

Tracking deep geothermal energy

Leibniz Institute for Applied Geophysics offers Internet access to basic data for deep geothermal energy



There are many places in Germany where deep geothermal energy is available as an environmentally friendly alternative to fossil fuels as a source of power and heat. When it comes to utilising this energy, drilling is the most expensive part. Power and heat generation is only cost-effective if sufficiently high water temperatures and flow rates are found. Via GeotIS, an online information system, planners can now gain fast access to geological and geophysical data for Germany.

In Germany, geoscientific data is managed by the geological services in the federal states. Data from thousands of boreholes drilled by the oil and gas industry in Germany is kept by the industry and for commercial reasons has hardly ever been published. Using this valuable data can help to better estimate the exploration risk for deep boreholes and increase the chances of success for geothermal energy projects.

Hence the aim of the Geothermal Information System (GeotIS) is to record, analyse and process this data so that it can be used in geothermal energy projects. GeotIS makes the data available in the Internet as a digital geothermal atlas which helps interested parties such as planners, investors, public authorities and insurance companies carry out a basic assessment of a site.

At present, the database mainly covers regions which are already used for geothermal energy, such as the Molasse Basin in southern Germany (geographically the area between the Danube and the Alps), the Upper Rhine Graben and the North German Basin. There are plans to add further regions. GeotIS provides extensive data on the subsurface, such as the depth of rock layers, the type and permeability of rock, and the temperature and structure. Operating data from

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geothermal systems is also displayed, such as heat and electricity output, temperatures, flow rates and extraction depth.

The Leibniz Institute for Applied Geophysics (LIAG) in Hanover coordinates and runs GeotIS. Data for developing GeotIS is supplied by the state geological services, Freie Universität Berlin and Geothermie Neubrandenburg GmbH. For the first time, the member companies in Wirtschaftsverband Erdöl- und Erdgasgewinnung (WEG) have made a large volume of data from past oil and gas drilling available and are assisting in the development of the information system content.

Data from geological surveys in neighbouring countries is also being incorporated into GeotIS. The French Bureau de Recherches Géologiques et Minières (BRGM) has provided archive documents from boreholes in the French part of the Upper Rhine Graben for further investigations through the Department of Environment of the Regierungspräsidium (District Authority) Freiburg of the State of Baden-Württemberg. A similar exchange of data is taking place with Switzerland for south-western Germany.

Regions covered so far

Geothermal plants (see fig. 1) for heat utilisation and power generation pump hot water from deep rock layers (formations) having various different characteristics. In northern Germany, thermal water occurs in various sandstone formations of the Mesozoic. The water contains high concentrations of salt and at depths of 1,300 to 3,800 m is at temperatures between 55 and 170 °C. In southern Germany, the Upper Jurassic strata, which are composed of limestone, are the most important geological formation containing usable thermal water deposits. This water only has low concentrations of salt and at current sites the water temperature is between 70 and 140 °C at depths of 800 to 4,500 m.

In the Upper Rhine Graben, the layers which are relevant for geothermal energy are of the Upper Muschelkalk (Middle Triassic), the Middle Buntsandstein (Lower Triassic) and in the southern part the Hauptrogenstein Formation (Middle Jurassic). Because the subsurface is highly fractured, mainly upwelling deep water can be utilised. These waters contain high concentrations of dissolved salts and current plants operate with water temperatures between 135 and 160 °C at depths of 2,500 to 3,300 m. High salt concentrations do not generally prevent the geothermal use of deep aquifers, but they place particular demands on the equipment used.

What are the benefits of the information system?

The database-driven presentation of complex geoscientific content in the Internet offers many advantages: anyone can look up specific facts to answer their individual question, a large number of output and export formats are available, regardless of scale, and information that is held in a database is easier to keep up-to-date. Prof. Dr. Rüdiger Schulz, project manager at LIAG in Hanover, hopes that GeotIS will open up opportunities to potential plant operators: "Every geothermal energy project needs to be planned individually because there is great variation in the geological conditions deep below ground. To assess the chances of success, with GeotIS we provide an overview of available data and help answer the question of which utilisation op-

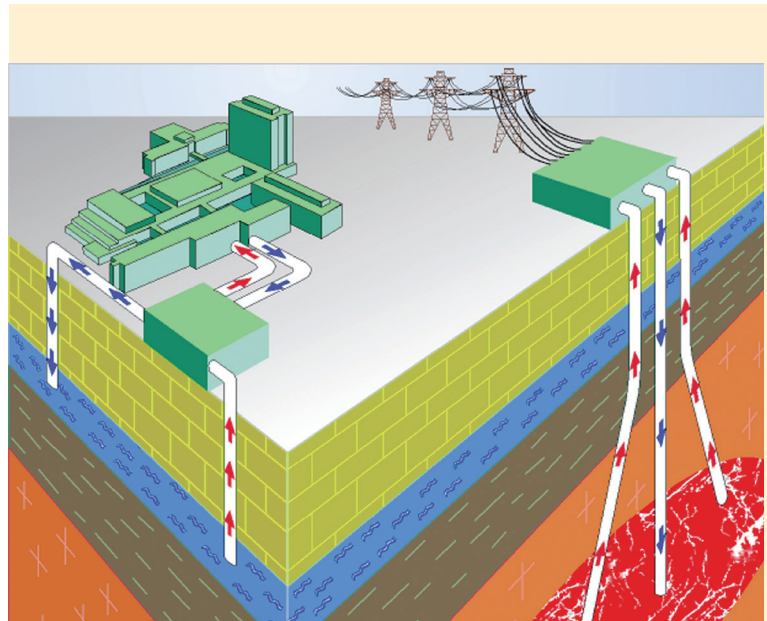


Fig. 1 Geothermal plants: hydrothermal (left) and petrothermal (right).

Source: German Federal Institute for Geosciences and Natural Resources (BGR)

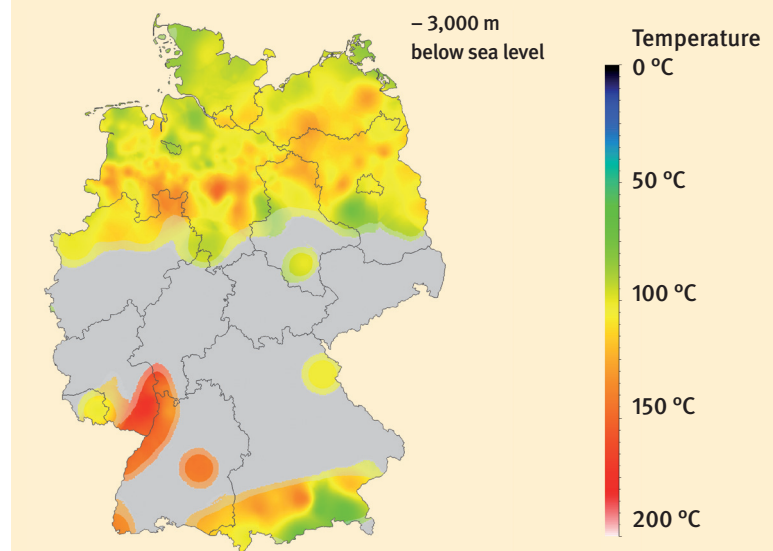


Fig. 2 Temperatures at a depth of 3,000 m below sea level. No values are provided for the grey areas because no borehole data is available for these areas.

Source: LIAG

tions make most sense at the site."

Typical areas of interest in GeotIS are the temperature and depth of geothermal resources (see fig. 2), the thickness of deep aquifers and the hydraulic conditions, and information on more than 30,000 deep boreholes in Germany. For both modules "Geothermal Potentials" and "Geothermal Sites" the system offers interactive maps including reference maps with modifiable map layers, research options, and information windows displaying object data.

The "Geothermal Sites" module provides information on existing and planned geothermal plants in Germany. Operating data for the selected plant is displayed in an information window. For Baden-Württemberg, the map also shows existing concession areas. Operating data and maps can be exported and printed as a PDF file.

The "Geothermal Potentials" module gives a regional overview of geological layers that look promising for geothermal exploration. The system provides information on the location of boreholes and seismic profiles on the earth's surface and enables vertical and horizontal cross-sections down to depths of 5,000 m below sea level. The temperature below ground can be shown via contour lines and colour spectrums. A 3D model is available for north-



Deep geothermal energy / exploration risk

In Germany, the term “deep geothermal” is used for boreholes which tap geothermal energy at a depth exceeding 400 m and at a temperature above 20 °C. Using deep geothermal energy either involves natural hot water resources (hydrothermal plants) or the heat stored in the rock (petrothermal plants). Both can be used to supply heat (at temperatures above approx. 60 °C) and for combined power generation (at temperatures above approx. 100 °C). 17 larger-sized geothermal plants are in operation in Germany, including 5 power plants in Unterhaching, Landau, Bruchsal, Neustadt-Glewe and Simbach. Geothermal exploration permits have been issued for a further 150 planned projects.

A geological site assessment is essential when planning a geothermal plant. As part of this assessment, the available geological data and maps are analysed in order to draw conclusions about local conditions. However, in every project there is still a risk that a suitable reservoir will not be found at the planned drilling depth. While the temperature can often be predicted with relative accuracy, it is still difficult to estimate the actual flow rate, which is highly dependent on the hydraulic conditions. Since drilling work can account for up to two-thirds of the investment costs of a geothermal energy project, there is a great economic interest in improving exploration prognoses.

homogenised, added to in some cases, and linked together using mathematical processes. In the system, the data is managed in an internal working database. Operating as a relational database, in mid-2011 it comprised around 4 million records in 156 tables. In order to satisfy all legal requirements, the data is only published in an anonymised and generalised form in the presentation database, which can be accessed with any conventional web browser.

What happens next?

LIAG and the GeotIS project partners will continue to maintain and add to the database. In 2011 the data on the geothermal sites was updated via a survey, and new units were added. The temperature models and exploration prognoses will be improved further and the development of subsurface models will continue. New regions for hydrogeothermal energy usage will be added with data from the Thuringian Basin, parts of Hesse and other areas in north west Germany. Information for petrothermal geothermal energy will also be included. In the medium term, the aim is that relevant data for geothermal energy should be available for as many regions as possible in Germany.

At the European level, preliminary work has started on a European geothermal database, for which GeotIS would be the national cooperation partner.

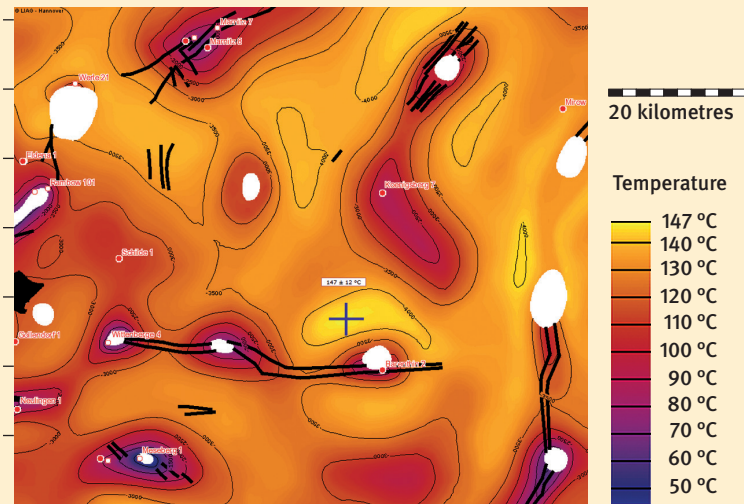


Fig. 3 GeotIS display of the horizontal temperature profile and depth at the base of the Middle Buntsandstein in an area of north-eastern Germany. Fracture zones appear as black lines and boreholes are shown in red. Source: LIAG

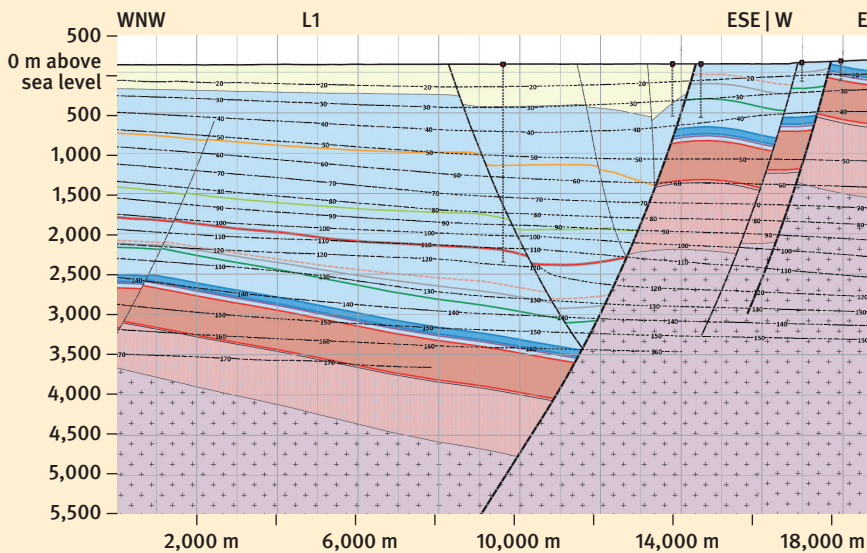


Fig. 4 Geological cross-section through the Upper Rhine Graben with basement rock and deep aquifers. The temperature profile is represented by black dotted lines. Source: RPF & LIAG / RP Freiburg

eastern Germany and for the Molasse Basin in southern Germany. It provides an interactive display of the depth and temperature of the relevant layers and large-scale fault structures (see fig. 3). In addition, geological cross-sections can be drawn between any points. For the Upper Rhine Graben (see fig. 4), further 6 longitudinal and 18 transversal cross-sections are available at intervals of 10 km as static graphics. To enable an estimate of the aquifer yield, for the Molasse Basin in southern Germany there is a map of the hydraulic conductivity of the Malm aquifer. For north-eastern Germany, facies maps provide information on the overall thickness of the most important aquifers for deep geothermal energy.

Systematically tapping into data

Work on GeotIS began with a major data acquisition task involving state and industry partners – it was possible to use the two specialised information systems for geophysics and hydrocarbons – as well as the operators of geothermal plants and thermal water boreholes. Allowances had to be made for the fact that, in most cases, former well owners had pursued their own specific goals. This heterogeneous mix of source data needs to be



Geothermal – energy with hidden depths

Germany has far more geothermal resources than are currently used. These energy sources deep in the Earth are available all day long, all year round, making them ideal for contributing to covering base-load heat and electricity demands.

In addition to GeotIS, the German Federal Ministry for the Environment also supports numerous application-oriented developments relating to geothermal energy. The common goal of all research projects is to improve economic efficiency and reliability. One focus area is the development and testing of optimised drilling and pipe concepts that are better suited to geothermal energy. In future they should reduce the time and costs associated with drilling, and simplify pipe installation. Geothermal plants also require specially adapted pumps. These must be resistant to high temperatures, pressures and the corrosion caused by saline media. Longevity is also an important issue. Similarly demanding material requirements apply to the measurement technology and procedures, and also to heat exchangers.

Special power plant processes exist (e.g. organic rankine cycle (ORC), Kalina cycle) which enable the generation of electricity even with comparatively low-temperature media (approx. 100-200 °C). Improving the efficiency of these processes and developing new processes may improve the market opportunities for geothermal energy. Depending on the geological conditions, the natural productivity of a geothermal reservoir is sometimes not sufficient. It may first be necessary to pump water under pressure to expand and enlarge natural fracture systems in order to extract enough hot water, for example. In contrast to oil and gas extraction, in geothermal applications chemicals are generally not used in these fracture processes. This hydraulic stimulation allows the thermal water to circulate better and draw more heat from the rock.

In 2010, the German Federal Ministry for the Environment approved approximately 15 million euros in funding for new geothermal research projects.

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Links and literature (in German)

- » www.geotis.de | www.forschungsjahrbuch.de (→ Geothermie) | www.erneuerbare-energien.de (→ Geothermie) | www.geothermie.de

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