Underground Thermal Energy Storage

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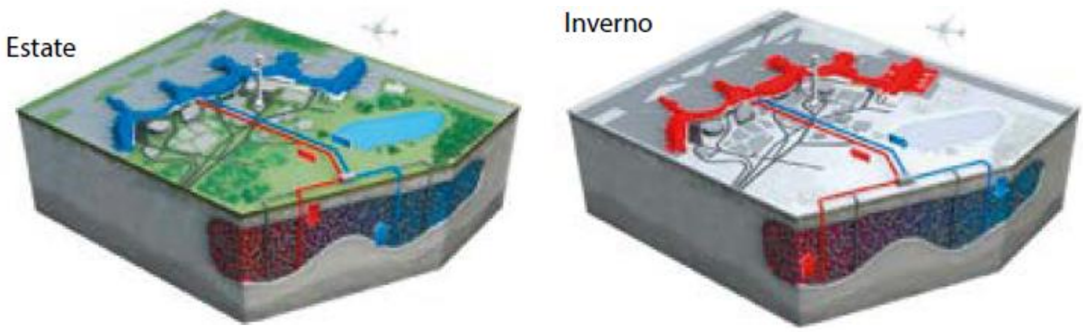
Underground thermal energy storage (UTES) uses the ground to store heat and cold. Depending on the geological, hydrogeological, and other sites conditions, aquifer TES (ATES), borehole TES (BTES), or cavern TES (CTES) is selected as storage system. Today ATES and BTES seem to be the most interesting, CTES is rarely applied.
BTES uses the underground itself as the storage material. Instead, in ATES systems, groundwater is used to carry in and out thermal energy from and to an aquifer, using water wells and in the solid mass around it. As the thermal conductivity of underground material is rather moderate, in a range of 1–5 W/m·K, heat losses can be kept low if the total volume is large enough to achieve a good surface-to-volume ratio. Size is important because the heat losses are proportional to the storage surface, while the storage capacity is proportional to the volume. The PhD research project will provide a comparison study between BTES and ATES systems, as seasonal and short time storage method, developing specific numerical analysis and a deep sensitivity evaluation considering a wide range of ground thermal properties and geological settings. Laboratory and field investigations are foreseen. A test site, where to carry out field tests, is also available at the headquarters of the CNR research area in Padua. The possible application range for electric power production and heating aims over single house to large-scale commercial buildings and district heating systems will be also simulated.

Geothermal energy is considered clean and renewable, and geothermal wells have been drilled and used for heat and electricity generation for many years. However, the economical extraction of geothermal energy has been mostly limited to countries and regions with high subsurface temperature gradients (e.g. areas with active volcanism and tectonic activity) and permeable aquifers. Conventional enhanced geothermal systems (EGS) require high rock porosity and permeability, sufficient fluid in place, and adequate fluid recharge, which are not always available. Moreover, the direct contact between fluid and rock through fractures might cause problems such as fluid contamination, surface gas emissions, and induced seismicity. To avoid these issues and to enable global scaling of geothermal energy generation, closed-loop geothermal systems (CLGS) were introduced. A CLGS well essentially works as an indirect heat exchanger, where the circulating fluid absorbs energy from the rock formation as it flows through the well, eliminating the reliance on fractures and the associated issues observed in EGS wells.



The project's overall aim is to analyse the potential of deep closed loop systems for heat underground storage by different deep-closed geothermal technological solutions.
Representative case studies will be selected considering geological, geophysical and environmental features to define the thermo-physical-mechanical and hydrogeological site conditions.
The amount of thermal energy that can be stored and made available on demand for the local community needs will be assessed by the numerical modelling of different deep closed loop solutions for selected case studies.

The project outcomes are expected to promote the energy transition towards renewables, boosting the sustainable use of geothermal energy in the circular economy and contributing to a substantial reduction of greenhouse gas emission. In fact, Geothermal energy (GTE), defined as the thermal energy stored in the earth, is considered a critical renewable energy source for the future, as c. 99 % of the earth's mass is hotter than 1000 °C allowing GTE to be tapped through environmentally friendly carbon-neutral energy conversion. Today's installed geothermal capacity accounts for less than 1% of global geothermal resource. Therefore, cost reduction and system performance improvement, together with a better understanding of the geological conditions in which these solutions can be applied, are key factors to stimulate the uptake of GTE at national, European and global level.

The project has the potential to give a substantial contribution to geothermal energy exploitation as renewable energy source. If successful, the approach promoted by the project will revolutionise the geothermal energy sector, by allowing a new 'geothermal anywhere' approach to exploit geothermal energy based on storing the heat coming from waste heat or solar sources, representing a preferential access to heat stored at different depths. The proposed approach will make geothermal heat more economically attractive with significant socio-economic benefits both in terms of access to the resource and as a preferential way to propose technological innovations.
The technological improvements proposed by the project will act as a driving factor to implement the leading role of Italian industries in the green economy sector, enhancing the number of job positions related to the geothermal sector.

A period of abroad experience for further study in the specific field of the PhD topic is planned in collaboration with experts from one or more international institutions, already cooperating with Prof. Galgaro and Dr. Di Sipio (i.e. Center For Renewable Energy Sources in Athens Greece, Universitat Politècnica de València Spain, Friedrich-Alexander-Universität in Erlangen-Nürnberg Germany, Eni SpA, Italy …).

The project will be financially supported by DOR funds of Prof. Galgaro and Dr.ssa Di Sipio and other funds from ongoing research collaborations (e.g.; GEOSTORE Project, ENI Project of Prof. Galgaro).