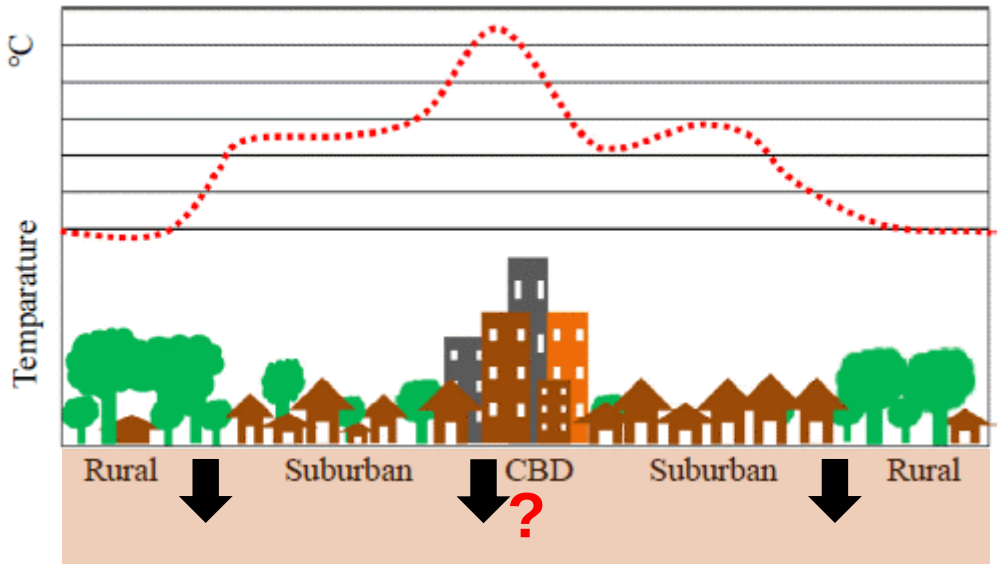
Subsurface urban heat islands and their geothermal energy potential

(Proposer: Dott.ssa Eloisa Di Sipio, Prof. Antonio Galgaro)

The European Union (EU) presented in 2018 a long-term strategy leading to a climate-neutral economy by 2050 in order to keep the global temperature increase below 2 °C. In this framework, a key role is played by the integration of alternative and renewable energy sources in city energy planning. In the heating and cooling sector, a considerable alternative to fossil fuel is the utilization of shallow geothermal energy (SGE). In fact, urbanization alters the land thermal properties, changes the energy budget at the ground surface, changes the surrounding atmospheric circulation characteristics, generates a great amount of anthropogenic waste heat, and leads to changes in the urban environmental system. The impacts of urbanization on the thermal environment are generally termed as Urban Heat Island (UHI) effects, whose consequences on the subsurface temperature (T) and environment are still poorly understood. Several studies proved that urban development can be expected to raise ground surface temperatures of the composite urban landscape by a noticeable amount (2–5 °C), because buildings, asphalt and concrete surfaces have higher mean annual surface T than grass and bare soil.

Groundwater, especially shallow groundwater, gains or loses heat from the ground surface, whose mean annual T is controlled both by climate change and by land use. On this regard, both long-term trends and seasonal cycles in surface air (SAT), subsurface (SST), ground surface (GST) and groundwater (GWT) temperature changes must be considered. As T fluctuations at Earth' surface diffuse downward, their amplitudes diminish exponentially with depth.
The induced large-scale thermal anomalies in the ground are called Subsurface Urban Heat Islands (SUHIs). Borehole T profiles reveal the accumulated energy by characteristic trends, where the urban heating induces a growing T towards the surface. The anomalous urban GST anomalies propagate both upward into the atmosphere and downward into the subsurface.



With the worldwide urbanization growing at an unprecedented pace, there is an urgent need to improve our understanding of the SUHI and its environmental, social, and economical consequences. As a result of the increasing interest in geothermal use, the extra heat stored in urban aquifers is considered an attractive thermal reservoir for space heating and cooling. Efficiently and sustainably extracting this large amount of energy will not only fulfill part of the energy demand in urban areas, but also play a positive role in slowing down urban warming, because of the reduction of greenhouse gas emissions. Several (S)UHI case studies in Germany, Switzerland and Japan are available. However, up to now, few extensive scientific researches have correlated the exploration of shallow

geothermal energy with SUHI. In Italy preliminary studies on this topic have been realized in few cities. A unique workflow for SGE sources exploitation is expected to be produced available for application in different locations as an added value for the transition to green, sustainable and circular energy

The overall aim of the "Subsurface urban heat islands and their geothermal energy potential" Project is to assess the geothermal energy potential at first in the underground of Padova urban area. Specific objectives are:

- to detect the urban thermal footprint on the ground by analyzing SAT, SST, GST and GWT records available in the metropolitan and rural area of Padova;
- to assess preliminarily the geothermal potential of the shallow urban ground, suggesting its exploitation by means of 'active' SGE solutions;
- to develop a multi-scale approach, where a first local assessment and planning of geothermal utilization is embedded in a district or even city-wide integrated energy management plan.

The thermal potential assessment is expected to provide a scientific basis for the development of application-oriented management tools on the city-scale and the city quarter scale of use for architects, city planners and stakeholders interested in acquiring initial site-specific information on the technical feasibility of SGE use in the context of city development.

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).

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