Geothermal energy is indispensable for transforming the heating sector

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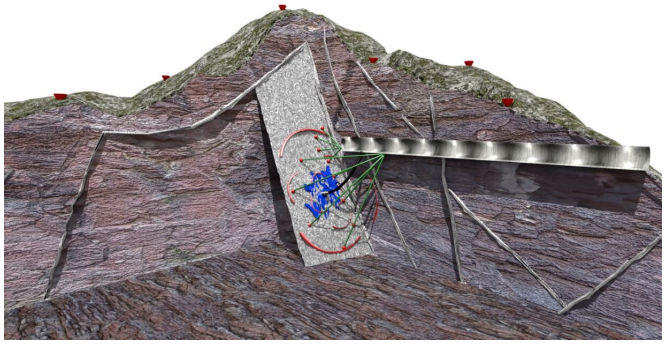

GeoLaB is a generic geoscientific underground laboratory in crystalline bedrock. Research is aimed at a safe and ecologically sustainable use of major geothermal energy resources in Germany. Credit: KIT

Half of municipal heating is envisaged to come from climate-neutral sources by 2030. Deep geothermal energy can largely contribute to reaching this goal of the federal government, as it ensures stable and weather-independent energy supply on a local level and needs little space in populated areas. A joint roadmap of centers of the Helmholtz Association, including Karlsruhe Institute of Technology (KIT), and Fraunhofer Society now shows that deep geothermal energy has a market potential in Germany and that its expanded use could cover more than a quarter of Germany's annual heat consumption (more than 300 TWh). The roadmap also contains recommendations to reach this goal and underscores the need for expansion targets, large-scale geological exploration, investment in key technologies, and training of a skilled workforce.

"To reach the goal of more than 300 terawatt hours, we need technology development," says Professor Thomas Kohl from KIT's Institute of Applied Geosciences. He will coordinate the future underground research laboratory GeoLaB, a joint initiative of KIT, the German Research Centre for Geosciences (GFZ), and the Helmholtz Centre for Environmental Research (UFZ). "Application and development of latest monitoring and analysis tools at GeoLaB will provide insights that will be of crucial importance to the safe and ecologically sustainable use of geothermal energy and other subsurface resources. We attach very high priority to transparent interaction with the public and decision-makers," Kohl continues.

"Without geothermal energy, decarbonization of Germany's heating sector will be impossible. The natural underground heat potentials are available in most urban areas. Sustainable development of geothermal energy use is an investment in the cities of our future," says Professor Ingo Sass, who heads the Geoenergy Section of GFZ. "With their strategic research programs and their unique research infrastructures, such as the future underground research laboratory GeoLaB, the Helmholtz centers contribute significantly to the success of this transformation," Sass adds.

According to Sass, underground research laboratories, such as GeoLaB, are of central importance, because they enhance basic physical, chemical, and biological understanding of sites with similar geological properties. And he points out: "We use our research findings in applied, industrial, and pilot projects in order to demonstrate to society that safe and large-scale supply of geothermal energy is possible."

Subsurface local heat sources and potential storage systems exist in wide areas in Germany. "In urban spaces, we will have to balance demand and local supply. KIT is presently developing the storage technology required at its DeepStor facility," says Professor Eva Schill from KIT's Institute for Nuclear Waste Disposal, who heads DeepStor. "An essential element is the regional heating concept developed in cooperation with citizens."

"UFZ contributions focus on digitalization and on geothermal systems analyses," says Professor Olaf Kolditz, Head of the Department of Environmental Informatics of UFZ. "Among others, we are studying concepts of 'digital twins' and virtualization to digitally replicate natural and technical systems (real-world labs) as realistically as possible. In this way, geothermal systems can be technically optimized, their efficient integration in the overall energy system can be simulated, and environmental impacts can be estimated in the long term."

The roadmap was developed by GFZ in cooperation with colleagues from KIT and UFZ as well as from the Fraunhofer Society. GFZ researcher Professor Ernst Huenges, who issued the roadmap together with Professor Rolf Bracke from the Fraunhofer Research Institution for Energy Infrastructures and Geothermal Systems (IEG), says: "It is a huge challenge to achieve climate neutrality of the heating market. This requires a whole package of measures. Market players, such as the utilities, industrial companies, housing industry, the financial sector, politics, administration, trainers, and municipalities need new tools for this complex task."

The roadmap contains necessary information on geothermal heat supplies, on the diversity of the heating market, and on technical implementation of a transformation of the heating sector. Moreover, it recommends actions to promote the use of geothermal energy for climate-neutral heat supply.

Five recommendations are given to expand the use of geothermal energy for the heating market in Germany:

1. Clear expansion targets: Parliaments and municipal councils should define clear expansion targets, accompanied by the corresponding legislation and statutes, ranging from the Federal Mining Act to regional planning.
2. Risk compensation for companies and municipalities: Small and medium-sized companies, such as municipal utilities, are active on the heating market. They can bear economic risks, such as the exploration of deep geothermal energy sources, to a limited extent only. Consequently, financial instruments are needed for inter-municipal risk compensation, such as state insurances or revolving funds that finance shares of the projects. In addition, the federal states should set up a nationwide geoscientific exploration program to reduce the discovery risk for municipalities and companies.
3. Investments in key technologies: To increase the number of deep geothermal energy plants in Germany from a few tens to thousands, investment in key technologies is needed. Such key technologies include drilling methods, reservoir management, borehole water pumps, high-temperature heat pumps, large-scale heat storage systems, trans-municipal heat networks, and cross-sectoral systems integration.
4. Education and training of skilled workers: The growing geothermal energy industry creates regional jobs in technology development, planning, and production as well as in plant construction and operation in the amount of about five to ten full-time equivalent jobs per megawatt installed power. To educate and train thousands of specialists, academic education is required and courses offered by the chambers of trade, industry, and commerce need to be supplemented.
5. Dialog with citizens: Managing the society's challenges requires the society's acceptance. Municipal stakeholders will therefore need more than just business management and plant engineering strategies. Citizen energy models, municipal communication strategies, and transparent projects will be required to take all local stakeholders along on the way towards transformation of the regional heating sector.

The heating sector accounts for 56 percent of the national energy demand. Only about 15 percent of the heat are based on regenerative sources. The roadmap presented now discusses the contribution of geothermal energy to the transformation of the

heating sector. The focus is on hydrothermal reservoirs, i.e. thermal water-bearing rocks at depths between 400 and 5000 meters. Geothermal waters with temperatures ranging from 15 to 180 degrees Celsius may be extracted from such deep wells. They are available regardless of the season and time of day and can be used in particular for local and district heating and even for low-temperature processes in industry. The technology is mature and has been used for decades in many European cities, such as Paris and Munich.

According to the roadmap's estimates, hydrothermal geothermal energy—combined with large-scale heat pumps—as a heat source for district heating networks could cover around a quarter of Germany's total heat demand, theoretically around 300 terawatt hours of annual work with 70 gigawatts of installed capacity. For comparison: In 2020, 42 plants supplied 359 megawatts of installed thermal capacity and 45 megawatts of electrical capacity in Germany.

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