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Synthetic Geothermal Reservoirs: Optimized Drilling Patterns for Cost-Effective Efficient Energy Recovery

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Abstract

Synthetic Geothermal Reservoir (“SGR”) is a technology to create a useful thermal energy storage system in any permeable sedimentary formation, regardless of the initial temperature of the formation. This can be valuable as a way to convert the growing amount of excess grid power (primarily from wind and solar) and/or solar thermal collectors into a fully dispatchable 24/7 geothermal reservoir that can be used for power generation or process heating or cooling. Numerical models of an SGR were created using different vertical wellbore configurations and then optimized to identify the best thermal and economic performance. The model includes a permeable and porous reservoir delimited by a caprock and bedrock as a seal with poor thermal conductive properties. The well configuration forms a geothermal battery considering hot wells and cold wells, where the source of the hot water comes from solar-heated water or excess local electricity supply. Most published studies to date have only modeled a 5-spot configuration. This study considers and compares other vertical configurations. First, a configuration of vertical wells (5-spot) model was designed as a pilot to evaluate well distance, flow balance, charging/discharging schedule, and pressure limits. Then, the drilling and completion cost is evaluated to compare the energy cumulated by the type of the wellbore model. This study analyzes and develops a workflow to generate sensitivity analysis and optimize energy storage geo-systems with vertical wells in different patterns by analyzing the influence of well configurations, reservoir properties, and well distance on the reservoir's heat recovery and pressure/temperature behavior. Some North Dakota, Wyoming, and Colorado locations have the reservoir conditions to store energy. The relation between the energy injected to heat and the energy produced from the reservoir is also evaluated. In each cycle, the temperature of the reservoir increases, affecting the storage efficiency. The well distance configuration was analyzed. Sensitivity analysis was also conducted using the recovery factor, heat extraction factor, and Net Present Value (NPV) to understand each pattern.