Evaluating the Geothermal Potential in Depleted Hydrocarbon Fields: A Case Study of Cambrian Reservoirs in Lithuania

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Abstract

Introduction and Objectives
Lithuania exhibits a geothermal anomaly in its southwestern region, attributed to Middle Proterozoic cratonic granitoid intrusions rich in radiogenic heat-producing elements such as Th, U, and K [1]. The sedimentary cover in western Lithuania features three hydrothermal complexes: Cambrian (140 m), Middle-Lower Devonian (400 m), and Upper-Middle Devonian (200 m) [2]. For many years Cambrian sandstone reservoirs have been extensively studied and exploited due to oil production. These reservoirs are now in decline with many wells running at 99% water-cut. The produced water shows temperatures varying between 75 and 90°C, presenting an opportunity to repurpose these wells for geothermal energy production.

The primary objectives of this work are to investigate Cambrian sandstone formation flow transport properties and to evaluate its potential use for geothermal energy production.

Procedure
A screening study has been conducted and some key Cambrian hydrocarbon reservoirs have been identified showing the largest geothermal energy potential. A modelling workflow is developed to evaluate the geothermal potential of screened hydrocarbon reservoirs through use of mini-mechanistic 3D models, with the help of finite- volume-based methods, ensuring accurate flow physics. Uncertainty analysis is carried out and a probabilistic modelling workflow is also developed to address the uncertainties in geological and dynamic parameters of the reservoirs and to assess their impacts on geothermal energy production. This study will serve as a benchmark study for assessing geothermal potential and sustainability not only in Lithuania but also in Latvia, Kaliningrad, and Poland, where Cambrian sandstone formation is widely spread.

Results
The results of this work show that out of all screened sites at least 5 sites have significant geothermal potential. The findings indicate that with a well spacing of 1300 m, it is feasible to produce heat at a rate of 3.74 GWh annually (power output of ~427kW). Furthermore, the results demonstrate the potential for achieving doublet injection and production rates reaching up to 800 m3/day for some of the reservoirs. The analysis underscores the significance of both water temperature and production rate in determining the geothermal potential of each site over a 50-year period.

Conclusions

This study highlights the pivotal role of current production availability and application of uncertainty modelling workflow in computing geothermal potential of the depleted hydrocarbon reservoirs. Based solely on that, 5 sites were selected from Lithuania's Cambrian reservoir complexes that have the biggest reported fluid production among all of its wells. Their average geological properties were compiled in 5 different doublet wells, computer models were then used to determine optimal well spacing of 1300 m. Each case provided different thermal output estimations over a 50-year period with water temperature and production rate being the determining factors.