Freitag, 27. Februar 2026, 13.00 Uhr
Ortenauhalle Kongress 1
Tiefe Geothermie

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Ortenauhalle Congress 1
Deep geothermal energy

Progressive planning and management of the exploration of deep greenfield hydrothermal reservoirs

Progressive Planung und Management der Erforschung tiefer hydrothermaler Greenfield-Reservoirs

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The realisation of deep geothermal projects is extremely difficult due to uncertainties in reservoir characterisation, challenges in drilling operations and the complexity of defining stress fields caused by abundant faults and fractures, leaving the significant potential for carbon-free energy mostly untapped. These issues are particularly critical during the planning stages of greenfield developments, such as potential definition, well design and placement, reservoir performance prediction, environmental compliance and concession acquisition. Although not all information is available, a step-by-step, agile project management approach using all physical and numerical modelling possibilities, in addition to systematic data acquisition, is required (Geopfalz, 2025).

A good example of such a project development is actually being carried out for multilateral well development of a selected location in Upper Rhine Graben (URG) (Geopfalz, 2025). The project has been divided into various subtopics such as geomechanics, well planning, reservoir-location definition and characterization, reservoir modelling as well as geochemistry especially of the near wellbore zone starting with an extensive literature and available material (cores, outcrops) survey.

Geological settings associated with intense tectonic activity such as extensional domains and plate boundaries may provide favorable flow pathways for brine migration and convective circulation. However, the high density and uncertain distribution of faults and fractures introduce a significant risk in drilling operations and furtherly reservoir management, as geomechanical equilibrium is disturbed by the reinjection of cold water following hot brine production and utilization. This project addresses these uncertainties with a focus on identifying productive and stable reservoir intervals within the URG. Specifically, it explores methodologies of simulation to predict and enhance the commercial viability and performance of sedimentary formations such as the Buntsandstein and Muschelkalk. The objective of this location-based numerical assessment is to run through various scenarios using the available data that are semi-real (literature data). These simulations will be re-adjusted later as the project progresses, and more realistic data becomes available. This pro-active progressive methodology enables preliminary predictions to be made about the behavior of the reservoir under various conditions, in line with regulatory requirements. This is also important for supporting decisions made during the planning, drilling and completion of multilateral wells. A parallel study is conducted to estimate the geomechanical parameters of the outcrop cores that are representative for the targeted geology using biaxial and triaxial stress tests.

For enabling a faster-early decision-making on the design and planning of the drilling activities following information and parameters are determined using analytical and/or numerical simulations as possible ranges based on available row data:

- Minimum flow rates, minimum temperatures and expected performance of the reservoir, as well as the required minimum length of the lateral wells, depending on permeability and diameter.
- Junction type and the position of the various Technology Advancement for Multi-Laterals (TAML) configurations.
- Well (lateral) diameter as a function of types of completion, the desired flow rate and flow scenarios, as well as associated pressure losses.
- Assessment of the economic potential of multilateral wells.
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Preliminary numerical reservoir simulation studies are performed using generic models in the first stage based on data available from the similar studies as well as results of the petrophysical tests up to date. This reservoir modelling is coupled first with the wellbore model created with the corresponding module (COFLOW) of the commercial reservoir simulator CMG GEM (CMG, 2025). In a second step, the coupling with reactive module allows modelling of the geochemical interactions especially in the near wellbore region. Some of the outputs of the study are e.g.:

- Creating graphics showing possible lateral distances to minimize interaction between them.
- Prediction and optimization of the reservoir energy production depending on various data sets and cooling-injection management strategies.
- The PVT behavior of thermal water in the near-wellbore area (single-phase and/or two-phase), and the resulting scale formation, including that in the completion.

Clearly, the data sets and information available for any numerical study are quite limited at the beginning due to a lack of operational and exploratory experience in greenfields. The issue of balancing the need for timely progress with data limitations can be addressed by applying various statistical approaches using analogue and preliminary data. In the study, geometry, porosity, permeability, specific heat capacity, and thermal conductivity are considered as the critical parameters for the reservoir modelling. For the base case these parameters are selected according to the results of previous projects such as Landau in der Pfalz, Bruchsal, and Insheim (Frey et.al, 2022). Moreover, a detailed literature survey from reservoir and geology definition studies are carried out. The minimum and maximum values of the parameters are selected based on research and industrial projects conducted in the region. To capture an experimental reservoir simulation for variety of numeric combinations of these parameters, Monte-Carlo simulation method is designed and coupled to the integrated reservoir and wellbore simulator using CMOST module of the selected simulator. At this point a complementary parametrization is needed for the operational constraints. However, since unalterable reservoir deliverability parameter permeability is stated as an uncertain parameter, the operational successors such as drawdown and tubing diameter are considered to understand their relationship between permeability. This approach provides flexibility in engineering decisions in planning phase and reservoir data verification phase (drilling/logging/well testing) by creating the mathematical relationship between permeability, drawdown and flow rate.

Uncertainty studies were conducted using above discussed approach to estimate the production-energy rates as function of realization probabilities also accounting the effect of various parameters on these selected objective functions. Figure 1 discusses the impact of investigated reservoir and operational parameters on the energy rate which can be used as a determining objective function on project economics as an example.

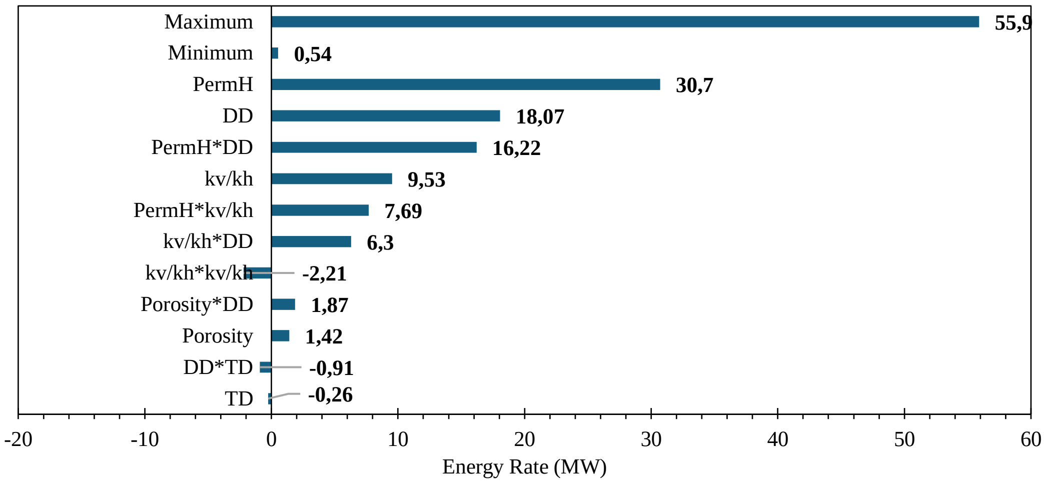

Figure 1: Tornado plot of Monte Carlo Simulation shows impact of independent variables on energy rate.

From a geochemical perspective, the availability of rock mineral data and fluid composition data is crucial for understanding geochemical processes, particularly those occurring in the near-wellbore region. The URG literature provides several open-source datasets on fluid composition collected from projects in Germany and France. However, applying these datasets to a new location may require adjustments due to site-specific alterations. To conduct risk assessments such as evaluating corrosion rates in production wellbores and petrophysical changes around the near-wellbore zone, coupled numerical geochemical simulations are performed. These projections are being developed using best- and worst-case scenarios based on existing rock and fluid data from completed projects.

These simulations are to be re-adjusted progressively with the project as more realistic data becomes available from the greenfield. However, even at this stage, these initial steps enable preliminary predictions about the behavior of the reservoir under various conditions and production scenarios, in line with regulatory requirements also allowing economic perspectives. These steps based on physical and numerical modelling studies are also a part of the risk reduction and mitigation efforts and with this a very valuable part of the planning and management of the greenfields included the exploration of the deep hydrothermal reservoirs.