A NUMERICAL SIMULATION STUDY OF THE PERFORMANCE OF ENHANCED GEOTHERMAL SYSTEMS

Steven J. Butler, Subir K. Sanyal and Ann Robertson-Tait
GeothermEx, Inc., 5221 Central Ave, Suite 201, Richmond, California 94804

Key Words:
EGS, numerical simulation, subcommercial permeability

ABSTRACT

This paper presents the results of a numerical simulation study of the performance of Enhanced Geothermal Systems (EGS), specifically, reservoirs with subcommercial permeability enhanced by hydraulic stimulation. The performance under consideration here is the net electrical power delivered as a function of time and the parameters in this exercise reflect conditions encountered at the Desert Peak EGS project in Nevada. Three well geometries are considered: (a) doublet (an injection and production well pair), (b) triplet (an injector flanked by a production well on each side), and (c) five-spot (an injector at the center and a production well at each corner of a square). The injector and producers communicate through a double-porosity reservoir with a thickness of 4,000 feet and at a temperature of 410°F. After enhancement by stimulation, the hydraulic characteristics of the reservoir are assumed to remain constant. The thickness of the stimulated zone was varied from 500 to 4,000 feet, and a range of fracture spacings (from 1 to 1,000 feet) and fracture permeabilities (from 1 to 100 millidarcy) following enhancement were considered. The spacing between the injector and producers was varied over a wide range. The injection water temperature was assumed to be 180°F, which is the temperature of the separated brine available from the existing Desert Peak power plant. The injection rate was dictated, through reservoir simulation, by the production rate assigned to the producers. Production wells were allowed a maximum drawdown of 500 psi
and the injection well was limited to a maximum pressure buildup of 1,000 psi. From the forecast of the production rate and temperature, the gross power available was calculated as a function of time from the First and Second Laws of Thermodynamics; from this, the net power available versus time was calculated for each scenario, after subtracting the parasitic power needed by injection and production pumps. For each combination of assumed geometry, injector-producer spacing, stimulated thickness, and enhancement level (fracture spacing and permeability), the net power generation capacity versus time ("net generation profile") was calculated. For each case, the mean and variance of the net generation over 30 years, net power produced per unit injection rate, and the fraction of the in-place heat energy recovered were estimated. The results indicate that power generation from an enhanced geothermal system, such as at Desert Peak, should be technically feasible under a variety of development scenarios.