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Shallow geothermal potential of Cantone Ticino through map modeling

Rodolfo Perego (1), Sebastian Pera (1), and Marco Belliardi (2)

(1) Institute of Earth Sciences - SUPSI, Campus Trevano, CH-6952 Canobbio, (2) Institute for Applied Sustainability to the Built Environment - SUPSI, Campus Trevano, CH-6952 Canobbio

Low enthalpy geothermal energy is continuously growing in importance within Europe, since it is a reliable and efficient renewable energy, especially when exploited by closed-loop systems. Switzerland hosts one of the greatest density of low temperature geothermal systems in the world. Cantone Ticino includes more than 4000 probes, with an overall installed length of more than 500 km and the requests are continuously growing: the management of this technology must be therefore accurately faced both from a physical and political standpoint. The current authorization approach for closed-loop systems in Cantone Ticino, however, is mainly based on basic maps taking into account the presence of restrictions arising from the enforcement of the water protection act and ordinance. Closed-loop systems cannot be installed within S groundwater protection zones, and within the Au (usable groundwater) sector the installation of such systems is allowed in specific areas where the presence of conflicts precludes groundwater exploitation for drinking purposes. The described procedure, however, does not consider the subsurface potential nor the techno-economic constraints. More empirically based maps could instead give precious planning indications and they could also be useful, if properly verified, to perform pre-emptive estimates of technical and economic parameters. The procedure for the mapping of the geothermal potential started with the identification of the main parameters affecting it, such as the ground surface temperature (GST), thermal conductivity of both outcrops/unconsolidated material and heat flux/geothermal gradient. Maps for all of these parameters were created and some of them were compared with real measurement data, with satisfactory results. The estimated error for the ground temperature reconstruction was quantified in $\pm 1°C$, while the error of the hydraulic conductivity reconstruction was estimated as half of an order of magnitude. A reference set of thermal properties was then assigned to each lithological unit (both rocky and sedimentary) according to SIA 384/6 regulation and a thermal conductivity map (for outcrops and equivalent Quaternary deposits) was produced. 128 simulations with EED software varying λ, GST and heat flux were then performed in order to find a regression that could allow calculating for the whole region the total borehole length required to satisfy a hypothesized annual heat demand of 30 MWh/year. BHE length map was then verified against 967 real systems and the overall error was quantified in approximately 21% ($\pm$27m). Maps of technological, economical and market indexes were finally produced also with the help a newly developed economic tool. Geothermal potential maps were also compared with the current authorization map and the disparity was clearly observable: the areas where new closed loop systems are currently allowed often represent the ones with a lower geothermal potential. This means that a revision of the authorization process is necessary in order to have a more optimized management of this resource that could also take into account the natural, technological and economic constraints. In parallel, the verified maps proposed in this work proved to be a reliable instrument to pre-emptively perform semi-quantitative estimates for new GSHP systems.