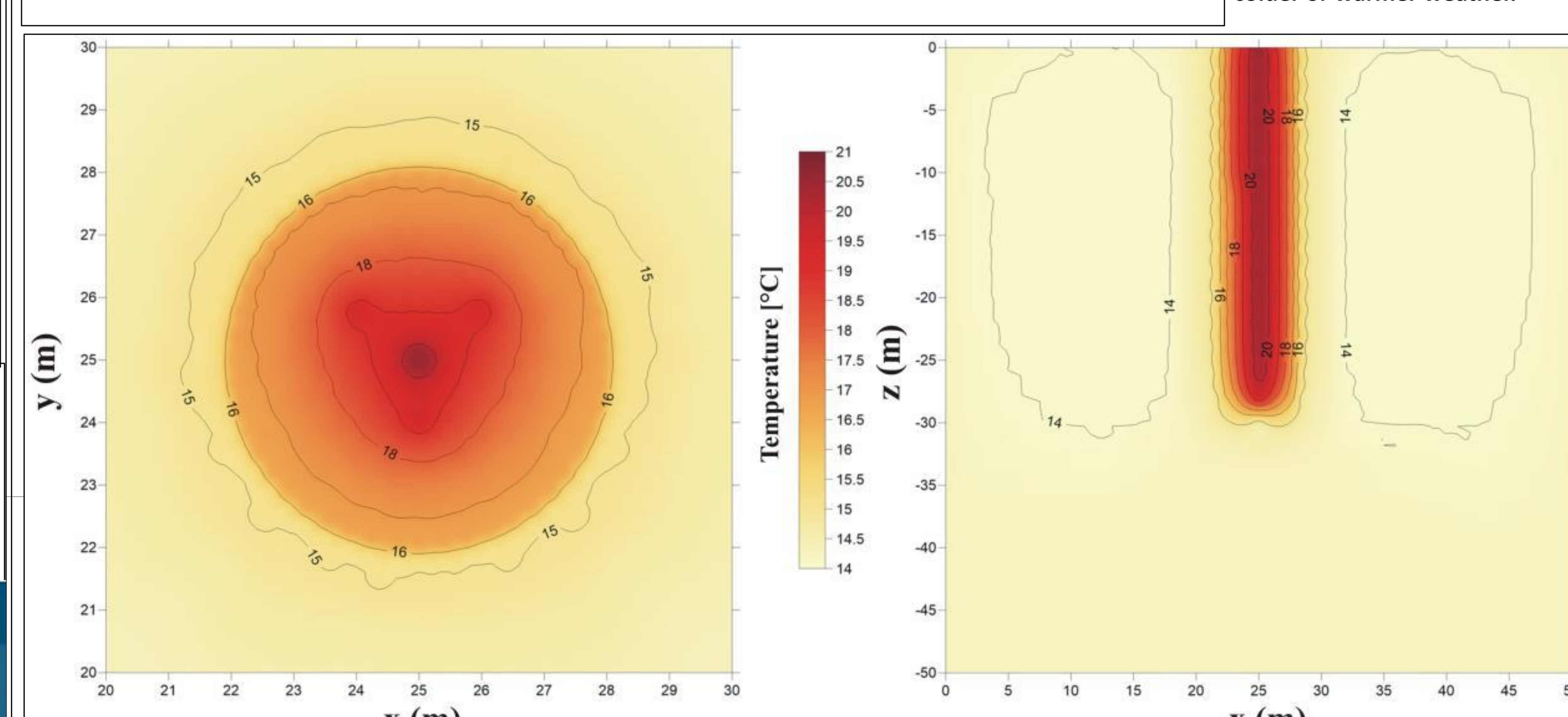



**Figure 5. Simulation results. On the right: X-Y axis plan view; On the let: X-Z axis view (From Giordano et al., 2016).**
**Numerical simulations were set in order to verify thermal behavior in the long time (5 years). It shows a negligible on the underground impact because of a charge/discharge cycle two times per year (heating and cooling modalities).**

## 4. Discussion and Conclusions

Realization of the BTES living lab here presented, derives from a detailed study conducted by our team (Giordano et al., and references therein). The plant functionality and hence the thermal behavior of the underground, are constantly monitored.
The future research on the Grugliasco plant will focus on the implementation of the BHE field and of the monitoring devices, as well as on the evaluation of the thermal plume around the BTES plant. Furthermore the interest to transfer this model to other hydrogeological contexts such as Mediterranean areas with different modalities (increase demand of cooling than heating), is one of the next steps we expect to obtain.

## Aknowledgements

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