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InGEO: GEOthermal resources and reserves potential assessment for the decarbonisation of power/thermal sectors

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Geothermal energy, as a renewable and green source for power generation and district heating and/or cooling, is available all year round, at all times of the day, and has great potential for development in any country. However, the exploitation of deep geothermal resources is only possible after detailed characterization of the potential reservoir. In fact, knowledge of the thermo-physical properties of the underground reservoir is crucial for generate a forecast estimation of the geothermal reservoir thermodynamic behavior, as well as for mining risk reduction and optimization of the sound design of geothermal energy production systems.

The InGEO project (*Innovation in GEOthermal resources and reserves potential assessment for the decarbonisation of power/thermal sectors*) aims to develop an innovative exploration workflow integrating geophysical data and other direct and indirect information, organized to make available a sort of decision support system of geothermal projects. It consists of the reconstruction of the crustal and subcrustal structures by joint analyses and interpretations of available and acquired geological and geophysical data (e.g., those provided by mechanical and thermal rock samples laboratory analyses, seismic and gravity anomalies), taking advantage of the different sensitivity that geophysical methods have on physical rock's parameters (temperature and composition). The results will be the input for the geothermal model that will quantify the deep geothermal resource potential of the area. The designed workflow will be tested in a case study area and partially calibrated with developed (hydrothermal) available data. The methodological approach proposed by InGEO is also expected to define the potential local use of geothermal systems by Deep Closed-loop Borehole Heat Exchangers (DBHE) for power generation, district heating and/or cooling. The InGEO results will contribute to the second mission of PNRR "MISSION 2: GREEN REVOLUTION AND ECOLOGICAL TRANSITION", by expanding the business planning of deep geothermal resource use in Italy.

The test area, chosen because it is considered particularly representative of the project topic and of potential reproducibility, includes the sector of the Northern Apennine buried structures, belonging to the Romagna and Ferrara Folds (RFF). The RFF area has been the target of previous

geothermal studies highlighting relatively low geothermal gradients within the deep carbonate units (on average 14 °C/km) and more significant thermal gradients (on average 53 °C/km) in the overlying impermeable formations [1-2]. This feature in temperature distribution with depth is clear evidence for fluid thermal convection occurring in the deep-seated carbonate units of Mesozoic age, which constitutes the local geothermal reservoir.

[1] Pasquale et al., 2013. Evidence for thermal convection in the deep carbonate aquifer of the eastern sector of the Po Plain Italy. *Tectonophysics*, 594, 1-12.

[2] Pasquale et al., 2014. Heat flow and geothermal resources in northern Italy. *Ren. Sust. Energy Rev.*, 36, 277-285.