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# Optimizing Wellbore Trajectories for Closed Loop Geothermal Operations

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## Abstract

One emerging application in geothermal energy is that of closed-loop systems, where two laterals are intersected so that a working fluid can be pumped down one wellhead and up another. These solutions are attractive because they do not rely on the natural permeability of a formation or a reservoir of heated water already in place, they simply require a high enough downhole temperature. While a great deal of discussion exists on wellbore intersection, most applications are by their nature heavily constrained by tight geologic requirements (e.g. coal-bed methane) or have one wellbore trajectory rigidly defined (e.g. relief well drilling). These intersection operations require extensive use of specialized ranging technologies and control drilling at the intersection point which can be time-consuming. Closed-loop geothermal presents a unique opportunity, with relatively few constraints to satisfy (e.g. target depth, lateral length). This study uses this freedom in trajectory design and quantifies the extent that various wellbore positioning techniques can increase the probability of intersection while minimizing the need for ranging workflows.

A baseline scenario is described, with wells originating from differing pad locations, drilling with standard practices and active magnetic ranging. Using Monte Carlo techniques, the probability of successful intercept is evaluated for alternate trajectory combinations and compared to the baseline. These include well pairs originating from the same pad and pairs from differing pad locations. Major factors contributing to relative survey errors are identified and the impact of uncertainty reducing techniques are explored for each trajectory type. Techniques include survey corrections, variation of the trajectory profiles, incidence angle at intersection, and the use of alternative solutions to control relative vertical uncertainty. For each scenario, the probability of intercept was evaluated for cases without using ranging tools and for both passive and active ranging technologies. A cost-benefit comparison is conducted, and an optimal combination of factors is identified.

For the baseline scenario, low probabilities of collision imply that extensive use of ranging is required for a successful operation. Positional uncertainty reduction techniques and multiple target intervals can greatly increase the collision probability and reduce the need for ranging. Of importance to increasing the probability of successful interception are techniques that maximize the uncertainty reduction along a single axis (e.g. the vertical plane). This enables a "sweep" across the other plane to achieve intersection. Value provided by additional uncertainty reduction techniques depends on the assumed costs of drilling additional footage, performing ranging operations, and rig spread rate.

The application of sophisticated wellbore positioning techniques at scale to the closed-loop geothermal problem has not been previously explored. The relatively low number of constraints compared to traditional wellbore intersections enables strategies not otherwise available for successful project construction.