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# Geothermal Energy Use in Germany

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## ABSTRACT

At present, 162 geothermal installations for direct use of geothermal energy are operating in Germany. The installed capacity of these plants amounts to roughly 255 $MW_t$. The installations comprise centralized heating units (district heating), space heating in some cases combined with greenhouses, and thermal spas. Most of the centralized plants are located in the Northern German Basin, the Molasse Basin in Southern Germany, or along the Upper Rhine Graben. In addition to these large-scale plants there are numerous small- and medium-size decentralized geothermal heat pump units (ground coupled heat pumps and groundwater heat pumps). Their installed capacity exceeds 2230 $MW_t$. By the end of 2009 direct thermal use of geothermal energy in Germany amounted to a total installed thermal capacity of about 2500 $MW_t$ with a pure geothermal contribution of 1800 $MW_t$.

Three geothermal plants for power generation are working in Germany, two of them combined with district heating. These plants are located in the North German Basin at Neustadt-Glewe, in the Rhine Graben at Landau and in the Molasse Basin at Unterhaching. The Unterhaching and Landau projects have triggered a boom in deep geothermal energy use in the Munich region and the Rhine Graben.

The Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG) guarantees system operators fixed payment rates for electricity fed into the main grid. These are laid down over years, ensuring economical operation. The EEG will presumably stimulate the build-up of a geothermal power industry in Germany and will open new opportunities for geosciences and for the drilling and service industry.

In collaboration with the “KfW Bankengruppe” (group of banks) the BMU has created a new loan programme for the long-term financing of deep geothermal drillings. The loan programme helps to hedge the discovery risk.

## 1. INTRODUCTION

Due to a lack of natural steam reservoirs geothermal energy cannot be converted in Dry Steam or Flash Steam power plants into electric power in Germany. At present only Kalina or Organic Rankin Cycle (ORC) power plants can be used for electrical power generation. At Neustadt-Glewe the first German geothermal plant for electrical power generation is working since November 2003 with an installed capacity of about 230 $kW_e$. In 2008 and in 2009 power plants at Landau and at Unterhaching started to convert geothermal energy into electric power, each with a capacity of about 3.0 $MW_e$.

A successful development of the hydraulic stimulation technique in sediments and crystalline rocks (Hot Dry Rock technology) would change the situation in Germany fundamentally. An HDR geothermal power plant is in realisation at Groß Schönebeck. New innovative technologies are currently being developed for converting the heat of deep seated hot aquifers into power. Innovative projects are in realisation in Bruchsal and Insheim (Upper Rhine Graben), as well as in Garching, Sauerlach and Unterföhring (Molasse Basin). The plants for combined power generation and district heating are scheduled to be completed in the years 2010 and 2011.

This paper describes the existing geothermal resources and potentials followed by the status of geothermal utilisation in Germany by the end of 2009, and the contribution from each type of installation: geothermal power production, large-scale centralised and small scale decentralised units. Future perspective of the use of geothermal energy in Germany will be discussed.

## 2. GEOTHERMAL RESOURCES AND POTENTIAL

The potential for geothermal power production in Germany was investigated in a study published in 2003 by the “Office of Technology Assessment at the German Parliament (Paschen et al. 2003)”, whereas the resources for direct use of geothermal energy in Germany were estimated in two European atlases: the “Atlas of Geothermal Resources in the European Community, Austria and Switzerland” (Haenel and Staroste 1988), and the “Atlas of Geothermal Resources in Europe” (Hurter and Haenel 2002).

### 2.1 Potential for Geothermal Power Production

Organic Rankine and Kalina cycle techniques allow efficient electricity production at temperatures down to 100°C and makes geothermal power production feasible even for countries like Germany lacking high enthalpy resources at shallow depth. The geothermal resources for geothermal power production in Germany were estimated in a study performed in 2002 (Jung et al. 2002). Three types of reservoirs were considered: hot water aquifers (Fig. 1), faults (Fig.2) and crystalline rocks (Fig. 3) with temperatures above 100°C and at depths down to 7000 m.

Assuming realistic values for the recovery factor and the efficiency factor the accessible electrical energy was calculated. The electrical energy was estimated to 10 EJ (1 EJ = $10^{18}$ J) for the hot water aquifers, to 45 EJ for deep reaching faults, and to 1,100 EJ for crystalline rock. In comparison to these potentials the annual power consumption in 2007 for Germany was 1.9 EJ (BMWi 2009). To recover at least part of this huge resources further research and developments are necessary especially in accessing heat from faults and crystalline rocks.

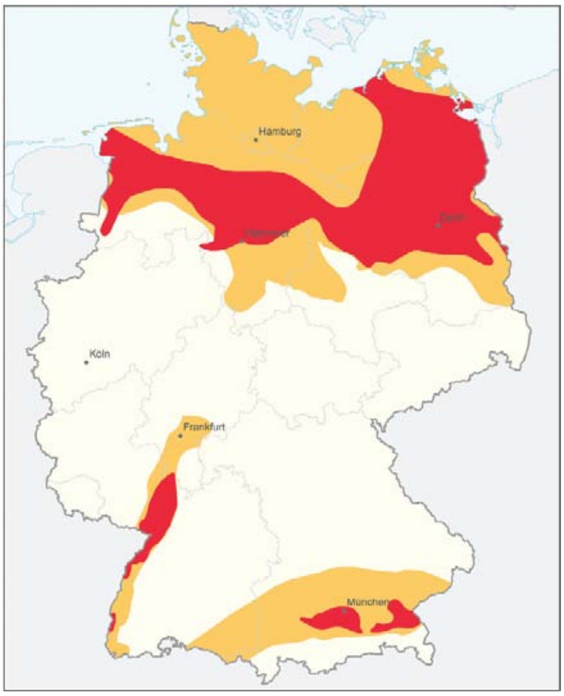


**Figure 1: Red areas: Hot water aquifers for geothermal power production, temperature above 100°C. Yellow areas: Hot water aquifers direct use of geothermal energy, temperature above 60 °C. (Schulz et al. 2007). From North to South: Upper Rotliegend (Upper Permian) sand stone aquifer in the North German Basin; Upper Muschelkalk and Buntsandstein (Middle and Early Triassic) aquifers of the Upper Rhine Graben; Malmkarst (Upper Jurassic) aquifer in the South German Molasse Basin.**

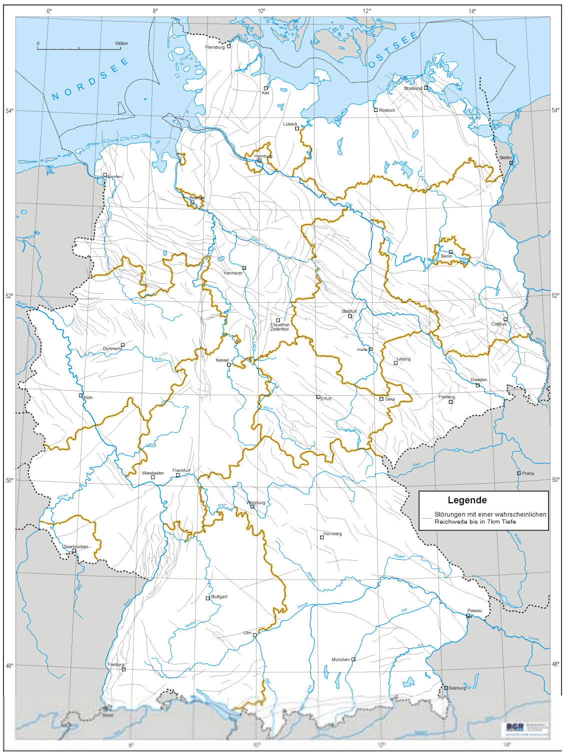


**Figure 2: Deep-seated fault systems with a possible extension up to 7 km depth.**

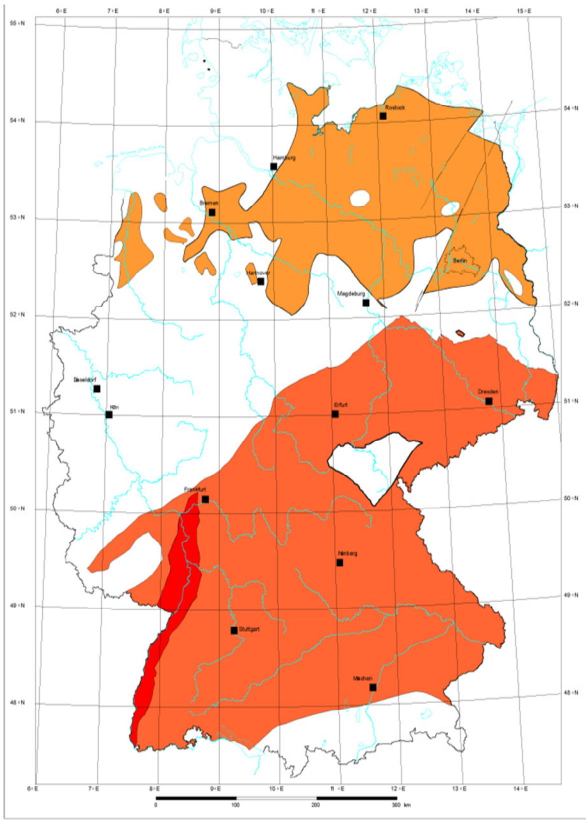

**Figure 3: Crystalline rocks for geothermal power production in Germany. Red area: crystalline rock at 3 km depth and with a mean temperature of 100°C; dark red area: crystalline rock in the Upper Rhine Graben at 3 km depth and with a temperature of 130°C; orange area: Rotliegend (Permian) volcanic rock with temperatures exceeding 100°C.**

### 2.2 Resources for Direct Use of Geothermal Energy

The geothermal resources for most European countries have been estimated and compiled in the Atlas of Geothermal Resources in Europe (Hurter and Haenel 2002), a companion volume to the Atlas of Geothermal Resources in the European Community, Austria and Switzerland (Haenel and Staroste 1988). The German contributions to these two atlases display the resources for direct use of geothermal energy in Germany. All aquifers of interest are located in the North German sedimentary basin, the Molasse Basin in southern Germany, and along the Upper Rhine Graben.

The North German Basin is the central part of the Central European Basin. The present-day sediment thickness ranges from 2 km - 10 km. Halokinetic movements of the Zechstein layers are responsible for the intense and complex deformation of Mesozoic and Cenozoic formations (Franke et al. 1996). These movements were active up to recent times. This tectonic disturbance strongly influences the local conditions of the geothermal reservoirs.

The Mesozoic deposits of the North German Basin are made up of sandstones, clay and carbonates, with evaporite intercalations. Six Cretaceous, Jurassic and Triassic sandstone aquifers are of interest for direct use of geothermal energy: Valendis-Sandstein, Bentheimer Sandstein, Aalen, Lias and Rhät, Schilfsandstein, and Buntsandstein. Because of the salt tectonics, great variations of depth and thickness, exceeding locally 1000 m, occur along short distances. Therefore, the temperature and energy content of the geothermal resources vary strongly on a regional scale. Table 1 shows the resources of these aquifers.

The Molasse Basin in southern Germany is an asymmetrical foreland basin associated with the uplift of the Alps. It extends over more than 300 km from Switzerland in the southwest to Austria in the east.

The basin is made up mainly by Tertiary, Upper Jurassic (Malm) and Triassic sediments. Eight aquifers of these sedimentary layers are of interest for direct use of geothermal energy: Burdigal-Sande, Aquitan-Sande, Chatt-Sande, Baustein-Schichten, Ampfinger Schichten, Gault/ Cenoman-Sandsteine, Malm and Upper Muschelkalk. The Malm (karstic limestone aquifer of the Upper Jurassic) is one of the most important hydro-geothermal energy reservoirs in Central Europe because the aquifer is highly productive and present throughout almost the whole Molasse Basin. The Malm aquifer dips from north to south to increasing depths and temperatures. The estimate of resources of the Molasse aquifers is listed in Table 1.

The Upper Rhine Graben belongs to a large rift system which crosses the north-western European plate (e.g. Villemin et al. 1986). Between 30 and 40 km wide, the graben runs from Basel, Switzerland, to Frankfurt, Germany. The structure was formed in the Tertiary at about 45-60 Ma by up-doming of the crust-mantle boundary due to magmatic intrusions in 80-100 km depth. The induced thermo-mechanical stress results in extensional tectonics with a maximum vertical offset of 4.8 km.

Six aquifers (Tertiary, Jurassic, Triassic and Permian) are of interest for direct use of geothermal energy: Hydrobien-Schichten, Grafenberg-Schicht, Hauptrogenstein, Upper Muschelkalk, Buntsandstein and Rotliegend. The resources of these aquifers are listed in Table 1.

## 3. STATUS OF GEOTHERMAL ENERGY USE

Geothermal energy (Bertani 2005, Lund et al. 2005) is worldwide the most extensively used renewable energy besides hydro-power and biomass (direct use). Due to the lack of natural steam reservoirs geothermal energy got little attention in Germany in the past. The use of geothermal energy in Germany is actually restricted to a relatively small number of centralised installations and numerous small decentralised units (heat pump units). Geothermal power production has just started. But the new payment rates for power production by the Renewable Energy Sources Act had a positive effect, several plants for combined power generation and district heating are under construction.

### 3.1 Geothermal Power Production

Three geothermal plants for power generation are working in Germany (Table 2), two of them combined with district heating. These plants (Fig. 4) are located in the North German Basin at Neustadt-Glewe, in the Rhine Graben at Landau and in the Molasse Basin at Unterhaching. The major use at Landau is the power generation whereas the major use at Neustadt-Glewe and at Unterhaching district heating is. The total capacity of these plants is about 6.6 $MW_e$ for power generation and additional 55 $MW_t$ for district heating (Table 2). The power production of 50,200 MWh/a (6.6 $MW_e$ * 7600 h, estimated) will provide about 13,200 households with electric power (with 3,800 kWh/household per year).

The first geothermal plant for electric power generation in Germany is working since November 2003. The power plant is situated in the eastern part of the North German Basin at

**Table 1: Resources of Germany (Schellschmidt et al. 2002).**

| Reg. | Aquifer | A km² | $T_t$ °C | Resources $10^{18}$ J | GJ/m² |
|---|---|---|---|---|---|
| A | Valendis Sst. | 143 | 50 | 0.11 | 0.79 |
| | Bentheimer Sst. | 361 | 54 | 0.28 | 0.78 |
| B | Aalen | 66250 | 43 | 80.83 | 1.22 |
| | Lias and Rhät | 68125 | 38 | 102.87 | 1.51 |
| | Schilfsandstein | 63125 | 48 | 37.88 | 0.60 |
| | Buntsandstein | 67500 | 49 | 70.88 | 1.05 |
| C | Garfenberg-Schicht | 597 | 28 | 0.29 | 0.48 |
| D | Hydrobien-Schicht. | 2117 | 30 | 5.72 | 2.70 |
| | Ob. Muschelkalk | 2060 | 137 | 3.17 | 1.53 |
| | Buntsandstein | 2746 | 137 | 45.72 | 16.65 |
| | Rotliegendes | 2117 | 110 | 89.79 | 42.41 |
| E | Hauptrogenstein | 332 | 79 | 0.49 | 1.47 |
| | Ob. Muschelkalk | 1616 | 75 | 1.11 | 0.69 |
| | Buntsandstein | 1688 | 85 | 9.78 | 5.80 |
| F | Aquitan-Sande | 3776 | 48 | 6.79 | 1.80 |
| | Chatt-Sande | 2564 | 72 | 9.05 | 3.53 |
| | Baustein-Schichten | 880 | 45 | 0.36 | 0.41 |
| | Malm | 7740 | 69 | 11.79 | 1.52 |
| | Ob. Muschelkalk | 3728 | 67 | 1.29 | 0.34 |
| G | Burdigal-Sande | 268 | 45 | 0.22 | 0.82 |
| | Aquitan-Sande | 763 | 45 | 1.33 | 1.82 |
| | Chatt-Sande | 3348 | 53 | 10.48 | 3.13 |
| | Baustein-Schichten | 304 | 42 | 0.14 | 0.47 |
| | Ampf., Priabon | 436 | 79 | 0.39 | 0.89 |
| | Gault/Cenoman | 6112 | 77 | 4.61 | 0.75 |
| | Malm | 8790 | 78 | 17.05 | 1.94 |

$T_t$ = mean Temperature at top of aquifer Reg.:
A = areal extent of potential area
A´ = areal extent of probable reserves
P = thermal power (= reserves/30 years)

A = Western North German Basin
B = Eastern North German Basin
C = Lower Rhine Graben
D = Northern Upper Rhine Graben
E = Southern Upper Rhine Graben
F = Western Molasse Basin
G = Eastern Molasse Basin

Neustadt-Glewe (Fig. 4). The installed capacity is about 230 $kW_e$ (Table 2) to generate power. In addition 17 $MW_t$ are used for district and space heating. An Organic Rankin Cycle (ORC) is used for the electrical power generation. The thermal water enters the ORC-system with a temperature of 98°C and is cooled down to 72°C. For the thermodynamic realisation at these low temperatures perfluoropentan gas (C5F12) is used, which starts boiling at 31°C at normal pressure (Kranz 2003).

The positive trend in the use of geothermal energy continued in 2008. In 2008 and 2009 power plants at Landau and at Unterhaching started to convert geothermal energy into electric power, each with a capacity of about 3.0 $MW_e$ (Table 2). At Landau (Fig. 4) an Organic Rankin Cycle is used for the electrical power generation whereas at Unterhaching (Fig. 4) the Kalina technology is used.

The Unterhaching and Landau projects have triggered a boom in deep geothermal energy use in the Munich region and the Upper Rhine Graben.

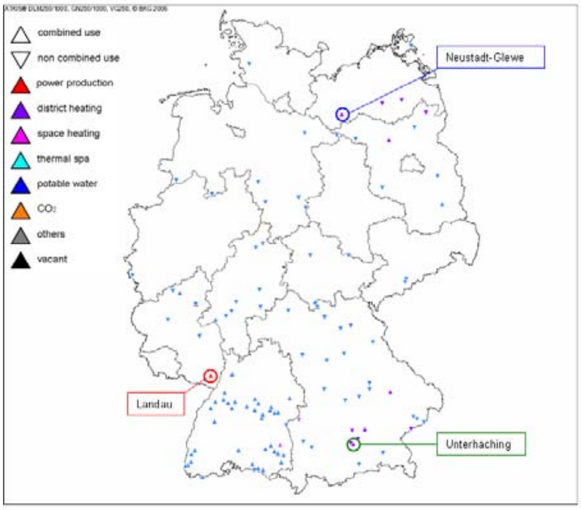


**Figure 4: Operating installations for geothermal energy use in Germany (www.geotis.de). Circles indicate plants with combined power and heat supply.**

**Table 2: Plants for combined power generation (p) and district heating (h) are located in the North German Basin (NG), the Rhine Graben (RG) and the Molasse Basin (M).**

| power plant | basin | major use | flow rate max. l/s | capacity power MWe | capacity heat MWt |
|---|---|---|---|---|---|
| Neustadt-Glewe | NG | h | 35 | 0.23 | 17.0 |
| Landau | RG | p | 70 | 3.00 | --- |
| Unterhaching | M | h | 150 | 3.36 | 38.0 |
| total 2009 | | | 255 | 6.59 | 55.0 |

### 3.2 Centralised Installations for Direct Use

At present, 162 geothermal installations for direct use of geothermal energy are operating in Germany (Fig. 4 and Table 3). The installations comprise centralised heating units (district heating), space heating in some cases combined with greenhouses, and thermal spas. The total thermal capacity installed is 255.4 $MW_t$ with a geothermal contribution of 144.0 $MW_t$. The annual utilization amounts to roughly 666 GWh/a (Table 3) or 2398 TJ/a.

Under the prevailing economic and political conditions, multiple uses or cascades can help to improve the economic efficiency of direct use of geothermal heat. For this reason many installations combine district or space heating with greenhouses and thermal spas.

The geothermal units for district heating with an installed capacity of about 210 $MW_t$ (Table 4) are located in the North German Basin and in the Molasse Basin. Ten installations for power production most of them combined with district heating are under construction in the Rhine Graben and the Molasse Basin (Fig. 5). These regions have the most favourable conditions in terms of geothermal potentials, temperature and achievable flow rates in Germany (Haenel and Staroste 1988, Hurter and Haenel 2002). In addition eight installations for district heating are under construction in the Rhine Graben and the Molasse Basin (Fig. 5).

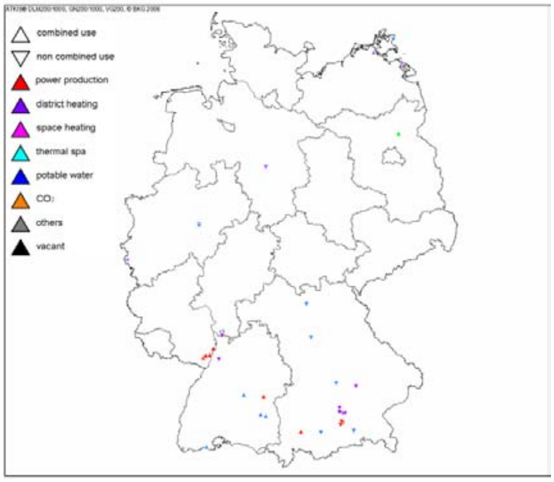


**Figure 5: Installations under construction for geothermal energy use in Germany. Red (major use): power plants (www.geotis.de).**

**Table 3: Installed total and geothermal capacity as well as annual utilization.**

| major use | number of installations | capacity total MWt | capacity geothermal MWt | annual use GWh/a |
|---|---|---|---|---|
| district heating | 12 | 209.3 | 97.9 | 292.9 |
| space heating | 2 | 1.2 | 1.2 | 0.8 |
| thermal spa | 148 | 44.9 | 44.9 | 372.0 |
| greenhouse | - | - | - | - |
| total 2009 | 162 | 255.4 | 144.0 | 665.7 |
| *total 2006* | *140* | *177.3* | *92.3* | *523.4* |

**Table 4: The geothermal units for district heating are located in the North German Basin (NG) and the Molasse Basin (M).**

| location | basin | capacity total MWt | capacity geothermal MWt | annual use GWh/a |
|---|---|---|---|---|
| Unterhaching | M | 38.0 | 30.4 | 66.6 |
| Unterschleißheim | M | 12.9 | 12.9 | 28.3 |
| München Riem | M | 42.0 | 12.0 | 43.3 |
| Pullach | M | 9.6 | 9.6 | 21.0 |
| Erding | M | 18.0 | 8.0 | 28.0 |
| Simbach-Braunau | M | 40.0 | 7.0 | 67.0 |
| Neustadt-Glewe | NG | 17.0 | 7.0 | 11.9 |
| Straubing | M | 5.4 | 4.1 | 11.8 |
| Neubrandenburg | NG | 13.8 | 3.8 | 8.3 |
| Waren (Müritz) | NG | 10.0 | 1.3 | 2.9 |
| Neuruppin | NG | 2.1 | 1.3 | 2.7 |
| Prenzlau | NG | 0.5 | 0.5 | 1.1 |
| total | | 209.3 | 97.9 | 292.9 |

Applications for exploration permits had been submitted for a further 150 sites.

### 3.3 Small Decentralised Units for Direct Use

Geothermal energy use for space heating in small decentralised units is widespread in Germany and experience in that technology dates back to the 1970s. The market introduction of ground source heat pumps in larger scale began in the mid 1990s, and was backed by support programs from utilities and from the federal government. Depending on local conditions these units consist of ground coupled heat pumps (horizontal heat collectors, vertical heat exchangers), or groundwater heat pumps.

The exact number of units presently installed in Germany is unknown since no national statistics are available. However, based on the number of heat pump sales in Germany, a good estimation can be undertaken. According to sales statistics (BWP 2009) about 34,500 small decentralised unites have been newly installed in 2008, nearly three times of sales compared to 2005 (Fig. 6). The mean installed geothermal power of each of these units typically varies from 10-15 $kW_t$.

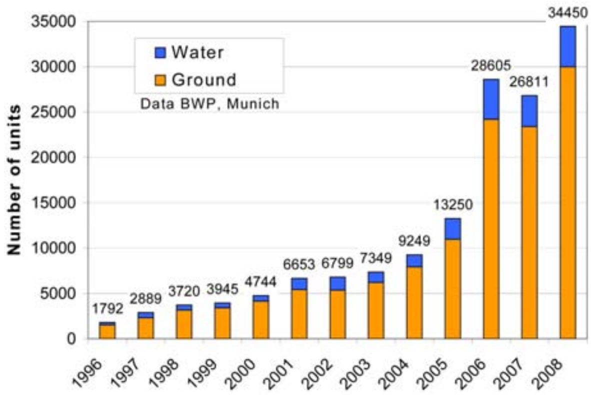


**Figure 6: Annual number of new ground source heat pump units since 1996 (data from BWP 2009).**

Figure 7 shows the number of all operating ground source heat pump units since 2003. This evaluation considered a replacement of older heat pumps, and abandonment of old plants, with a total of about 10% of the new units. In the year 2008 were about 148,000 units operating. The increase of operating ground source heat pump units amounted in the year 2006, 2007 and 2008 to 37%, 28% and 25% respectively. A conservative estimate for the increase in 2009 can be given with 20%. This results in 178,000 units for 2009.

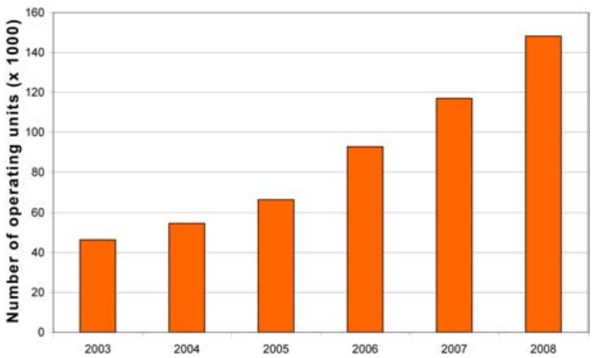


**Figure 7: Number of operating ground source heat pump units since 2003 (Sanner 2009).**

Figure 8 gives the development of the installed capacity of all operating ground source heat pump units. The geothermal contribution was calculated in consideration of the guidelines in Annex VII of the EU directive "Renewable Energy". Thus it was used a seasonal performance factor (ß) of 3.5 and a coefficient of performance (COP) of 4.0. In 2008 the installed capacity in small size decentralised units is equal to 1860 $MW_t$ and the pure geothermal contribution amounts to 1395 $MW_t$. A conservative estimate for the increase in 2009 can be given with 20%, which results in 2230 $MW_t$ and the pure geothermal contribution increases to 1670 $MW_t$. Thus, in decentralised units about 12 times more pure geothermal output is installed than in centralised installations.

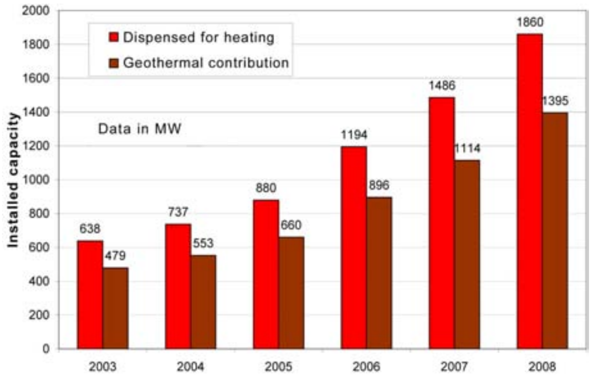


**Figure 8: Installed capacity of all earth coupled heat pumps (Sanner, SONG of the GtV-BV, 2009).**

The development of the annual heat delivery of ground source heat pumps is given in figure 9. In 2008 the annual use in small size decentralised units is equal to 2.40 TWh/a and the pure geothermal contribution amounts to 1.71 TWh/a. A conservative estimate for the increase in 2009 can be given as above with 20%, which results in 2.88 TWh/a (10,368 TJ/a) with a pure geothermal contribution of 2.05 TWh/a (7380 TJ/a).

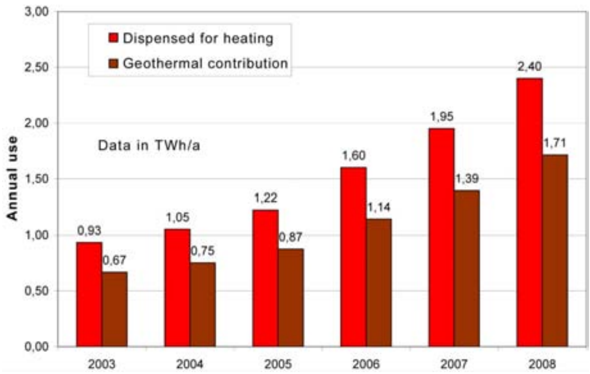


**Figure 9: Annual use of all earth coupled heat pumps (Sanner, SONG of the GtV-BV, 2009).**

## 4. PERSPECTIVE OF THE USE OF GEOTHERMAL ENERGY

A new, conservative estimate of the total thermal power currently installed for direct use of geothermal energy in Germany amounts to roughly 2500 $MW_t$. The pure geothermal part of this sum amounts to 1800 $MW_t$ or 72 %. About 12 times more pure geothermal output is installed in decentralised units than in centralised installations.

### 4.1 Final Energy Consumption in Germany

The final energy consumption in Germany in 2007 was 8585 PJ (1 PJ = $10^{15}$ J) (BMWi 2009). A breakdown in Figure 10 shows that 54% of the final energy consumption was required for space-heating, hot water, or process heat (BMWi 2009). Most of this demand is at present supplied by fossil fuel. A significant proportion of this demand could, in principle, be supplied by geothermal heat. This would make a significant contribution to reducing the present $CO_2$ output of Germany.

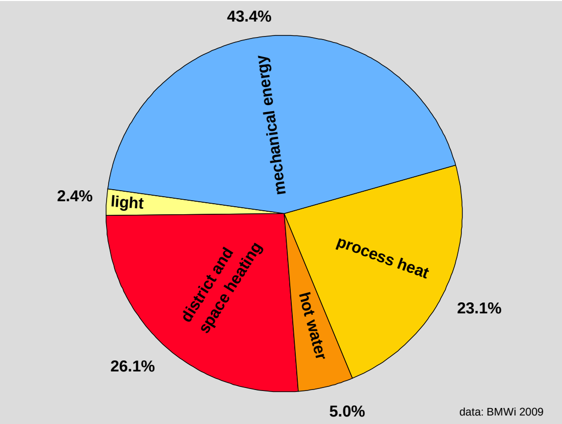


**Figure 10: Final energy consumption in Germany according to usage (data BMWi 2009). Distribution shown is for Germany in 2007. Final energy consumption in Germany was 8585 PJ in 2007 (1 PJ = $10^{15}$ J).**

According to Kayser (1999) the potential demand for geothermal heat from centralized geothermal units in Germany amounts to 1165 PJ $a^{-1}$. This would correspond to an installed thermal capacity of 36,917 $MW_t$. Kaltschmitt et al. (1995) assessed the potential demand for geothermal energy from ground coupled and groundwater heat pumps to 960 PJ $a^{-1}$, corresponding to an installed capacity of about 30,420 $MW_t$. The total potential demand for the direct use of geothermal energy in Germany is therefore 2125 PJ $a^{-1}$ corresponding to 67,337 $MW_t$. This corresponds to 25 % of the 2007 German final energy consumption of 8585 PJ.

Thus, a fourth of the final energy consumption in Germany could be supplied by the direct use of geothermal energy. However, at present only about 0.7 % of the potential demand is covered by geothermal heat.

### 4.2 Renewable Energy Source Act and Governmental Support of Geothermal Energy

The Renewable Energy Sources Act (Erneuerbare Energien Gesetz, EEG) guarantees system operators fixed payment rates for electricity fed into the main grid. These are laid down over years, ensuring economical operation. Duration for the fixed payment rates is 20 years (BMU 2008).

A first revised edition of the Renewable Energy Source Act came into force in August 2004. The payment rates for the feed-in allowance increased from 0.089 to 0.15 €/kWh for electricity produced from geothermal energy. With the adoption of the amended Renewable Energy Sources Act on 6th June 2008, the German Bundestag (Lower House of the German Parliament) further significantly improved the conditions for geothermal energy in Germany. Table 5 gives the new provisions valid from January 2009.Download of the EEG:

http://www.bmu.de/files/pdfs/allgemein/application/pdf/eeg_2009_en.pdf

The strong market development for deep geothermal energy in Germany is primarily attributable to the Renewable Energy Sources Act (EEG), which created good economic framework conditions for the operation of geothermal plants thanks to its fee scale. There is now a real chance for planning and installing geothermal power plants on a sound economic basis. The EEG will presumably stimulate the build-up of a geothermal power industry in Germany and will open new opportunities for geosciences and for the drilling and service industry.

**Table 5: The new feed-in tariffs for power production by the Renewable Energy Source Act (valid since January 2009). Basic tariff from a plant capacity of 10 MW or more is 10.5 cents per kilowatt.**

| basic tariff and bonuses from a plant capacity < 10 MW | payment rates €-Ct/kWh |
|---|---|
| Electrical power basic tariff | 16 |
| Plants starting up until 2015 | 4 |
| Power-heat-coupling | 3 |
| Petrothermal techniques (EGS) | 4 |
| maximum of feed-in tariff | 27 |

The positive effect of the new Renewable Energy Act has been further enhanced by financial support of pilot and demonstration projects (Market Incentive Programme, Future Investments Programme) by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU). As part of the German Government's integrated energy and climate programme, the BMU has adopted new funding guidelines for the Market Incentive Programme, which offers subsidies for installation of the power or heating plant, deep boreholes and heat extraction. The Market Incentive Programme also supports district heating networks that run on regenerative resources. Under this programme, in 2009 some 400 million Euros will be made available to promote renewable energies in the heat market. Figure 11 shows the annual project funding (research and development) by BMU in the field of geothermal energy from 1974 to 2008 (BMU 2008).

In collaboration with the "KfW Bankengruppe" (group of banks) the BMU has created a new loan programme for the long-term financing of deep geothermal drillings. Münchener Rück (Munich Re Group, insurance provider) is supporting the KfW as a cooperation partner. The loan programme helps to hedge the discovery risk – i.e. the risk of failing to find sufficient temperatures or water volumes when drilling, and should therefore minimize one of the main barriers to the faster market development of deep geothermal projects. For more details see this issue Schulz et al. (2010).

The Heat Act (EEWärmeG) was adopted by the Bundestag (Lower House of Parliament) on 6 June 2008 and entered into force on 1 January 2009. Under this Act, all owners of new buildings are obliged to purchase part of their heat demand from renewable energy sources.

The Installation of ground coupled heat pumps will be supported by the German Government as follows: 20 €/ m² living space, but not more than 3.000 € per house for existing houses and 10 €/ m² lining space, but not more than 2.000 € per house for new houses (http://www.erneuerbare-energien.de/files/pdfs/allgemein/application/pdf/foerderrichtlinie_waerme_09.pdf).

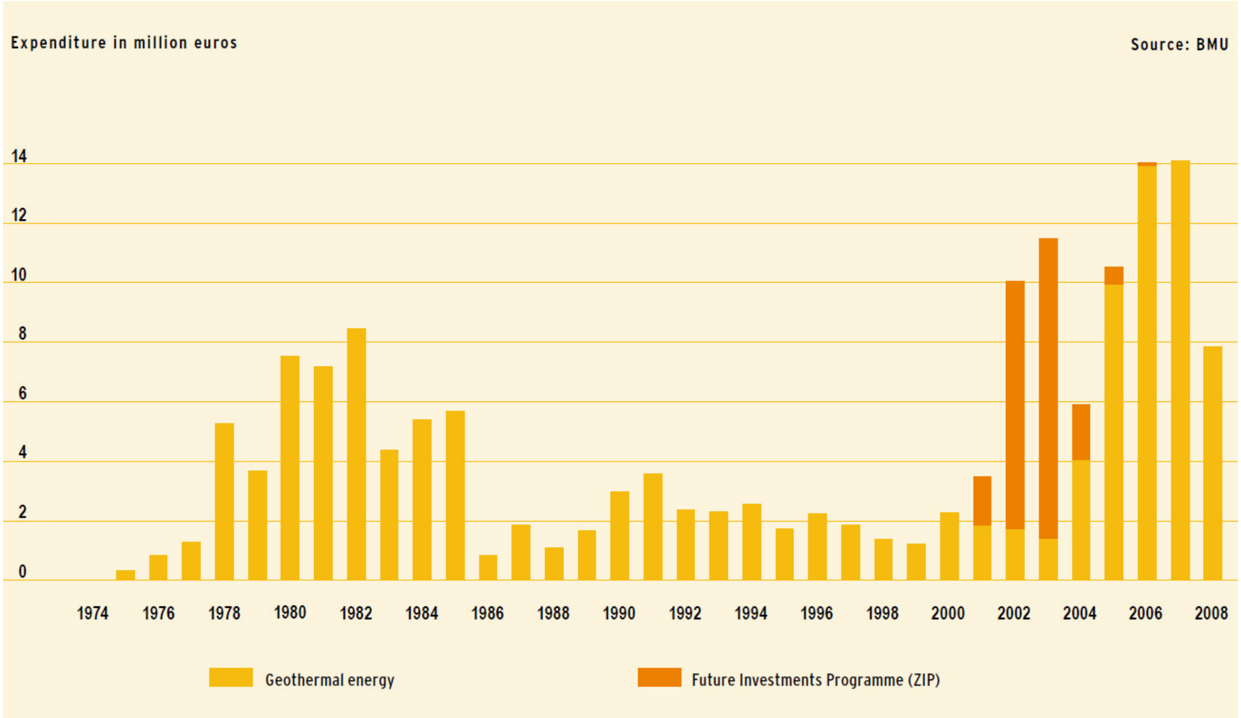


**Figure 11: Annual research expenditure by BMU in the in the field of geothermal energy from 1974 to 2008 (BMU 2008).**

### 4.3 Internet Based Information System

In order to improve the project-planning quality of geothermal plants and minimise the finding risk, the Leibniz Institut für Angewandte Geophysik (LIAG, Leibniz Institute for Applied Geophysics) former Institut für Geowissenschaftliche Gemeinschaftsaufgaben (GGA, Institute for Applied Geosciences) in Hanover has developed a unique information system.

The geothermal information system (GeotIS) provides information and data compilations on deep aquifers in Germany relevant for geothermal exploitation. GeotIS is a public internet based information system and satisfies the demand for a comprehensive, largely scale-independent form of a geothermal atlas which can be continuously updated. GeotIS helps users identify geothermal potentials by visualizing temperature, hydraulic properties and depth levels of relevant stratigraphic units. A sophisticated map interface simplifies the navigation to all areas of interest. An additional component contains a catalogue of all geothermal installations in Germany.

The project is funded by the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The Leibniz Institute for Applied Geophysics realises this project in close collaboration with partners. The purpose of the project is to minimise the exploration risk of geothermal wells and to improve the quality in the planning of geothermal plants. The current stage of expansion includes the South German Molasse Basin, the Upper Rhine Graben, and the North German Basin.

GeotIS is designed as a digital information system which will be available to the public through the World Wide Web (www.geotis.de).

For more details see this issue Pester et al. (2010).

## 5. CONCLUSIONS

Due to the moderate temperature gradients persisting in most parts of Germany geothermal energy use is still on a comparatively low level. The installed capacity for geothermal heat is about 2500 $MW_t$. 90% of which is attributed to about 178,000 decentralized units using heat from shallow depth. The remaining 10% is attributed to 162 centralized installations exploiting mainly deep-seated aquifers.

Three geothermal plants for power generation are working in Germany at Neustadt-Glewe, Landau and Unterhaching, two of them combined with district heating. The total capacity of these plants is 6.6 $MW_e$ for power generation and additional 55 $MW_t$ for district heating. The Unterhaching and Landau projects have triggered a boom in deep geothermal energy use in the Munich region and the Upper Rhine Graben.

With the adoption of the amended Renewable Energy Sources Act on 6 June 2008, the German Bundestag (Lower House of Parliament) further significantly improved the conditions for geothermal energy in Germany. The positive effect of the new Renewable Energy Act has been further enhanced by financial support of pilot and demonstration projects (Market Incentive Programme, Future Investments Programme) by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU).

The Renewable Energy Sources Act will presumably stimulate the build-up of a geothermal power industry in Germany and will open new opportunities for geosciences and for the drilling and service industry.

In its most recent funding announcement of 20 November 2008, the BMU outlined its priority areas for research funding in the field of geothermal energy. The aim is to continuously reduce the cost of extracting and using heat and electricity from geothermal reservoirs. For more details see BMU report (2008) “Annual Report on Research Funding in the Renewable Energies Sector”.

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**Tables 1-8**

**TABLE 1. PRESENT AND PLANNED PRODUCTION OF ELECTRICITY**

| | Geothermal | | Fossil Fuels | | Hydro | | Nuclear | | Other Renewables (wind, photovoltaics, biomass energy ) | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr | Capac-ity MWe | Gross Prod. GWh/yr |
| In operation in December 2008 | 6.59 | 50084 | 78500 | 372000 | 10100 | 27000 | 21300 | 148800 | 27500 | 77100 | 137407 | 674984 |
| Under construction in December 2008 | | | | | | | | | | | | |
| Funds committed, but not yet under construction in December 2009 | | | | | | | | | | | | |
| Total projected use by 2015 | | | | | | | | | | | | |

(data BMWi 2009)

**TABLE 2. UTILIZATION OF GEOTHERMAL ENERGY FOR ELECTRIC POWER GENERATION AS OF 31 DECEMBER 2009**

1) N = Not operating (temporary), R = Retired. Otherwise leave blank if presently operating.

2) 1F = Single Flash B = Binary (Rankine Cycle)
2F = Double Flash H = Hybrid (explain)
3F = Triple Flash O = Other (Kalina technology)
D = Dry Steam

3) Data for 2009 if available, otherwise for 2008. Please specify which.

| Locality | Power Plant Name | Year Com-missioned | No. of Units | Status[1)] | Type of Unit[2)] | Total Installed Capacity MWe* | Total Running Capacity MWe* | Annual Energy Produced 2009[3)] GWh/yr | Total under Constr. or Planned MWe |
|---|---|---|---|---|---|---|---|---|---|
| Neustadt-Glewe | Neustadt-Glewe | 2003 | 1 | | B | 0.23 | 0.23 | 1748 | |
| Landau | Landau | 2008 | 1 | | B | 3.00 | 3.00 | 22800 | |
| Unter-haching | Unter-haching | 2009 | 1 | | O | 3.36 | 3.36 | 25536 | |
| Total | | | | | | 6.59 | 6.59 | 50084 | |

* Installed capacity is maximum gross output of the plant; running capacity is the actual gross being produced.

## TABLE 3. UTILIZATION OF GEOTHERMAL ENERGY FOR DIRECT HEAT

GeotIS
www.geotis.de/vgs

**Übersicht aller ausgewählten geothermischen Anlagen**

| Name | Zustand | Hauptnutzung | Nebennutzung | Temperatur [max.] | Fließrate [max.] | Teufe [max.] | Leistung gesamt | Leistung geothermisch | Jahresproduktion |
|---|---|---|---|---|---|---|---|---|---|
| Aachen, Kaiserquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 53 °C | 9,7 l/s | kein Eintrag | 0,34 $MW_t$ | 0,34 $MW_t$ | 3,02 GWh/a |
| Aachen, Landesbadquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 72 °C | 22 l/s | kein Eintrag | 3,48 $MW_t$ | 3,48 $MW_t$ | 30,47 GWh/a |
| Aachen, Rosenquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 47 °C | 15 l/s | kein Eintrag | 1,35 $MW_t$ | 1,35 $MW_t$ | 11,86 GWh/a |
| Aachen, Schwertbadquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 70 °C | 1,67 l/s | kein Eintrag | 0,12 $MW_t$ | 0,12 $MW_t$ | 1,03 GWh/a |
| Aachen-Burtscheid, Rosenquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 61 °C | 10 l/s | kein Eintrag | 0,57 $MW_t$ | 0,57 $MW_t$ | 5,00 GWh/a |
| Aalen, TB I u. II | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 36,35 °C | 4,5 l/s | 650,4 m | 0,31 $MW_t$ | 0,31 $MW_t$ | 2,69 GWh/a |
| Aulendorf | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 54 °C | 4,8 l/s | 2076 m | 0,50 $MW_t$ | 0,50 $MW_t$ | 4,36 GWh/a |
| B. Peterstal, Br. 1, Parkpl. | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 20,5 °C | 0,2 l/s | 438,5 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | < 0,01 GWh/a |
| B. Teinach, Otto-Therme II | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 20 °C | 0,64 l/s | 460 m | kein Wert | kein Wert | kein Wert |
| Bad Abbach | Betrieb | Thermalbad / Balneologie | kein Eintrag | 26,4 °C | 6,5 l/s | 676,5 m | 0,05 $MW_t$ | 0,05 $MW_t$ | 0,48 GWh/a |
| Bad Bellingen Markusquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 36,45 °C | 5 l/s | 650 m | 0,34 $MW_t$ | 0,34 $MW_t$ | 3,01 GWh/a |
| Bad Bellingen, Leodegar | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 37,9 °C | 8 l/s | 650 m | 0,60 $MW_t$ | 0,60 $MW_t$ | 5,24 GWh/a |
| Bad Bellingen, QU III | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 39,8 °C | 8 l/s | 1194 m | 0,66 $MW_t$ | 0,66 $MW_t$ | 5,80 GWh/a |
| Bad Bentheim - Fürsten-Quelle (Solequelle) | Betrieb | Thermalbad / Balneologie | kein Eintrag | 40 °C | kein Eintrag | 1175 m | kein Wert | kein Wert | kein Wert |
| Bad Bergzabern, Petronella-Quelle I | Betrieb | Thermalbad / Balneologie | kein Eintrag | 21,9 °C | kein Eintrag | 358 m | kein Wert | kein Wert | kein Wert |
| Bad Bertrich, Bergquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 31,7 °C | kein Eintrag | kein Eintrag | kein Wert | kein Wert | kein Wert |
| Bad Bevensen - Thermal-Jod-Sole-Quelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 24 °C | kein Eintrag | 629 m | kein Wert | kein Wert | kein Wert |
| Bad Birnbach T 3 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 48 °C | 2,5 l/s | 1618 m | 0,29 $MW_t$ | 0,29 $MW_t$ | 2,56 GWh/a |
| Bad Birnbach T 4 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 62 °C | 14 l/s | 1362 m | 2,46 $MW_t$ | 2,46 $MW_t$ | 21,53 GWh/a |
| Bad Breisig, Geiersprudel | Betrieb | Thermalbad / Balneologie | $CO_2$ -Gewinnung | 31,4 °C | kein Eintrag | 605 m | kein Wert | kein Wert | kein Wert |
| Bad Breisig, Ludgerussprudel | Betrieb | $CO_2$ -Gewinnung | Thermalbad / Balneologie | 26 °C | kein Eintrag | 608 m | kein Wert | kein Wert | kein Wert |
| Bad Buchau 1 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 45,7 °C | 5 l/s | 795 m | 1,13 $MW_t$ | 1,13 $MW_t$ | 2,47 GWh/a |
| Bad Buchau 2 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 44,4 °C | 5 l/s | 852,5 m | 0,51 $MW_t$ | 0,51 $MW_t$ | 4,47 GWh/a |
| Bad Colberg, Thermalsolebohrung 1994 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 59 °C | 4,72 l/s | 1400 m | 0,03 $MW_t$ | 0,03 $MW_t$ | 0,30 GWh/a |
| Bad Ditzenbach, Canisius I | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 45,7 °C | 14,03 l/s | 560,7 m | 1,19 $MW_t$ | 1,19 $MW_t$ | 10,45 GWh/a |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Bad Ems, Bohrung Ia (Robert-Kampe-Sprudel) | Betrieb | Thermalbad / Balneologie | kein Eintrag | 57,2 °C | kein Eintrag | 72,9 m | kein Wert | kein Wert | kein Wert |
| Bad Ems, Bohrung IV | Betrieb | Thermalbad / Balneologie | kein Eintrag | 39 °C | kein Eintrag | 130,45 m | kein Wert | kein Wert | kein Wert |
| Bad Ems, Bohrung V | Betrieb | Thermalbad / Balneologie | kein Eintrag | 55,2 °C | kein Eintrag | 368,5 m | kein Wert | kein Wert | kein Wert |
| Bad Ems, Emser Kränchen | Betrieb | Thermalbad / Balneologie | kein Eintrag | 32,1 °C | kein Eintrag | kein Eintrag | kein Wert | kein Wert | kein Wert |
| Bad Ems, Römerquelle | Betrieb | Trink- / Brauchwasser | Thermalbad / Balneologie | 46,2 °C | kein Eintrag | kein Eintrag | kein Wert | kein Wert | kein Wert |
| Bad Emstal | Betrieb | Thermalbad / Balneologie | kein Eintrag | 34 °C | 4 l/s | 759 m | 0,12 $MW_t$ | 0,12 $MW_t$ | 1,03 GWh/a |
| Bad Endorf 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 90 °C | kein Eintrag | 4263,5 m | kein Wert | kein Wert | kein Wert |
| Bad Endorf Gt 3 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 52 °C | 2,1 l/s | 2450 m | 0,21 $MW_t$ | 0,21 $MW_t$ | 1,82 GWh/a |
| Bad Füssing 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 58,6 °C | 16 l/s | 1142,3 m | 2,58 $MW_t$ | 2,58 $MW_t$ | 22,61 GWh/a |
| Bad Füssing 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 53,8 °C | 13,5 l/s | 978,8 m | 1,91 $MW_t$ | 1,91 $MW_t$ | 16,71 GWh/a |
| Bad Füssing 3 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 49,9 °C | 13,4 l/s | 1060,6 m | 1,67 $MW_t$ | 1,67 $MW_t$ | 14,67 GWh/a |
| Bad Gögging Thermalbr. 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 24 °C | 6,8 l/s | 652,2 m | 0,11 $MW_t$ | 0,11 $MW_t$ | 1,00 GWh/a |
| Bad Gögging Therme 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 26,4 °C | 5 l/s | 563 m | 0,13 $MW_t$ | 0,13 $MW_t$ | 1,17 GWh/a |
| Bad Griesbach 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 34,8 °C | 2 l/s | 878 m | 0,12 $MW_t$ | 0,12 $MW_t$ | 1,08 GWh/a |
| Bad Griesbach 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 29 °C | 11 l/s | 480 m | 0,41 $MW_t$ | 0,41 $MW_t$ | 3,63 GWh/a |
| Bad Griesbach 3 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 57 °C | 5 l/s | 1522,4 m | 0,77 $MW_t$ | 0,77 $MW_t$ | 6,77 GWh/a |
| Bad Harzburg - Harras-Schneider-Quelle (Neue Solebohrung) | Betrieb | Thermalbad / Balneologie | kein Eintrag | 20,6 °C | kein Eintrag | 840 m | kein Wert | kein Wert | kein Wert |
| Bad Herrenalb I | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 28,3 °C | 2,5 l/s | 599 m | 0,09 $MW_t$ | 0,09 $MW_t$ | 0,76 GWh/a |
| Bad Herrenalb IV | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 20,6 °C | kein Eintrag | 536 m | kein Wert | kein Wert | kein Wert |
| Bad Homburg: Viktoria Louisenbrunnen | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22,4 °C | 1,6 l/s | 250 m | 0,02 $MW_t$ | 0,02 $MW_t$ | 0,14 GWh/a |
| Bad Hönningen, Deutschland-Sprudel (MQ 7) | Betrieb | Thermalbad / Balneologie | $CO_2$ -Gewinnung | 27,9 °C | kein Eintrag | 372 m | kein Wert | kein Wert | kein Wert |
| Bad Hönningen, Hönniger Sprudel-Neubohrung | Betrieb | $CO_2$ -Gewinnung | Thermalbad / Balneologie | 31,2 °C | kein Eintrag | 580,8 m | kein Wert | kein Wert | kein Wert |
| Bad Kissingen Schönbornsprudel | Betrieb | Thermalbad / Balneologie | kein Eintrag | kein Eintrag | kein Eintrag | kein Eintrag | kein Wert | kein Wert | kein Wert |
| Bad Kreuznach, Theodorshaller Brunnen | Betrieb | Thermalbad / Balneologie | kein Eintrag | 28,8 °C | kein Eintrag | 500,5 m | kein Wert | kein Wert | kein Wert |
| Bad Krozingen TB 2 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 38,1 °C | 0,8 l/s | 596 m | 0,06 $MW_t$ | 0,06 $MW_t$ | 0,53 GWh/a |
| Bad Krozingen TB 3 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 39,4 °C | 20 l/s | 610 m | 0,15 $MW_t$ | 0,15 $MW_t$ | 1,35 GWh/a |
| Bad Krozingen TB 4 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 37,6 °C | 12 l/s | 580 m | 0,12 $MW_t$ | 0,12 $MW_t$ | 1,03 GWh/a |
| Bad Laer - Neue Martinsquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 20,6 °C | kein Eintrag | 159 m | kein Wert | kein Wert | kein Wert |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Bad Langensalza, Thermalsolebohrung 1996 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 25 °C | 0,1 l/s | 741 m | kein Wert | kein Wert | kein Wert |
| Bad Liebenzell (summarisch) | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 23 °C | 6 l/s | 250 m | 0,06 $MW_t$ | 0,06 $MW_t$ | 0,55 GWh/a |
| Bad Mingolsheim, St. Rochus I | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 25,8 °C | 3,5 l/s | 214 m | 0,06 $MW_t$ | 0,06 $MW_t$ | 0,51 GWh/a |
| Bad Münster am Stein, Rheingrafenquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 29,6 °C | kein Eintrag | 20 m | kein Wert | kein Wert | kein Wert |
| Bad Nauheim, Sprudel VII | Betrieb | Thermalbad / Balneologie | kein Eintrag | 30 °C | 4,2 l/s | 151 m | 0,18 $MW_t$ | 0,18 $MW_t$ | 1,54 GWh/a |
| Bad Nauheim, Sprudel XII | Betrieb | Thermalbad / Balneologie | kein Eintrag | 33 °C | 11 l/s | 176 m | 0,60 $MW_t$ | 0,60 $MW_t$ | 5,24 GWh/a |
| Bad Nauheim, Sprudel XIV | Betrieb | Thermalbad / Balneologie | kein Eintrag | 31 °C | 4,3 l/s | 182 m | 0,20 $MW_t$ | 0,20 $MW_t$ | 1,73 GWh/a |
| Bad Nenndorf/ Soldorf - Neue Landgrafenquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 21,7 °C | kein Eintrag | 297 m | kein Wert | kein Wert | kein Wert |
| Bad Neuenahr, Großer Sprudel | Betrieb | Thermalbad / Balneologie | kein Eintrag | 28,5 °C | kein Eintrag | 88,2 m | kein Wert | kein Wert | kein Wert |
| Bad Rodach Therme 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 33,4 °C | 8,2 l/s | 652 m | 0,46 $MW_t$ | 0,46 $MW_t$ | 4,02 GWh/a |
| Bad Rodach Therme 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 35 °C | 5,3 l/s | 1015 m | 0,33 $MW_t$ | 0,33 $MW_t$ | 2,91 GWh/a |
| Bad Saarow-Pieskow | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22 °C | kein Eintrag | 457 m | kein Wert | kein Wert | kein Wert |
| Bad Säckingen, Badquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 31 °C | 15 l/s | 600,3 m | 0,06 $MW_t$ | 0,06 $MW_t$ | 0,56 GWh/a |
| Bad Säckingen, Fridolinquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 28,3 °C | 8 l/s | 505 m | 0,28 $MW_t$ | 0,28 $MW_t$ | 2,43 GWh/a |
| Bad Schönborn, Karl Sigel | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 48,5 °C | 6,25 l/s | 607 m | 0,25 $MW_t$ | 0,25 $MW_t$ | 2,19 GWh/a |
| Bad Schönborn, Lambertus, | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 43,5 °C | 6,5 l/s | 636 m | 0,64 $MW_t$ | 0,64 $MW_t$ | 5,59 GWh/a |
| Bad Schönborn, St. Vitus | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 28 °C | 2 l/s | 208 m | 0,07 $MW_t$ | 0,07 $MW_t$ | 0,59 GWh/a |
| Bad Soden: Alter Sprudel | Betrieb | Thermalbad / Balneologie | kein Eintrag | 26,4 °C | kein Eintrag | 220 m | kein Wert | kein Wert | kein Wert |
| Bad Soden: Br. IIIa und IIIb | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22,7 °C | 0,39 l/s | 6 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,04 GWh/a |
| Bad Soden: Br. IIIa und IIIb | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22,7 °C | 0,39 l/s | 6 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,04 GWh/a |
| Bad Soden: Milchbrunnen | Betrieb | Thermalbad / Balneologie | kein Eintrag | 23 °C | 0,25 l/s | 7 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,03 GWh/a |
| Bad Soden: Neuer Sprudel | Betrieb | Thermalbad / Balneologie | kein Eintrag | 30,9 °C | kein Eintrag | 372 m | kein Wert | kein Wert | kein Wert |
| Bad Soden: Winklerbrunnen | Betrieb | Thermalbad / Balneologie | kein Eintrag | 21,4 °C | 0,07 l/s | kein Eintrag | < 0,01 $MW_t$ | < 0,01 $MW_t$ | < 0,01 GWh/a |
| Bad Soden-Salmünster, Fritz-Hamm-Sprudel | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22,5 °C | 1 l/s | 503 m | 0,01 $MW_t$ | 0,01 $MW_t$ | 0,09 GWh/a |
| Bad Staffelstein Therme 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 50 °C | 3,33 l/s | 1050 m | 0,42 $MW_t$ | 0,42 $MW_t$ | 3,66 GWh/a |
| Bad Staffelstein Therme 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 53,1 °C | 5 l/s | 1180 m | 0,69 $MW_t$ | 0,69 $MW_t$ | 6,06 GWh/a |
| Bad Sulza, Bohrung Bad Sulza 1984 (Sole 84) | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22,4 °C | 1,4 l/s | 613 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,02 GWh/a |
| Bad Überkingen, Ottotherme I | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 40,8 °C | 2,27 l/s | 1020 m | 0,20 $MW_t$ | 0,20 $MW_t$ | 1,73 GWh/a |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Bad Überkingen, Ottotherme II | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 43,2 °C | 11,6 l/s | 1051 m | 0,44 $MW_t$ | 0,44 $MW_t$ | 3,85 GWh/a |
| Bad Überkingen, Renato | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 34,4 °C | 10 l/s | 395 m | 0,36 $MW_t$ | 0,36 $MW_t$ | 3,16 GWh/a |
| Bad Urach (TB1, TB2) | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 54 °C | 10 l/s | 770 m | 1,0 $MW_t$ | 1,0 $MW_t$ | 1,5 GWh/a |
| Bad Waldsee 1 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 31 °C | 6,6 l/s | 1825 m | 0,44 $MW_t$ | 0,44 $MW_t$ | 0,96 GWh/a |
| Bad Waldsee 2 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 69 °C | 3,4 l/s | 1925 m | 0,27 $MW_t$ | 0,27 $MW_t$ | 2,33 GWh/a |
| Bad Wiessee | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22,8 °C | kein Eintrag | kein Eintrag | kein Wert | kein Wert | kein Wert |
| Bad Wilsnack | Betrieb | Thermalbad / Balneologie | kein Eintrag | 48,1 °C | kein Eintrag | 1017,5 m | kein Wert | kein Wert | kein Wert |
| Bad Windsheim TWB 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 20,8 °C | 0,22 l/s | 680 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | < 0,01 GWh/a |
| Bad Windsheim TWB 2 flach | Betrieb | Thermalbad / Balneologie | kein Eintrag | 20 °C | 1 l/s | 296 m | kein Wert | kein Wert | kein Wert |
| Bad Windsheim TWB 2 tief | Betrieb | Thermalbad / Balneologie | kein Eintrag | 25 °C | 0,5 l/s | 548 m | 0,01 $MW_t$ | 0,01 $MW_t$ | 0,09 GWh/a |
| Bad Wörishofen Gt 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 39,9 °C | 2 l/s | 1101 m | 0,17 $MW_t$ | 0,17 $MW_t$ | 1,46 GWh/a |
| Bad Wörishofen Gt 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | kein Eintrag | kein Eintrag | 2600 m | kein Wert | kein Wert | kein Wert |
| Bad Wurzach | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 33,7 °C | 3 l/s | 800 m | 0,02 $MW_t$ | 0,02 $MW_t$ | 0,15 GWh/a |
| Baden-Baden (summarisch) | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 60 °C | 9 l/s | 552 m | 1,49 $MW_t$ | 1,49 $MW_t$ | 13,04 GWh/a |
| Badenweiler | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 26,2 °C | 11,4 l/s | 364 m | 0,30 $MW_t$ | 0,30 $MW_t$ | 2,59 GWh/a |
| Bayreuth | Betrieb | Thermalbad / Balneologie | kein Eintrag | 36 °C | 17 l/s | 1122 m | 1,14 $MW_t$ | 1,14 $MW_t$ | 9,96 GWh/a |
| Belzig | Betrieb | Thermalbad / Balneologie | kein Eintrag | 34,2 °C | kein Eintrag | 786,5 m | kein Wert | kein Wert | kein Wert |
| Beuren TB I | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 48,7 °C | 8 l/s | 755 m | 0,24 $MW_t$ | 0,24 $MW_t$ | 2,10 GWh/a |
| Beuren TB II | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 38 °C | 2,5 l/s | 398 m | 0,15 $MW_t$ | 0,15 $MW_t$ | 1,32 GWh/a |
| Binz / Rügen | Betrieb | Thermalbad / Balneologie | kein Eintrag | 35 °C | kein Eintrag | 1100 m | kein Wert | kein Wert | kein Wert |
| Böblingen, TB II | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 33,6 °C | 3 l/s | 775 m | 0,17 $MW_t$ | 0,17 $MW_t$ | 1,49 GWh/a |
| Bodenwerder - Solebohrung (Kalibohrung Addashall) | Betrieb | Thermalbad / Balneologie | kein Eintrag | 21,5 °C | kein Eintrag | 489 m | kein Wert | kein Wert | kein Wert |
| Boll - Bad Boll, TB | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 45,6 °C | 11,7 l/s | 467 m | 1,07 $MW_t$ | 1,07 $MW_t$ | 9,37 GWh/a |
| Bonlanden | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 24 °C | 0,3 l/s | 365 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,04 GWh/a |
| Breitenbrunn/Bedernau | Betrieb | Thermalbad / Balneologie | kein Eintrag | 28 °C | 2,5 l/s | 760,1 m | 0,08 $MW_t$ | 0,08 $MW_t$ | 0,73 GWh/a |
| Burg | Betrieb | Thermalbad / Balneologie | Forschung | 55 °C | kein Eintrag | 1350 m | kein Wert | kein Wert | kein Wert |
| Erding | Betrieb | Fernwärme | Thermalbad / Balneologie | 65 °C | 55 l/s | 2200 m | 18,0 $MW_t$ | 8,0 $MW_t$ | 28,0 GWh/a |
| Esslingen, Merkelsches Bad | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 31,3 °C | 100 l/s | 184 m | 0,09 $MW_t$ | 0,09 $MW_t$ | 0,83 GWh/a |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Freiburg Mooswald 1 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 45,3 °C | 8,5 l/s | 858 m | 0,90 $MW_t$ | 0,90 $MW_t$ | 7,87 GWh/a |
| Freiburg Mooswald 2 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 30,1 °C | 2,2 l/s | 545 m | 0,09 $MW_t$ | 0,09 $MW_t$ | 0,81 GWh/a |
| Friedrichshafen 1 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 30,2 °C | 3 l/s | 710,3 m | 0,13 $MW_t$ | 0,13 $MW_t$ | 1,12 GWh/a |
| Gartow - Thermalsole-Brunnen | Betrieb | Thermalbad / Balneologie | kein Eintrag | 21,5 °C | kein Eintrag | 211 m | kein Wert | kein Wert | kein Wert |
| Göppingen | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 26 °C | 5,5 l/s | 512 m | 0,05 $MW_t$ | 0,05 $MW_t$ | 0,44 GWh/a |
| Günzburg | Betrieb | Gebäudeheizung | kein Eintrag | 24 °C | 30,5 l/s | 510 m | kein Wert | kein Wert | kein Wert |
| Heide | Betrieb | Thermalbad / Balneologie | kein Eintrag | 23 °C | 1 l/s | 530 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,04 GWh/a |
| Hersbruck TH 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 29,3 °C | 7,5 l/s | 717 m | 0,29 $MW_t$ | 0,29 $MW_t$ | 2,55 GWh/a |
| Hubbad, Ottersweier | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 36 °C | 1,2 l/s | 23 m | 0,08 $MW_t$ | 0,08 $MW_t$ | 0,70 GWh/a |
| Ingolstadt | Betrieb | Thermalbad / Balneologie | kein Eintrag | 28,4 °C | 2,75 l/s | 650 m | 0,10 $MW_t$ | 0,10 $MW_t$ | 0,85 GWh/a |
| Jordanbad, Biberach | Betrieb | Gebäudeheizung | Gewächshaus | 46,7 °C | 10 l/s | 955 m | 1,17 $MW_t$ | 1,17 $MW_t$ | 0,80 GWh/a |
| Kassel, Bohrung Wilhelmshöhe 3 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 40 °C | 0,8 l/s | 672 m | 0,01 $MW_t$ | 0,01 $MW_t$ | 0,11 GWh/a |
| Kißlegg, Otto, B12 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 31,2 °C | 4,9 l/s | 944 m | 0,23 $MW_t$ | 0,23 $MW_t$ | 2,01 GWh/a |
| Kißlegg, Otto, B13 | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 33,3 °C | kein Eintrag | 944 m | kein Wert | kein Wert | kein Wert |
| Konstanz | Betrieb | Thermalbad / Balneologie | kein Eintrag | 26 °C | 7 l/s | 625 m | 0,62 $MW_t$ | 0,62 $MW_t$ | 2,0 GWh/a |
| Landau in der Pfalz | Betrieb | Stromerzeugung | Fernwärme | 160 °C | 70 l/s | 3340 m | 3,5 $MW_t$ | 3,5 $MW_t$ | kein Wert |
| Meersburg | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 26 °C | 4 l/s | 501 m | 0,10 $MW_t$ | 0,10 $MW_t$ | 0,88 GWh/a |
| München Riem | Betrieb | Fernwärme | kein Eintrag | 98,4 °C | 75 l/s | 2746,7 m | 42,0 $MW_t$ | 12,0 $MW_t$ | 43,30 GWh/a |
| Neubrandenburg | Betrieb | Fernwärme | kein Eintrag | 53 °C | 28 l/s | 1267 m | 13,80 $MW_t$ | 3,80 $MW_t$ | 8,32 GWh/a |
| Neuruppin | Betrieb | Fernwärme | Thermalbad / Balneologie | 64 °C | 13,9 l/s | 1929,5 m | 2,10 $MW_t$ | 1,25 $MW_t$ | 2,74 GWh/a |
| Neustadt-Glewe | Betrieb | Fernwärme | Stromerzeugung | 99 °C | 35 l/s | 2320 m | 17,0 $MW_t$ | 7,0 $MW_t$ | 11,9 GWh/a |
| Neu-Ulm | Betrieb | Thermalbad / Balneologie | kein Eintrag | 56 °C | 2 l/s | 1036,6 m | 0,30 $MW_t$ | 0,30 $MW_t$ | 2,64 GWh/a |
| Obernsees | Betrieb | Thermalbad / Balneologie | kein Eintrag | 44,5 °C | 3,67 l/s | 1283 m | 0,38 $MW_t$ | 0,38 $MW_t$ | 3,29 GWh/a |
| Prenzlau | Betrieb | Fernwärme | kein Eintrag | 108 °C | kein Eintrag | 2790 m | 0,5 $MW_t$ | 0,5 $MW_t$ | 1,10 GWh/a |
| Pullach | Betrieb | Fernwärme | kein Eintrag | 102 °C | 43 l/s | 3445 m | 9,60 $MW_t$ | 9,60 $MW_t$ | 21,02 GWh/a |
| Regensburg | Betrieb | Thermalbad / Balneologie | kein Eintrag | 21,2 °C | 8 l/s | 623 m | 0,04 $MW_t$ | 0,04 $MW_t$ | 0,35 GWh/a |
| Rheinbrohl, Petronella-Quelle 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 22,8 °C | kein Eintrag | 411,5 m | kein Wert | kein Wert | kein Wert |
| Salzgitter-Bad - Solequelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 20 °C | kein Eintrag | 243 m | kein Wert | kein Wert | kein Wert |
| Saulgau TB I, TB II | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 40,9 °C | 12,5 l/s | 639 m | 1,09 $MW_t$ | 1,09 $MW_t$ | 9,57 GWh/a |
| S-Bad Cannstatt, Hofr. Seyffer Qu, | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 21,8 °C | 2,9 l/s | 477 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,02 GWh/a |
| Schliengen Schlossquelle | Betrieb | Thermalbad / | Gebäudeheizung | 35 °C | 3 l/s | 739 m | 0,19 $MW_t$ | 0,19 $MW_t$ | 1,65 GWh/a |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Balneologie | | | | | | | |
| Simbach-Braunau | Betrieb | Fernwärme | kein Eintrag | 80 °C | 80 l/s | 1941,8 m | 40,0 $MW_t$ | 7,0 $MW_t$ | 67,0 GWh/a |
| Stein b. Nbg. TH 1 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 20,5 °C | 3,5 l/s | 470 m | < 0,01 $MW_t$ | < 0,01 $MW_t$ | 0,06 GWh/a |
| Steinenstadt, Georgsquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 28 °C | 3,7 l/s | 487 m | 0,12 $MW_t$ | 0,12 $MW_t$ | 1,08 GWh/a |
| Straubing | Betrieb | Fernwärme | Thermalbad / Balneologie | 36,5 °C | 45 l/s | 824,8 m | 5,40 $MW_t$ | 4,10 $MW_t$ | 11,83 GWh/a |
| Templin | Betrieb | Thermalbad / Balneologie | kein Eintrag | 67,4 °C | kein Eintrag | 1788,1 m | kein Wert | kein Wert | kein Wert |
| Thermalwasserbrunnen Herbstein, Vogelsberg | Betrieb | Thermalbad / Balneologie | kein Eintrag | 32 °C | 2,5 l/s | 980 m | 0,13 $MW_t$ | 0,13 $MW_t$ | 1,10 GWh/a |
| Treuchtlingen T 1 (Schäffbräu) | Betrieb | Thermalbad / Balneologie | kein Eintrag | 27,4 °C | 10 l/s | 615,8 m | 0,31 $MW_t$ | 0,31 $MW_t$ | 2,71 GWh/a |
| Treuchtlingen T 2 | Betrieb | Thermalbad / Balneologie | kein Eintrag | 29 °C | 6,8 l/s | 812 m | 0,26 $MW_t$ | 0,26 $MW_t$ | 2,24 GWh/a |
| Tuttlingen I | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 45,3 °C | 10 l/s | 644,3 m | 0,32 $MW_t$ | 0,32 $MW_t$ | 2,78 GWh/a |
| Überlingen, Bodensee-Therme | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 36,8 °C | 4 l/s | 1006 m | 0,14 $MW_t$ | 0,14 $MW_t$ | 1,23 GWh/a |
| Unterhaching | Betrieb | Fernwärme | Stromerzeugung | 122,8 °C | 150 l/s | 3446 m | 38,0 $MW_t$ | 30,40 $MW_t$ | 66,58 GWh/a |
| Unterschleißheim | Betrieb | Fernwärme | kein Eintrag | 81 °C | 90 l/s | 1960 m | 12,9 $MW_t$ | 12,9 $MW_t$ | 28,25 GWh/a |
| Waldbronn, 2. R | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 25,3 °C | 0,85 l/s | 2000 m | 0,02 $MW_t$ | 0,02 $MW_t$ | 0,16 GWh/a |
| Waren / Müritz | Betrieb | Fernwärme | kein Eintrag | 63 °C | 17 l/s | 1566 m | 10,0 $MW_t$ | 1,3 $MW_t$ | 2,90 GWh/a |
| Warmbad Wolkenstein | Betrieb | Thermalbad / Balneologie | kein Eintrag | 26,3 °C | 2,5 l/s | kein Eintrag | 0,07 $MW_t$ | 0,07 $MW_t$ | 0,58 GWh/a |
| Weiden Therme | Betrieb | Thermalbad / Balneologie | kein Eintrag | 23,3 °C | 1,8 l/s | 1459,7 m | 0,02 $MW_t$ | 0,02 $MW_t$ | 0,22 GWh/a |
| Wiesbaden: Gr. Adlerquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 65,1 °C | 6 l/s | 60 m | 0,90 $MW_t$ | 0,90 $MW_t$ | 7,86 GWh/a |
| Wiesbaden: Kl. Adlerquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 62 °C | 6 l/s | 55 m | 0,28 $MW_t$ | 0,28 $MW_t$ | 2,45 GWh/a |
| Wiesbaden: Kochbrunnen | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 67,5 °C | 10 l/s | 40 m | 1,57 $MW_t$ | 1,57 $MW_t$ | 13,79 GWh/a |
| Wiesbaden: Salmquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 64,2 °C | 6 l/s | 47 m | 0,59 $MW_t$ | 0,59 $MW_t$ | 5,13 GWh/a |
| Wiesbaden: Schützenhofquelle | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 49,3 °C | 6 l/s | 65 m | 0,19 $MW_t$ | 0,19 $MW_t$ | 1,71 GWh/a |
| Wiesenbad Georgsquelle | Betrieb | Thermalbad / Balneologie | kein Eintrag | 26 °C | kein Eintrag | kein Eintrag | kein Wert | kein Wert | kein Wert |
| Wildbad I-VI | Betrieb | Thermalbad / Balneologie | Gebäudeheizung | 37,7 °C | 13 l/s | 200,7 m | 0,96 $MW_t$ | 0,96 $MW_t$ | 8,43 GWh/a |

Die Tabelle wurde nicht sortiert. Stand 27.10.2009

**TABLE 4. GEOTHERMAL (GROUND-SOURCE) HEAT PUMPS AS OF 31 DECEMBER 2009**

This table should report thermal energy used (i.e. energy removed from the ground or water) and report separately heat rejected to the ground or water in the cooling mode. Cooling energy numbers will be used to calculate carbon offsets.

1) Report the average ground temperature for ground-coupled units or average well water or lake water temperature for water-source heat pumps

2) Report type of installation as follows: V = vertical ground coupled (TJ = $10^{12}$ J)
H = horizontal ground coupled
W = water source (well or lake water)
O = others (please describe)

3) Report the COP = (output thermal energy/input energy of compressor) for your climate
SFP = seasonal performance factor

4) Report the equivalent full load operating hours per year, or = capacity factor x 8760

5) Thermal energy (TJ/yr) = flow rate in loop (kg/s) x [(inlet temp. (°C) - outlet temp. (°C)] x 0.1319
or = rated output energy (kJ/hr) x [(COP - 1)/COP] x equivalent full load hours/yr

**Note:** please report all numbers to three significant figures

| Locality | Ground or water temp. (°C)1) | Typical Heat Pump Rating or Capacity (kW) | Number of Units | Type2) | COP3) (SPF) | Heating Equivalent Full Load Hr/Year4) | Thermal Energy Used (TJ/yr) | Cooling Energy (TJ/yr) |
|---|---|---|---|---|---|---|---|---|
| Germany | 8 - 12 | 2,230,000 | 178,000 | V,H,W | 4 (3.5) | | 10,368 | |

**TABLE 5. SUMMARY TABLE OF GEOTHERMAL DIRECT HEAT USES AS OF 31 DECEMBER 2009**

1) Installed Capacity (thermal power) (MWt) = Max. flow rate (kg/s) x [inlet temp. ($^o$C) - outlet temp. ($^o$C)] x 0.004184
or = Max. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg)] x 0.001

2) Annual Energy Use (TJ/yr) = Ave. flow rate (kg/s) x [inlet temp. ($^o$C) - outlet temp. ($^o$C)] x 0.1319 (TJ = $10^{12}$ J)
or = Ave. flow rate (kg/s) x [inlet enthalpy (kJ/kg) - outlet enthalpy (kJ/kg) x 0.03154

3) Capacity Factor = [Annual Energy Use (TJ/yr)/Capacity (MWt)] x 0.03171 ( MW = $10^6$ W)
Note: the capacity factor must be less than or equal to 1.00 and is usually less,
since projects do not operate at 100% capacity all year

**Note:** please report all numbers to three significant figures.

| Use | Installed Capacity[1] (MWt) | Annual Energy Use[2] (TJ/yr = $10^{12}$ J/yr) | Capacity Factor[3] |
|---|---|---|---|
| Individual Space Heating[4] | 1.2 | 2.9 | 0.076633 |
| District Heating [4] | 209.3 | 1054.4 | 0.159747 |
| Air Conditioning (Cooling) | | | |
| Greenhouse Heating | | | |
| Fish Farming | | | |
| Animal Farming | | | |
| Agricultural Drying[5] | | | |
| Industrial Process Heat[6] | | | |
| Snow Melting | | | |
| Bathing and Swimming[7] | 44.9 | 1339.2 | 0.945791 |
| Other Uses (specify) | | | |
| **Subtotal** | 255.4 | 2396.5 | |
| Geothermal Heat Pumps | 2230 | 10368.0 | 0.14743 |
| **TOTAL** | 2485.4 | 12764.5 | |

4) Other than heat pumps
5) Includes drying or dehydration of grains, fruits and vegetables
6) Excludes agricultural drying and dehydration
7) Includes balneology

**TABLE 6. WELLS DRILLED FOR ELECTRICAL, DIRECT AND COMBINED USE OF GEOTHERMAL RESOURCES FROM JANUARY 1, 2005 TO DECEMBER 31, 2009 (excluding heat pump wells)**

1) Include thermal gradient wells, but not ones less than 100 m deep

| Purpose | Wellhead Temperature | Number of Wells Drilled | | | | Total Depth (km) |
|---|---|---|---|---|---|---|
| | | Electric Power | Direct Use | Combined | Other (specify) | |
| Exploration[1)] | (all) | 3 | 8 | 6 | 19 spa | 4 wells no information 57.0 |
| Production | >150° C | | | 1 | | 3.3 |
| | 150-100° C | | 2 | 1 | | 9.7 |
| | <100° C | | 8 | | | 14.5 |
| Injection | (all) | | 9 | 3 | | 27.0 |
| Total | | 3 | 27 | 11 | 19 | 111.5 |

**TABLE 7. ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES** (Restricted to personnel with University degrees)

(1) Government
(2) Public Utilities
(3) Universities
(4) Paid Foreign Consultants
(5) Contributed Through Foreign Aid Program
(6) Private Industry

| Year | Professional Person-Years of Effort | | | | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| 2005 | | | | | | |
| 2006 | | | | | | |
| 2007 | | | | | | |
| 2008 | | | | | | |
| 2009 | | | | | | |
| Total | | | | | | |

**ALLOCATION OF PROFESSIONAL PERSONNEL TO GEOTHERMAL ACTIVITIES**

Activities **not** restricted to personnel with University degrees

n. o. = not available

| Year | number of employees |
|---|---|
| 2004 | 1,800 |
| 2005 | n. o. |
| 2006 | 4,200 |
| 2007 | 4,500 |
| 2008 | 9,100 |

(data BMU 2009)

**TABLE 8. TOTAL INVESTMENTS IN GEOTHERMAL IN (2009) US$**

| Period | Research & Development Incl. Surface Explor. & Exploration Drilling | Field Development Including Production Drilling & Surface Equipment | Utilization | | Funding Type | |
|---|---|---|---|---|---|---|
| | | | Direct | Electrical | Private | Public |
| | Million US$ | Million US$ | Million US$ | Million US$ | % | % |
| 1995-1999 | see Figure 11 | | | | | |
| 2000-2004 | see Figure 11 | | | | | |
| 2005-2009 | see Figure 11 | | | | | |