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Geothermal application in low-enthalpy regions

Hubert Quick [a], Joachim Michael [a], Ulvi Arslan [b], Heiko Huber [b,*]

[a] Ingenieure und Geologen GmbH, Darmstadt, Munich, Abu Dhabi, Germany
[b] Technische Universität Darmstadt, Germany

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ABSTRACT

The development of geothermal energy application as a part of Germany's renewable energy portfolio is a multidimensional process with fast growing improvements. In this paper basic information on geothermal application in low-enthalpy regions, such as Germany and Abu Dhabi are given.

1. Introduction

Germany has high energy demand compared to other countries as displayed without any quantities in the infrared picture made from space in Fig. 1. Therefore, and with increasing concerns of global warming, green energy sources are becoming more important for Germany as well as for all countries in the world. The development of geothermal energy application as a part of Germany's renewable energy portfolio is a multidimensional process with fast growing improvements. One part of these improvements is the process of development of geothermal power plants in low-enthalpy regions. Other parts are current geothermal research projects at German universities.

Almost every geothermal power plant is located in high-enthalpy reservoirs, so called geothermal hot spots. These high-enthalpy hot spots do mainly correspond with the Ring of Fire, a zone of frequent earthquakes and volcanic eruptions that encircles the basin of the Pacific Ocean (Fig. 1). In Germany, Abu Dhabi and the most countries in the world, too, no high-enthalpy reservoirs with excellent geothermal conditions are given. Nevertheless different geothermal binary power plant projects were raised in Germany's low-enthalpy regions till 2010. For detailed information see [1].

To use the given low-enthalpy potential in Germany geothermal power has to be generated efficiently.

Therefore inventions and improvements for binary power plants need to be performed. The energy yield and the efficiency of all plant components of binary power plants need to be increased, modelling tools for the dimensioning of heat transport processes have to be improved.

To understand the development of geothermal inventions and improvements different examples of German geothermal pilot power plants in low-enthalpy regions as well as current research projects are described in the following.

2. Geothermal basics

Geothermal energy is energy stored below earth's surface. The word geothermal is derived from the Greek words geo (earth) and thermos (heat), and combining these two meanings yields "earth heat". Although geothermal energy is one of the youngest types of an economic use of renewable energy, it is certainly auspicious. While other renewable energy sources depend on the sun, geothermal energy originates in the earth's interior. This underground heat generation is caused mostly by the radioactive decay of persistent isotopes. On average, the temperature increases 0.03 C m^{-1} of depth which is called the geothermal gradient. Therefore, 99 percent of Earth is hotter than 1000 °C, while 99 percent of the remaining 1 percent is even hotter than 100 °C. At depths of about 1 km, temperatures of 35–40 °C can be achieved. In areas of geological anomalies, such as rifts or fault zones, geothermal gradients of about 0.06 C m^{-1}can be found, which allows economically viable use of deep geothermal systems with binary power plants. For detailed geothermal basics see [2].

To use the given low-enthalpy potential and generate geothermal power efficiently in all geothermal regions of interest, such as regions with geological anomaly zones as well as regions of average geological conditions without anomaly zones experiences have to be gathered. A map of Germany displaying the geothermal regions of interest is given in Fig. 2. After all there are three different geothermal regions of interest in Germany. The Bavarian Molasse Basin is located in the south of Bavaria in the south-east of

* Corresponding author.
E-mail address: huber@iwmb.tu-darmstadt.de (H. Huber).

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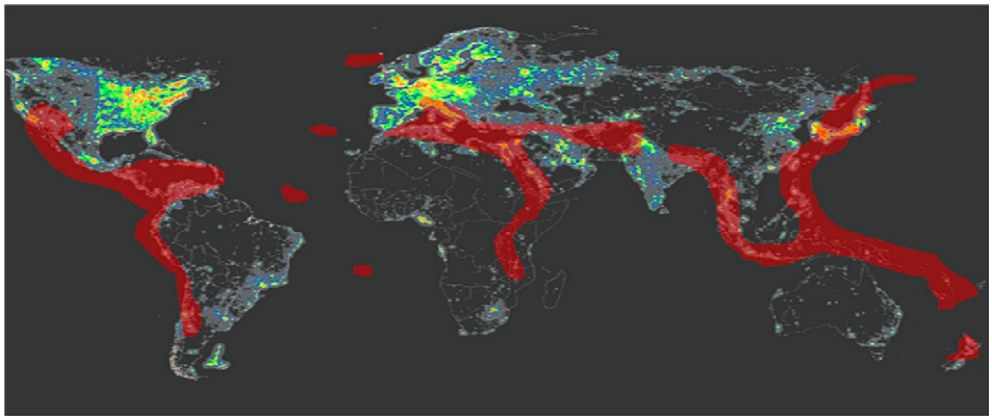

Fig. 1. Ring of fire.

Germany. The second geothermal region of interest is the Upper Rhine Rift, which is located in the south-west of Germany. The largest geothermal region of interest in Germany is the Northern-German Sedimentary Basin, being located in the north of Germany, as displayed in Fig. 2.

These three geothermal regions of interest in Germany are varying in their extension, geological and hydro-geological conditions and their theoretical geothermal potential, which is depending on geological and hydro geological conditions. An overview of the extensions and the theoretical geothermal potential of the three geothermal regions of interest in Germany is given in Table 1.

Table 1
Geothermal regions of interest in Germany.

Geothermal region of interest	Extension [km^2]	Theoretical geothermal potential [EJ]
Bavarian Molasse Basin	20,000	88
Upper Rhine Rift	5000	60
Northern-German Sedimentary Basin	100,000	50

The best ratio of theoretical geothermal potential per extension is given in the Upper Rhine Rift.

3. Deep geothermal pilot projects and current research

3.1. Deep geothermal pilot projects

In all of these three different regions of interest low-enthalpy geothermal power plants were raised since 2003. Main emphasis of every installed geothermal power plant is to gather experiences in the different low-enthalpy regions of interest in Germany. Therefore the installed geothermal power plants are in a state of pilot project for research purposes.

One geothermal binary power plant in each described low-enthalpy region of interest in Germany is introduced in the following. For detailed information see [2].

3.1.1. Geothermal power plant Neustadt-Glewe

The first geothermal power plant in Germany was developed in Neustatdt-Glewe in 2003. Neustadt-Glewe is located in the Northern-German Sedimentary Basin. At site, fluid with a temperature of 98 °C and a flow rate of only 35 l s^{-1} is gathered in a production well of depth of 2200 m used with a binary fluid cycle and reinsert to the ground again.

Currently, the geothermal power plant in Neustadt-Glewe has an output of up to 0.21 MW_{el}. This first geothermal power plant in Germany demonstrates successful the possibility of geothermal power production from fluids of less than 100 °C using the Organic Rankine Cycle (ORC). A picture of the geothermal power plant Neustadt-Glewe is given in Fig. 3.

3.1.2. Geothermal power plant Landau

The binary ORC power plant Landau was developed in 2007. Landau is located in the northern part of the Upper Rhine Rift. A picture of the geothermal power plant Landau is given in Fig. 4.

At site a geothermal gradient of about 0.047 °C m^{-1} is given, leading to a bottom hole temperature of 160 °C at a depth of about 3300 m. The geothermal power plant in Landau was the first

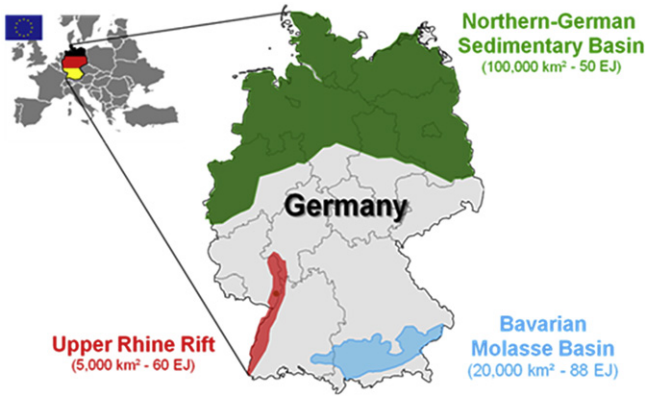

Fig. 2. Geothermal regions of interest.

Fig. 3. Geothermal power plant Neustadt-Glewe [4].