A Balanced Solution for Mining Heat in Deep-Earth Engineered Geothermal Heat Extraction

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Abstract

Critical factors in the extraction of geothermal energy from a deep heat source by fluid flow are the surface area in contact with the fluid used to bring the heat to the surface and the rate of fluid flow through the natural or stimulated fracture network. An Enhanced Geothermal System (EGS) relies on the concept that the greater the surface area, the greater the quantity of heat that can be extracted and transported, and the longer the geothermal system can function before cooling by advective heat transport reduces the temperature of the resource rocks to a non-economic state. Closed-loop systems proposed for heat extraction from the subsurface reduce the exposed surface area to the smallest possible size, the outer surface of the pipe, thereby reducing the viability of these types of systems by the maximum amount possible. Also challenging to the concepts of EGS and closed loop systems is the physics that the rate of heat removal by advection exceeds the rate of heat conduction from the host rock to the pipes by orders of magnitude. Responses to the advection/conduction challenges include increasing the contact surface area and slowing the flow rate using a network of pipes extending from manifolds at the injection and production ends of the system. In concept multiple pipes would act as a large-aperture fracture network with flow control that would eliminate the channeling problem in EGS. However, comparing the scale of hundreds of natural and stimulated fractures in an EGS to the scale of tens of pipes suggests that the economics of a closed-loop system would be prohibitive. We propose a hybrid version using a novel fluid handling system developed by Fishbones. The system would have kilometer-long injection and production manifolds, the “Fishbone” system and a combination of stimulated and natural fractures for fluid paths between the manifolds. This system would provide a total flow volume sufficient for economic power generation and long- life heat extraction from the reservoir rocks.