Research on geothermal electricity generation – On-site laboratory at Groß Schönebeck

Dr. Ernst Huenges
Helmholtz Centre Potsdam/German Research Centre for Geosciences
huenges@gfz-potsdam.de

In Germany, geothermal heat can be provided from deeper reservoirs from depths of 400 m or more (deep geothermal energy) for large-scale heat grids and for electricity generation – combinations are also possible.

The technologies for use in deep geothermal energy generally require at least one production borehole and one reinjection borehole, which access water with sufficient temperature from a deep geothermal reservoir as required. The thermal water circuit is closed above ground, the energy is generally transferred to the respective consumer via a heat exchanger, and the cooled water is returned to the reservoir via the reinjection borehole (*Figure 1*).

The geothermal resources available in Germany consist of deep hot water (hydrothermal systems) to a lesser extent, and to a far greater extent of thermal energy stored in plutonic rock (petrothermal systems).

Hydrothermal systems are deep strata which carry water (aquifers) with sufficient natural hydraulic conductivity (permeability). In addition to the temperature of the aquifer, the key for economic operation of hydrothermal systems is the pump rate which can be achieved. For reasons of economy, hot water production of at least 100 m³/h is often required. While a specific temperature can always be reached at a corresponding depth, the second condition considerably restricts the number of possible locations.

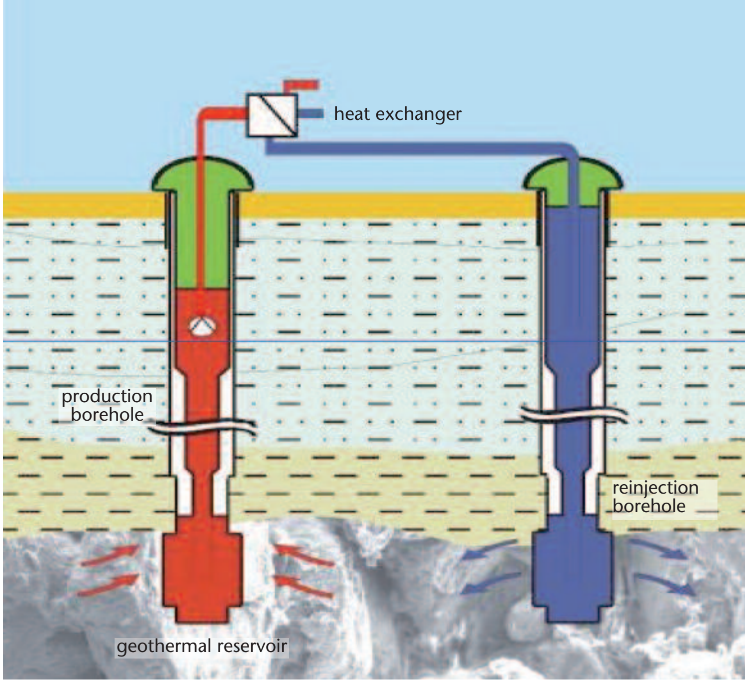

Figure 1
Accessing a geothermal reservoir

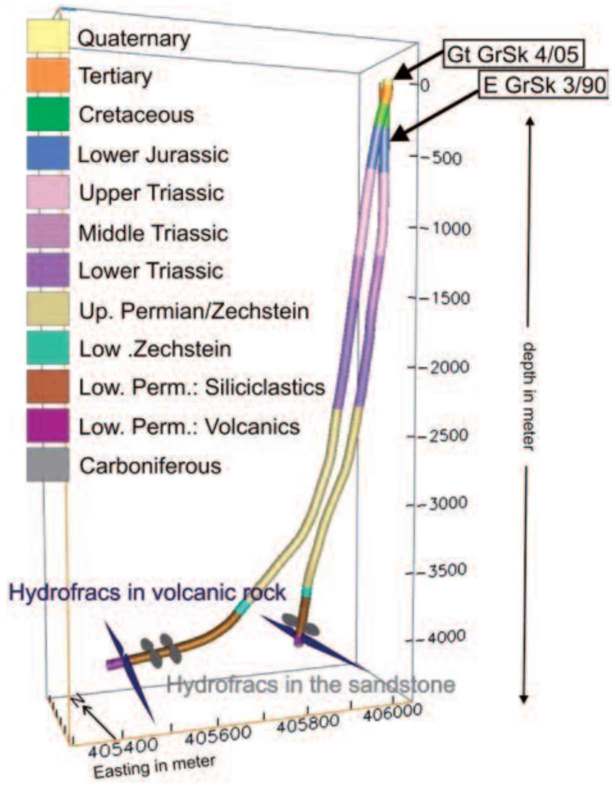

Figure 2
EGS project in Groß Schönebeck with the route of both boreholes and crack systems created in the storage area

Accessing these hot aquifers primarily involves a discovery risk. While the reservoir depth and temperature can be predicted relatively precisely, the main risk is insufficient aquifer permeability and thus insufficient thermal water production.

In petrothermal systems, geothermal energy is collected from plutonic rock strata irrespective of the hydraulic properties of the geothermal conductor. While the temperature distribution in the earth's crust is prescribed by nature, petrothermal systems can improve the flow conditions to the borehole via engineering processing with engineered geothermal systems (EGS) technologies. Figure 2 shows the result of such a treatment based on the example of the on-site geothermal laboratory in Groß Schönebeck. In special cases, such treatments can be used to generate an artificial heat exchanger underground, from which the deep geothermal energy is withdrawn with surface water. In this way, petrothermal systems can increase the economy of geothermal energy generation. For example, the hydraulic fracturing or acid treatment methods can artificially increase the hydraulic conductivity even in low permeability rock. In Germany, approx. 95% of the geothermal potential can only be accessed using this technology. All system components required for this are available, but only a few projects have implemented this technology to access a deep geothermal heat source.

Access to deep geothermal energy via boreholes and the subsequent provision of energy are largely dependent on two conditions: First of all, the temperature should significantly exceed 40 °C for heating or 100 °C for electricity generation.

On the other hand, a sufficient flow rate per borehole or pair of boreholes must be attainable.

These and other basic conditions generally cannot be proven until the project development is already underway, which means that a series of decisions must be made on the way to geothermal energy provision. Much research is still needed. The need for research for the corresponding project phases is shown by the fields with green backgrounds.

Systems for supplying heat to many or large-scale consumers, e.g. for feeding into large-scale heating grids of up to 40 MW (commerce, apartment buildings), use deep geothermal energy from boreholes approx. 2-3 km deep and feed the thermal energy into heating grids. In Germany, they currently have a total capacity of approx. 150 MW and a broader market introduction is imminent. The expansion of low-temperature heating grids would significantly expedite the market launch. Compared to smaller systems with shallow geothermal energy, these systems are more suitable for dense development.

To generate electricity, hot water is pumped from boreholes at depths of up to 4-5 km. In general, subterranean engineering work on the geothermal reservoir is required in Germany to achieve the flow rate required for economic use. Above ground, the thermal energy of the pumped hot water is converted to electricity via secondary circuits (ORC or Kalina). The first systems of this type connected to the grid in Germany, with roughly 7 MW of installed electric capacity, prove the fundamental feasibility of this type of electricity generation.