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Parameter analysis for feasibility evaluation of shallow groundwater cooling of power plants

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This paper presents the first results of a finite difference-based numerical model, aiming to evaluate the potential of a new cooling concept that is based on the use of closed loop groundwater cooling integrated in a binary cycle. The new concept includes the seasonal combination of air cooling and shallow groundwater cooling and is part of the H2020 MATChING project. The proposed cooling system under investigation will be compared with dry type cooler condenser (e.g. air cooled condenser systems) and aims to reduce overall water withdrawal without compromising the energy efficiency of the system.

The pilot site for this evaluation is the geothermal Balmatt site in Mol-Dessel, Belgium. When operating at its full potential, this site could produce up to 27 MW of heat. To (partly) cool this heat, water from the permeable Miocene 'Diest formation' could be used in a closed loop, i.e. without consuming water. This aquifer is located at a depth of 35 to 151 m bgl, consists of glauconitic coarse sands and has an average permeability of 10 m/day. The water has a temperature of ca. 12°C. In the design under evaluation, this water will be heated up to a maximum of 22°C after passing through the condenser. During summer months, the water will be injected directly back into the aquifer, while in winter, additional cooling will be realised using an air cooler before injecting the water (at ca. 6 °C). By adding this extra cooling step, the lifetime of the system will increase significantly.

To cool the large amount of rejected heat, over 2000 m^3/h of water needs to be extracted from the aquifer, requiring the installation of several doublet systems. The feasibility of such an installation depends on several interdependent factors, such as temperature, pressure, well distance, distance between the doublets, permeability and natural flow conditions. Since no exact values of most of these factors are available, a large uncertainty exists for feasibility predictions. To assess the sensitivity of the system to variations of these key parameters and the interaction between them, possible combinations of these parameters are modelled and subsequently optimized.

To simulate the coupled subsurface fluid- and heat flow, the TOUGH2 numerical simulator was used. However, changing the parameter values by manually adapting the TOUGH input files and successfully running each file is time-consuming, tedious and likely to create errors. Therefore, we made use of the PyTOUGH library, which allows running TOUGH2 trough scripting. Using PyTOUGH, multiple parameters can be varied using a single script and post-processing, result-analysis and data visualisation can be automatized. This approach of batch simulation hence has significant advantages in all studies aiming to better understand the effects of parameter uncertainty on geothermal potential.

The preliminary results of this project show that the proposed concept is technically feasible and that the most influent parameters are the distance between the wells and the doublets as well as the permeability of the shallow aquifer.