

A Deep Drilling Rig from Herrenknecht
in the Bavarian Kirchweidach



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GEO THERMAL ENERGY

the plus for the future energy mix

- + **FULLY** capable of supplying the base load
- + **COMPLETELY** decentralized
- + **ESPECIALLY** safe supply



Svartsengi geothermal power
plant close to Keflavik, Iceland

GEOTHERMAL ENERGY provides enormous potential for a reliable energy concept for the future.

WHAT WE NEED IS AN ENERGY SUPPLY THAT IS ENVIRONMENTALLY-FRIENDLY AND STABLE AT ALL TIMES. The success of Germany as a business location depends on an energy supply that is safe, capable of supplying the base load and cost-efficient. In view of an increasing demand for clean energy, geothermal energy can play a central role as an energy supply, because it reduces the impact on climate and environment, is constantly available and has a high energy efficiency. Geothermy or geothermal energy is the energy that is stored as heat beneath the earth's surface. In the same way as solar and wind energy, hydropower and biomass it belongs to the renewable forms of energy. Geothermal energy has the special advantage that it is constantly

available independent of the season and the time of the day, which means it is capable of supplying the base load. The temperature in the topmost layer of the Earth – the Earth's crust – increases by approx. 30°C at each kilometer of depth. The heat stored in the uppermost 3,000 meters could cover the current energy requirements of the world by 20,000 times. Geothermal energy can be used for both power generation and heating & cooling. Already today, shallow geothermal energy provides an unsubsidized and cost-efficient alternative to conventional energy sources. The consistent use of geothermal energy offers enormous potential for the energy mix of the future. As a local energy source, it guarantees a reliable basic service and increases independence from imports.

GEOTHERMAL ENERGY IS DECENTRALIZED!

The future of geothermal energy does not depend on the location. Electricity and/or heat can be generated where it is needed. And therefore there is no need for transmission lines that are thousands of kilometres long. This means that geothermal energy saves transport costs and reduces the impact on the environment and the landscape.

GEOTHERMAL ENERGY IS DURABLE!

Geothermal energy can be used in the long term and, as far as we can judge, it is inexhaustible, in the same way as wind or solar energy. In addition, the underground can be used as a storage facility for heat energy.

GEOTHERMAL ENERGY IS CAPABLE OF SUPPLYING THE BASE LOAD!

Geothermal energy is always available, independent of the time of the day, the season, the wind speed or the number of sunshine hours. This means that it can provide an optimum basic service.

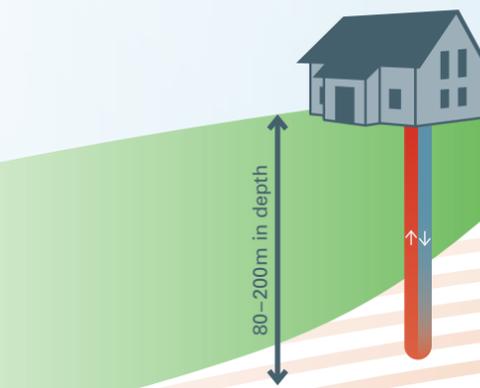
GEOTHERMAL ENERGY IS ENVIRONMENTALLY-FRIENDLY!

The use of geothermal energy for heating, cooling and power generation is a sustainable solution that causes almost no emissions. There are no major interferences into the landscape.

GEOTHERMAL ENERGY PROVIDES SECURITY OF SUPPLY!

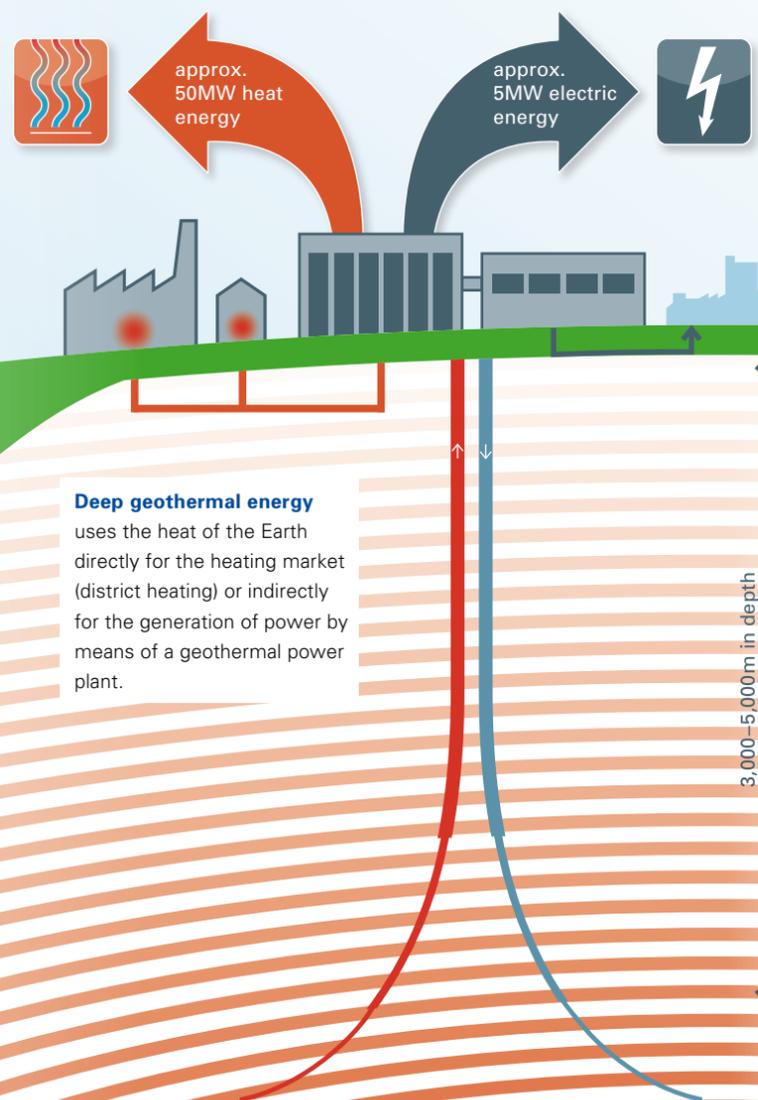
As a local energy source, geothermal energy provides high security of supply and it is completely independent of imports.

SHALLOW GEOTHERMAL ENERGY



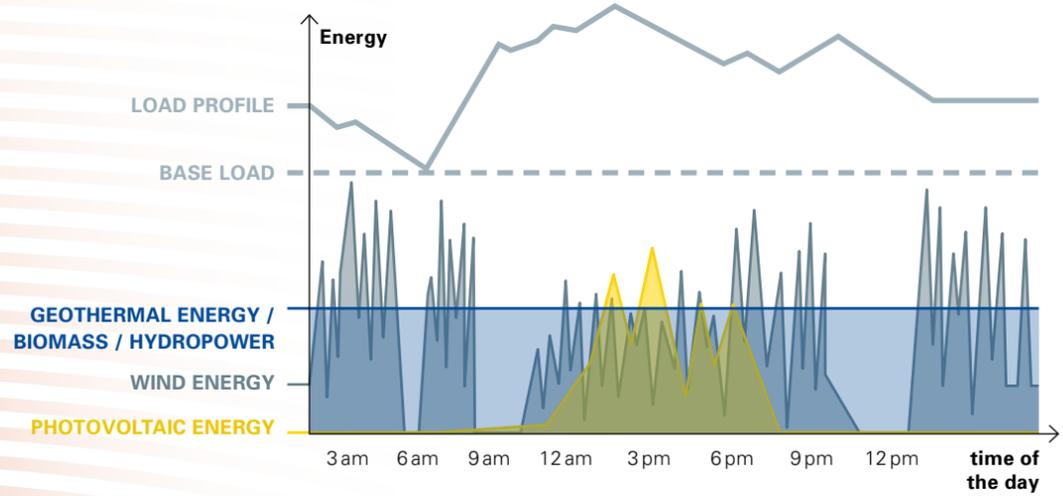
Shallow geothermal energy uses the heat of the Earth directly, for instance, for heating and cooling private houses or office buildings by means of heat pumps.

DEEP GEOTHERMAL ENERGY



Deep geothermal energy uses the heat of the Earth directly for the heating market (district heating) or indirectly for the generation of power by means of a geothermal power plant.

FULL BASE-LOAD CAPABILITY OF GEOTHERMAL ENERGY COMPARED WITH OTHER RENEWABLE ENERGY SOURCES



Base load refers to the network load which an electricity network does not fall below during a day. In Germany it lies at around 40 gigawatt.

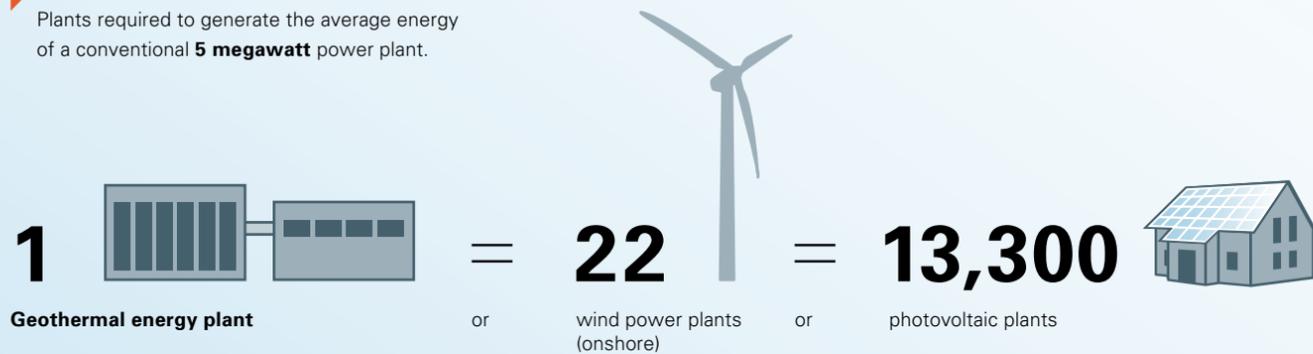
Investments in **GEOTHERMAL ENERGY** pay off.

GREAT ADVANTAGE FOR THE ENERGY MIX OF TOMORROW. Power generation from geothermal energy is a comparatively young technology in Central Europe. The technical challenges are greater here than is the case when accessed in volcanic regions such as Iceland. In Germany, the first geothermal energy plants were connected to the power grid as pilot plants in 2007. They have proved their worth with their base-load capability and environmental compatibility. Neither replacement plants nor large electricity storage facilities need to be maintained to adjust to times without sufficient solar radiation or wind, as is the case with other energy sources. This means that significant fossil resources can be saved and greenhouse gas emissions avoided.

As a young technology, geothermal energy offers enormous development potential. Together with an optimized drilling and power plant technology and a targeted choice of locations, geothermal energy can become an important component for the energy mix of the future. In contrast to other renewable energy sources, geothermal energy has not been systematically subsidized so far. Only if publicly-funded promotion measures begin to consistently focus on the environmental sustainability and base-load capability of an energy source, will this help geothermal energy to achieve a sustainable breakthrough. As with other renewable energies, Germany is also a pioneer in the development of this technology. The extension of geothermal energy will create new and safe jobs in Germany.

GEOTHERMAL ENERGY IS EFFICIENT!

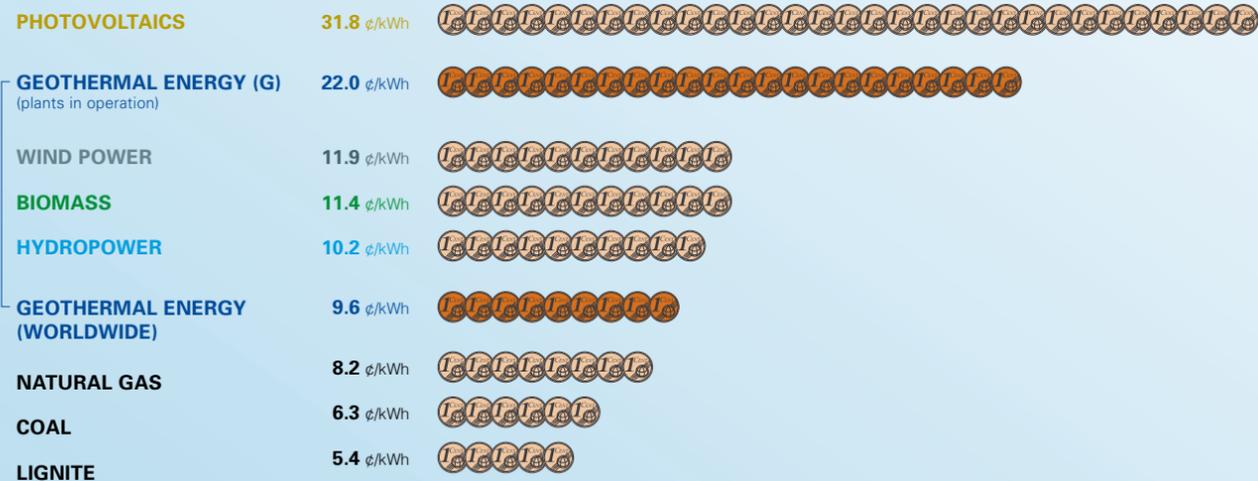
Plants required to generate the average energy of a conventional **5 megawatt** power plant.



Basis of calculation:
 Wind power: average power installed in Germany is 1,260 MW /plant and has an average energy efficiency of 18% (source: Federal Association for Wind Energy 2011)
 Photovoltaic energy: max. installed power per roof is 3.75 kW and has an average energy efficiency of 10% (source: EC Joint Research Centre Photovoltaic, PVGIS)

PROMOTING GEOTHERMAL ENERGY PAYS OFF!

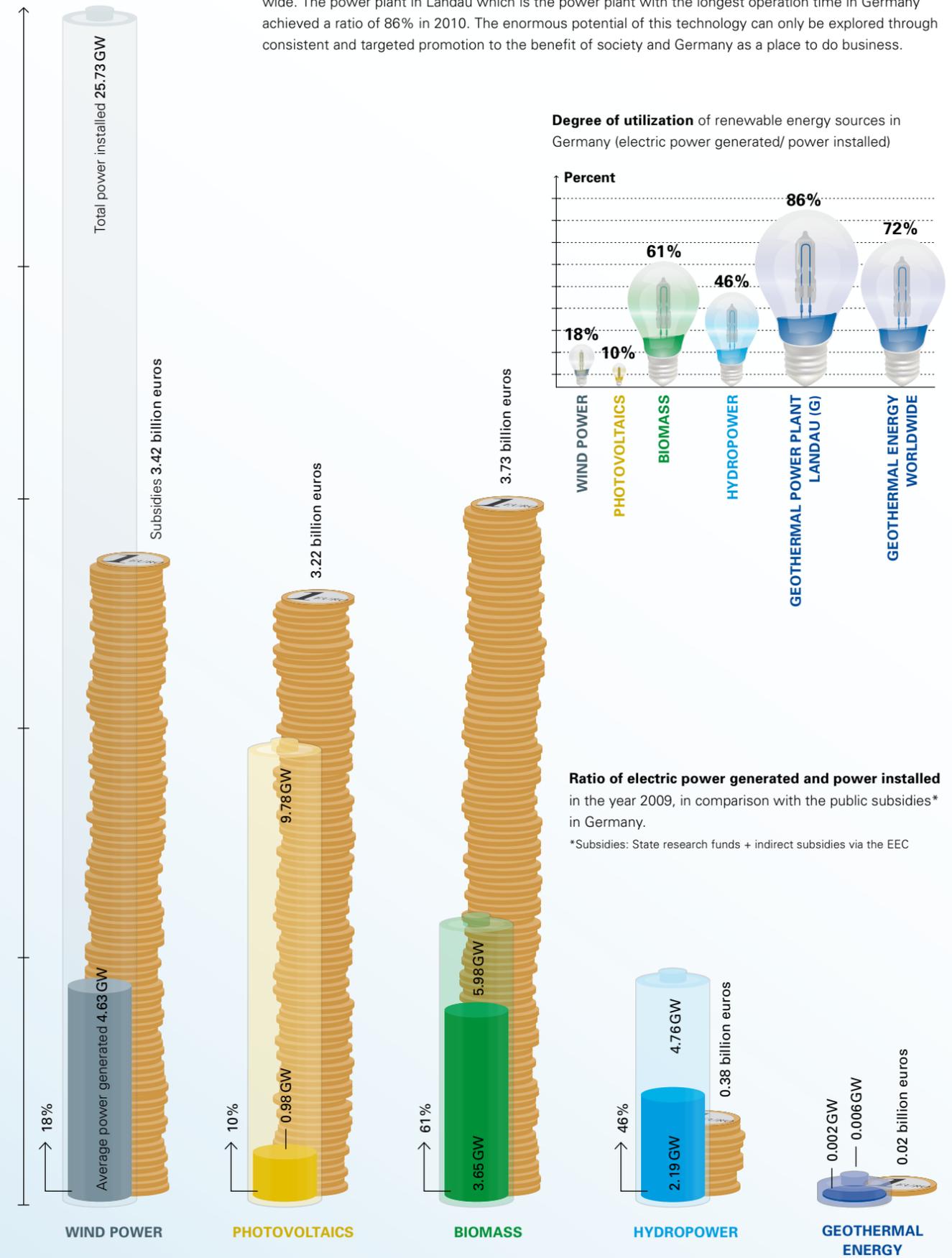
Average **power generation costs** in cent/kWh in Germany. The values include all life-cycle costs, including capital and operating costs, costs for replacement plants, CO₂ certificate trading and consider the development of fuel costs.



* Significantly higher prices are expected for offshore installations.
 Sources: Wissel et al. 2010, Voß et al. 2008; Geothermie – Basis Experience Report of the Federal Ministry for Environment (BMU) EEC 2010, MIT Report 2007

GEOTHERMAL ENERGY BRINGS GREAT BENEFITS!

Because of its high degree of utilization, geothermal energy helps to relieve the grid, causing comparatively low costs. The ratio between the power generated and the power installed lies at over 70% worldwide. The power plant in Landau which is the power plant with the longest operation time in Germany achieved a ratio of 86% in 2010. The enormous potential of this technology can only be explored through consistent and targeted promotion to the benefit of society and Germany as a place to do business.



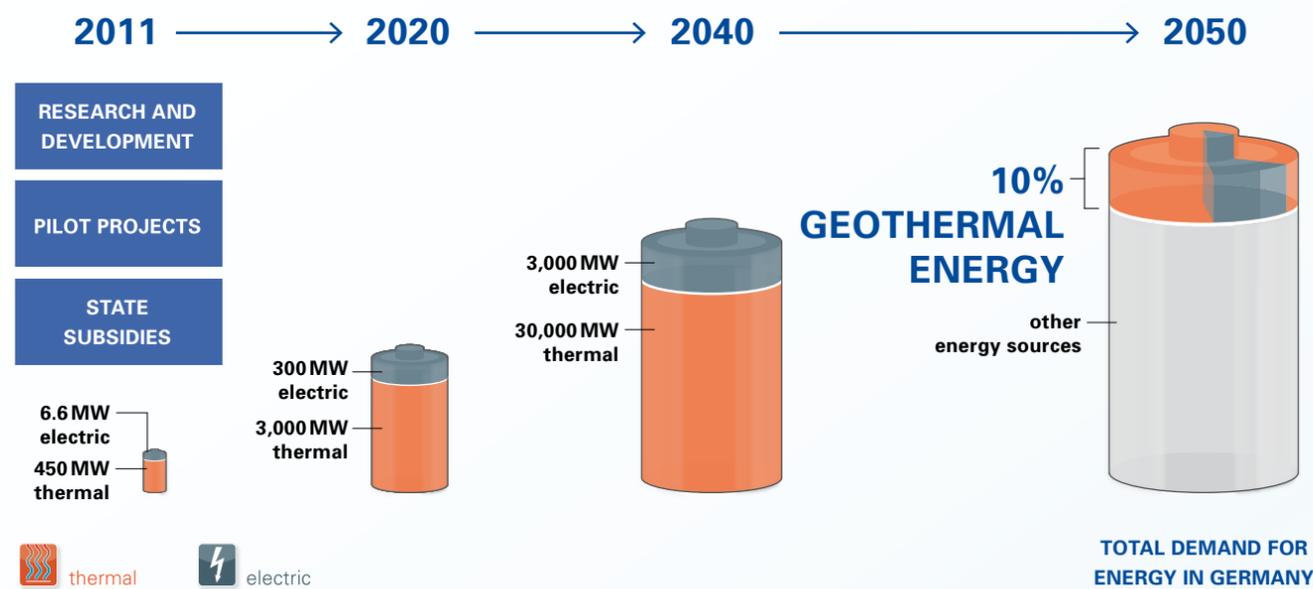
Sources for both diagrams: Annual report 2010 of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU); Working Group Renewable Energy Statistics (AGEE) 2011; Statistics Report of the Federal Network Agency (BNetzA) 2008/2009; Bertani 2010, Geothermal Power Generation in the World – 2005–2010 Update Report

Strong partners and clear-cut measures bring progress.

GEOHERMAL ENERGY IS A PROMISING PIONEER TECHNOLOGY WHICH NOW NEEDS CONSISTENT PROMOTION. Geothermal energy can play a decisive role among renewable energy sources to create the energy mix of the future. However, targeted state subsidies are required to allow a consistent use of the manifold advantages of geothermal energy. Now, investigation, drilling and power

plant technology must be developed in a systematic and holistic way together with the relevant research institutes. Based on the progress in engineering and supported by political decision-makers, geothermal energy can become an important component in securing an energy conversion that is capable of supplying the base load.

VISION OF THE USE OF GEOHERMAL ENERGY IN GERMANY



In the coming 10 years, new geothermal energy plants generating a total of 300 megawatt electric power must be built. The pilot and development projects necessary for that are to be planned and carried out under the guidance of a National Geothermal Energy Research Center, involving partners from public policy, industry and research institutes.

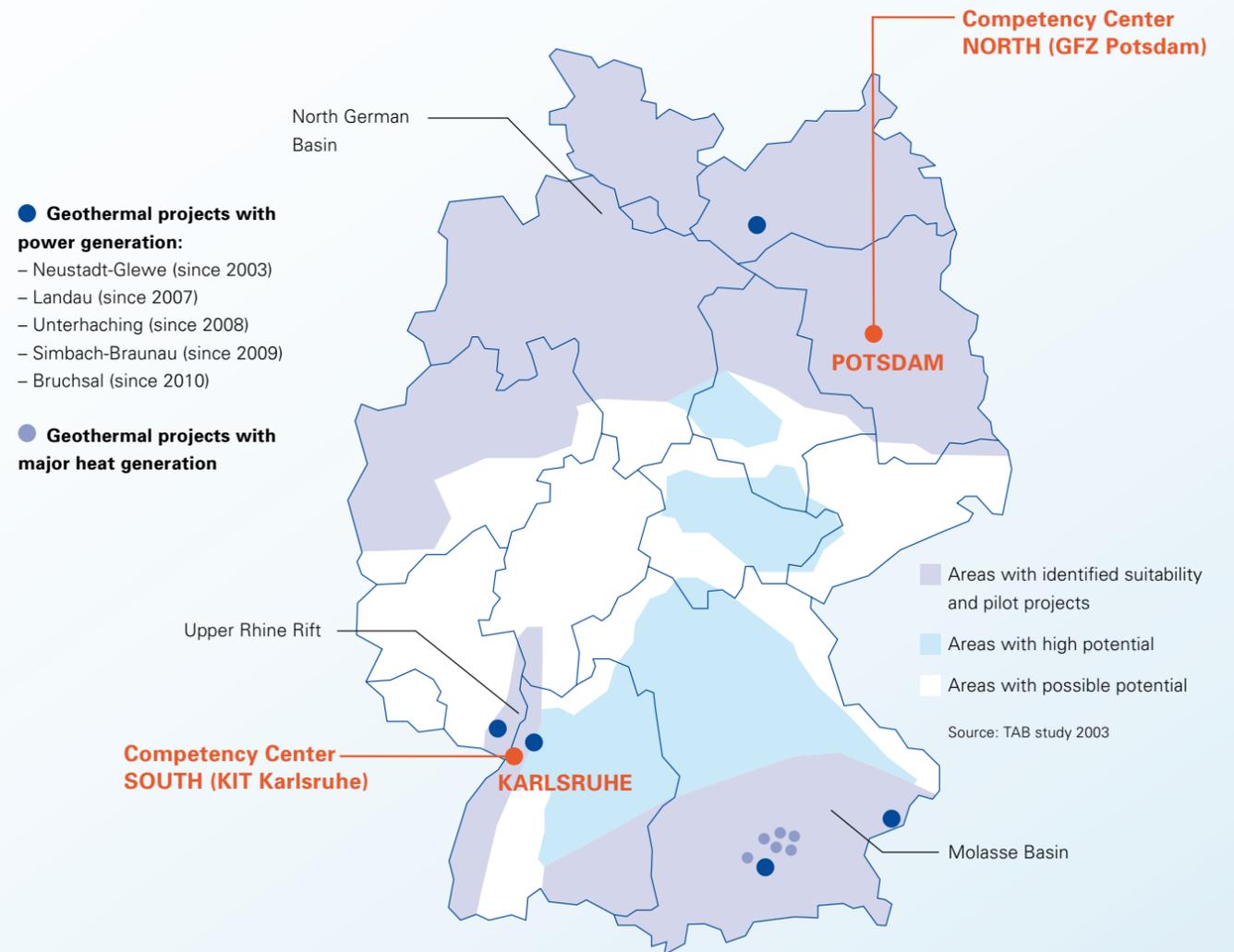
CHALLENGES AND GOALS

- 1 INCREASE IN EXPLORATION SAFETY**
Better and more reliable predictions are possible when searching for appropriate, water-bearing soil layers. Development and use of innovative exploration technologies in connection with scientific drilling.
- 2 OPTIMIZATION OF TECHNOLOGIES**
User-oriented development and optimization of drilling, plant and pumping technologies, aimed at considerably reducing costs and improving investment security.

- 3 MINIMIZATION OF RISKS**
Gaining a comprehensive understanding of all relevant underground processes in order to be able to prevent major seismic events and to increase cost effectiveness and efficiency. Setting up an underground laboratory in the Black Forest, in order to be able to investigate processes and events under realistic conditions.
- 4 INVOLVING THE PUBLIC**
The public shall be continuously informed about the developments within geothermal energy in an open and objective manner.

THE FUTURE OF GEOHERMAL ENERGY IN GERMANY

Because of the geological conditions in Germany, the settings for geothermal energy are different in the south and in the north and require different approaches. The necessary technologies must be further developed and implemented jointly by industry and scientific institutions in Germany. The necessary coordination is to be carried out by two major research centers in Karlsruhe and Potsdam.



MEASURES

- 1 RESEARCH & DEVELOPMENT**
Setting up a National Geothermal Energy Center, consisting of the research and competency centers KIT Karlsruhe (South) and the GFZ Potsdam (North). Quality assurance, monitoring and control of the engineering process; further development of deep geothermal energy to market maturity.
- 2 APPROVAL PROCEDURE**
Accelerated approval procedures and further development of the legal framework conditions (e.g. legally ensuring that 50% of the energy for heating and cooling in development and industrial areas must be provided by renewable energy sources).
- 3 PILOT PROJECTS**
Carrying out several development projects under scientific guidance with more than 10 megawatt electric and 100 megawatt thermal power. Examining the results gained in long-term studies.
- 4 STATE SUBSIDIES**
In order to replace the base-load capability of a conventional major power station with geothermal energy, corresponding subsidies are required, something that is usual in any technological development. This means that, in comparison to other forms of regenerative energy, subsidy programs must be expanded systematically to make available sums of up to several hundred million euros annually over the next 10 years.