GeoTHERM
expo & congress

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Oberflächennahe Geothermie

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Baden Arena Congress 2
Shallow geothermal energy

Modelling of the benefits of Curved Borehole Heat Exchangers

Modellierung der Vorteile von gekrümmten Erdwärmesonden

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Topic: benefits of curved borehole heat exchangers increased energy extraction, reduced: drilling space requirement and LCOH improvement. EED and FEFLOW.

The Canopus innovative directional steel shot drilling technology was originally developed for high rate of penetration low-cost cost directional drilling of deep geothermal wells. At the request of various customers in Europe it is now also being developed for the drilling of shallow curved Borehole Heat Exchangers (BHE's) coupled to ground-source heat pumps.

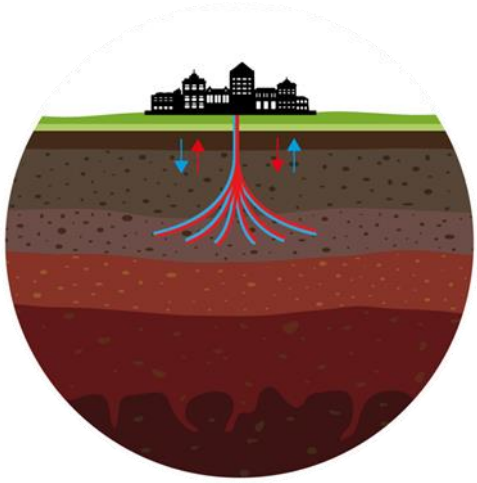

Figure 1: shallow geothermal wells drilled from one location

In this research, the performance of curved shallow BHE's was assessed theoretically in terms of energy output and economics. These curved BHE's have a small surface footprint because they can be drilled from one central location rather than several spots throughout a field. Also, earlier results and literature showcased higher rates of extraction per meter of BHE (W/m).

Simulations in Earth Energy Designer (EED) and FEFLOW have been carried out to validate the behaviour of the BHE's and in particular the thermal performance, comparing the design of Canopus curved wellbore to a traditional arrangement of vertical exchangers. Wellbore and ground temperature profiles were simulated during operations over a period of 25 years for a heating dominated case with BHE's of 1) a depth of 150 meter: case 1a with vertical BHE's with a length of 150 meter each and case 1b with curved BHE's with a length of 208 meter 2) two deeper cases with a depth of 500 meters: case 2a with a vertical BHE's and a length of 500 meter and case 2b with curved BHE's and a length of 694 meters. Lastly energy production and Levelized costs of Heat (LCOH) was calculated. The LCOH was calculated based on cost estimates provided by vendors and commonly accepted criteria about OPEX.

The results of this research were as follows:

- Curved BHE's are often more efficient thermally, i.e. for the same total drilled length and inlet fluid temperature limits. For instance, a relative energy output of 50 W/m was calculated for the first case, 1a compared to 90 W/m in the 1 b case. For the deeper cases the 105 W/m rate for the 2a case increased to 160 W/m in the 2b case. The increase in energy output can be explained through the increase of background temperature and the lack of interference between the BHEs for the curved cases.

- It was concluded that the LCOH declines from 0.28 Euro/kWh to 0.17 Euro/kWh from Case 1a to Case 2b (with curved wells with a total BHE length of 694 meter each). In practice it needs to be considered that the drilling costs of curved BHE's is higher so the reduction of the LCOH will not apply to every instance when curved BHE's are considered.

A successful modelling exercise has been conducted to understand the added value of curved wells in shallow geothermal BHE's, however a more thorough simulation is recommended tackling different types of Heating and Cooling demand profiles representative of the different European climates and users. Also, limitations of the tools used were identified in terms of ability to model curved wells as well as user-friendliness. It is proposed to do further research to validate the results and build more user-friendly modelling tools for curved BHE's.