The Impact Of Drilling Costs on Determining Optimal Well Depth for Geothermal Exploitation

Augustine, C., Thorsteinsson, H.H. and Tester, J.W.
Massachusetts Institute of Technology, 77 Massachusetts Avenue, Cambridge, MA, 02139, USA
Email: augie@mit.edu; hth@mit.edu; testerel@mit.edu

ABSTRACT

If we are to transition our global energy system and have geothermal energy play a significant role, it will be necessary to exploit the Engineered Geothermal Systems (EGS) resource on a large scale. To economically utilise low-grade geothermal energy for electricity generation from low gradient, conduction-dominated EGS resources, deep drilling will be required to depths of 6 km or more in most regions of the world. Even in mid- to high gradient regions where drilling depths will be less, drilling costs are still significant and inherently linked to reservoir productivity and reservoir temperature. Regardless of the fluid temperature or its enthalpy content, the lower the fluid productivity of the reservoir system per well, the greater the number of wells that are needed for a given energy production rate. Likewise, given the inherent limitations of thermodynamic conversion efficiencies, lower temperature reservoirs will require a greater number of wells for a given energy production rate. As well productivity or reservoir temperature decreases, individual well costs become increasingly important in terms of determining economic feasibility.

In general, higher reservoir temperatures are achieved with deeper wells. Higher geothermal fluid temperatures decrease per-kW-capacity surface plant costs. However, because drilling costs increase non-linearly with depth, a point is reached where the benefit of drilling deeper to reach higher reservoir temperatures is offset by the increased cost of drilling the wells. Our presentation reviews cost trends and limitations of conventional drilling and stimulation methods to identify a range of optimum drilling depths for developing an EGS resource. The sensitivity of optimum depth is explored as a function of resource parameters, including temperature gradient and well productivity. Our analysis illustrates that advanced technologies for drilling and reservoir stimulation are needed if we are to universally and economically utilise geothermal energy at levels that could make a difference in meeting national and international energy supply and environmental objectives.