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Competition and Synergy of Different Technologies in the Subsurface: A Case Study for CCS vs. Geothermal Energy Production

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Global climate change, shortage of resources and the resulting turn towards renewable sources of energy lead to a growing demand for the utilization of subsurface systems. Among these competing uses are Carbon Capture and Storage (CCS), geothermal energy, nuclear waste disposal, “renewable” methane or hydrogen storage as well as the ongoing production of fossil resources like oil, gas, and coal. The different uses of the subsurface can result in competition for the limited subsurface space, but in some cases there may also be synergetic effects, if the technologies are combined in a clever way. The idea behind this case study is to investigate the effects of a CCS site on a geothermal power plant operated in its vicinity and present both positive and negative impacts.

During CCS operations large quantities of carbon dioxide (CO_2) are injected into a storage formation. This causes a pressure increase as the brine in the formation is displaced by CO_2. These elevations in pressure can have an extent of several tens of kilometers from the injection well in contrast to the much smaller extent of the CO_2 plume. If geothermal power plants operate in the range influenced by pressure evaluation, this may have an impact on their performance. For example:

Increased discharge of “warm” brine could be favorable for geothermal power plants as the time until thermal depletion of the reservoir may also increase

Early breakthrough of the cold water front between an injection and an extraction well due to a brine discharge “pushing” the cold water front towards the extraction well may lead to a decrease in performance of the power plant

Of course, there is a huge number of possible hydrogeological settings and technical configurations for geothermal power production that may be combined to an even larger number of possible scenarios. In this work however we use a simple model setup in which we incorporate and vary the parameters that we think are crucial.

Only porous (not fractured) aquifer systems are considered here with a geothermal doublet system (cold water injection and warm water withdrawal). The CCS operation is assumed to take place in the same layer as the geothermal power/heat generation.

The CO_2 injection itself is not simulated, instead the brine discharge is implemented by an increase of pressure at one side of the domain with respect to the initial conditions. The discharge is varied by changing the pressure at the boundary within a range plausible for CCS operations.

Different configurations of the extraction and injection wells of the doublet system with respect to a CCS operation are tested and compared to a reference system without the effect of increased brine discharge.

With this work we want to explore the relevance of possible positive or negative impacts of a CCS operation on the performance of a geothermal power plant.