Geophysical Research Abstracts
Vol. 21, EGU2019-5078, 2019
EGU General Assembly 2019

Modelling low-enthalpy deep geothermal reservoirs in the Cheshire Basin, UK as a future renewable energy source

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Geothermal energy is considered a potential replacement for fossil fuel due to the possibility of high energy yields, geographically wide-spread resources and the ability to deliver a constant, weather independent base load of heat. Deep, hydrothermal reservoirs reside at depths of over 1km across the UK, storing a total resource in excess of 327 EJ. This is enough energy to heat 75 million homes for 100 years (assuming 12000 kWh used per household per year). The resource is concentrated in low- to medium- enthalpy resources, with 20 % of this energy untapped in the Mesozoic Cheshire Basin, northwest England. Within the basin, the Permian Collyhurst formation retains favourable hydraulic and thermal properties at depth, and is being investigated for geothermal extraction within the central part of the basin (Crewe area, Cheshire East). A series of numerical simulations are undertaken to conduct a sensitivity analysis investigating both engineering and geological parameters with the aim of identifying the key parameters which are most influential in impacting the productivity in a single well development scheme.

The Collyhurst formation is an aeolian- to fluvial- sandstone body, modelled at a depth of 2.8 km, with a thickness of 700 m and an average formation temperature of ∼80 °C. High hydraulic conductivities have been recorded from outcrop studies (as high as 10 m/day). The finite-difference method is used to simulate heat and fluid fluxes, in both the reservoir and wellbore, in order to evaluate the longevity, energy potential and heat production of the resource under exploitation from a single well scheme. Key influential geological and engineering parameters are determined, concluding that the thermal gradient, hydraulic conductivity, production rate and the length of the well screen within the extraction bore are most significant to the viability of a single well scheme. Seasonal variations in consumption are also considered in the study, highlighting that natural recharge and reduced production rates in the low demand months helps to increase well longevity and maintain the geothermal resource.

The study highlights key geological and engineering risk factors when exploiting geothermal energy from hydrothermal reservoirs under a single well development scheme, such that these factors can be planned for or mitigated against when possible. The results can also be used as a guide for decision makers developing the Cheshire Basin, but also for other low- to medium- enthalpy single well geothermal schemes in sedimentary basins.