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Summary

Geothermal Technologies in Urban Settings

A Contribution to the Heating Transition and Climate Protection

R. Emmermann et al.

Germany is pursuing ambitious climate policy goals as a contribution to the Paris Climate Agreement: greenhouse gas emissions are to be reduced by 65 per cent by 2030 and by 88 per cent by 2040 compared to 1990 levels in order to achieve climate neutrality by 2045 and negative greenhouse gas emissions after 2050. In comparison with the expansion of renewable energy sources in the electricity system, climate-friendly restructuring of the heating sector has so far been lagging well behind. The heating sector accounts for around half of Germany's primary energy consumption and is therefore a major climate protection lever. However, some two thirds of heat generation is still based on fossil fuels. In addition to renovation and efficiency improvements reducing heating energy requirements, the use of renewable energies will also have a vital part to play in making the supply of heat climate-neutral in the coming years.

Geothermal energy can make a significant contribution to defossilising heat generation. Although geothermal energy's share in renewable heat generation is currently still very low, Germany's geological structures have great potential in particular for the use of deep hydro-geothermal energy. It is precisely in urban areas with major heat demand that deep geothermal energy can replace existing fossil fuels to a significant extent. As a domestic energy source, geothermal energy can be easily and efficiently integrated into heating networks, which already exist in densely populated urban areas and will become increasingly important as the heating transition required by climate policy progresses. The already planned upgrades of heating networks to "heating networks 4.0", which can be operated at lower temperatures, will mean potential geothermal heat sources can be put to still more efficient use and combined with other renewables such as solar thermal energy, biomass or waste heat. In addition, geothermal technologies can also contribute to supplying cooling, something which, in the light of climate change, will in future become increasingly important in particular in urban areas.

Geothermal energy is not only a climate-friendly and domestic heat source that is independent of the seasons and weather and expands the portfolio of possible options for climate-friendly heat generation. Harnessing geothermal technologies also offers the potential for underground storage of heat and cold in suitable reservoirs, not only in the short term, but also seasonally. These storage options create additional energy system flexibility and can be combined with the use of large-scale and high-temperature heat pumps which can where necessary adjust the heat from geothermal energy to required higher flow

At a glance

- Around two thirds of Germany's heat generation is still based on fossil fuels.
- Geothermal energy is a domestic heat source that is independent of the seasons and weather and expands the portfolio of options for climate-friendly heat generation.
- Harnessing and exploiting geothermal potential for heat supply is a possibility in large parts of Germany. Geothermal energy also offers the possibility of storing heat and cold underground not only in the short term but also seasonally as part of an integrated energy system.
- Unlocking this potential requires the creation of a suitable political and regulatory framework, such as taking geothermal energy into account as part of mandatory local government heat planning or cushioning the financial risks of geothermal projects for less financially strong local authorities.

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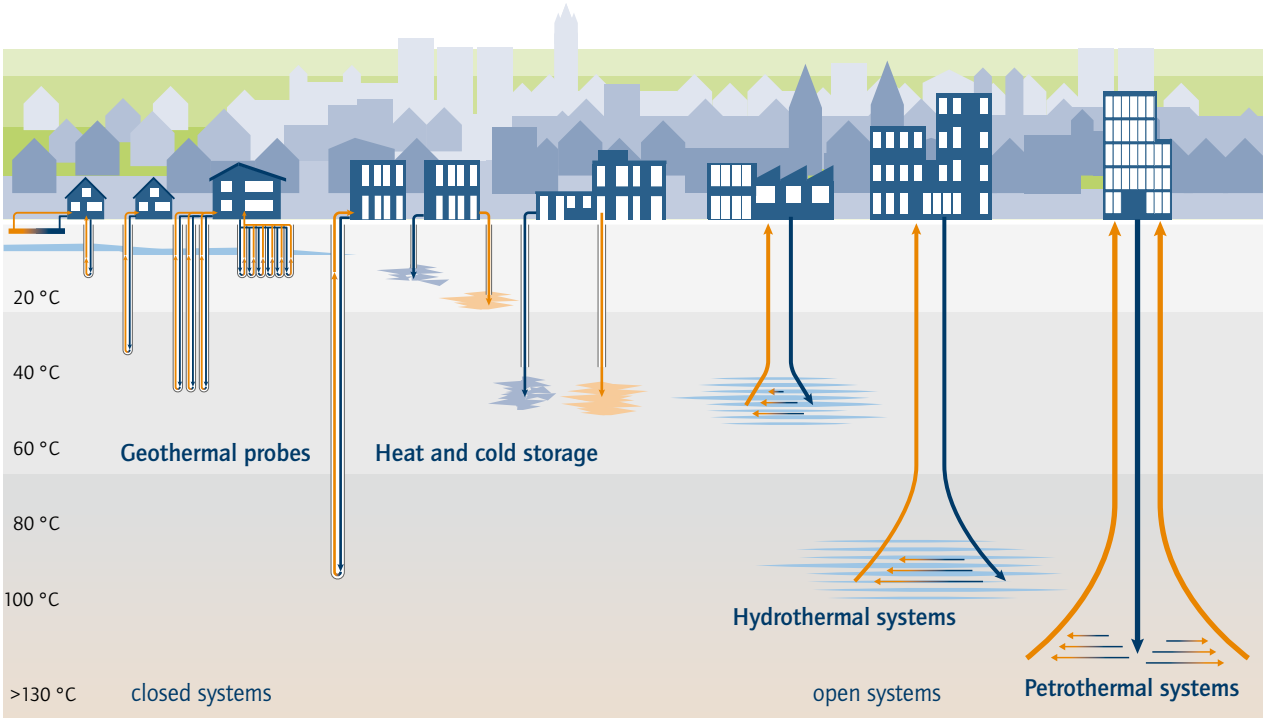
temperatures. Harnessing geothermal energy can therefore contribute to tighter and more efficient coupling of the electricity and heating sectors and make volatile wind and solar energy more usable for the energy system. Existing examples of using geothermal systems in urban areas show that it is possible to make extensive use of such systems. They can be operated economically and are widely accepted if the local population is adequately involved during planning, construction and operation.

Technological developments in recent years have made it possible to harness the potential of geothermal energy significantly better than in the past. Sophisticated exploration methods allow hydro-geothermal reservoirs to be identified more reliably, so reducing hot water prospecting risks. Combined with detailed monitoring and increasingly efficient drilling technology, this distinctly improves the probability of geothermal projects being technically and financially successful. Geothermal projects are also benefiting from advances in large-scale and high-temperature heat pumps, which can optionally be used and enable highly variable feed-in temperatures and thus flexible integration of geothermal energy into existing heating networks.

However, a suitable policy and regulatory framework is necessary for making more intensive use of geothermal energy in the heating sector. It is therefore essential to set the course of future developments today if geothermal energy is to be able to contribute to the heating transition and the implementation of climate policy goals in Germany. One good opportunity for making appropriate adjustments is the local government heating plan that all local authorities must draw up by 2028 at the latest. This planning process should focus more strongly and systematically on expanding heating networks and on the heat sources they use. All levels of government, federal, federal state and local, should ensure that geothermal energy is as standard considered an essential element of the heat supply.

Carbon pricing in the heating sector and the expectation of rising carbon prices generally act as a positive incentive for climate-neutral energy sources and therefore also help to make the use of geothermal technologies more economic. Nevertheless, high capital costs together with prospecting risks remain a major obstacle to geothermal energy projects. Detailed exploration of geothermal potential and simplified access to existing geodata can help to limit this risk. In the light of the high initial capital investment involved, smaller, financially weaker players in particular might be significantly more willing to harness geothermal energy if the financial risks were mitigated to a greater extent. Insurance schemes to cover prospecting risks are already under discussion and may receive government backing. They are a promising approach to boosting the use of geothermal technologies.



The most important systems for exploiting the geothermal economic zone in near-surface geothermal energy up to approx. 20°C, medium-depth geothermal energy up to approx. 60°C, and deep geothermal energy (source: own presentation based on Helmholtz Centre Potsdam – German Research Centre for Geosciences GFZ: *Geothermie – Regenerative Wärme aus der Erde,* 2023.)

Overall, as with other climate-neutral energy sources, there is a need for a federal level strategy that supports broad and sustainable implementation of geothermal energy and is holistically integrated into the transformation of the energy system. This requires long-term planning and investment in infrastructure, including the expansion of heating networks and their transformation into the low-temperature range.

This acatech STUDY takes a look at geothermal energy for heat supply in urban areas, the associated requirements and opportunities, as well as the challenges and reservations among the public. Sections 2 and 3 discuss the technologies and various options for use as well as the underground as a source of energy. This knowledge and prior experience in the implementation of geothermal projects provide the foundation for the discussion of the potential of geothermal energy and its possible applications for defossilising heat supply in section 4, including its ability to make a major contribution to boosting energy system efficiency by coupling electricity and heat supply by the use of geothermal storage. Section 5 examines related economic aspects and acceptance issues. Section 6 describes national and international examples of the use of geothermal technologies in urban settings. Finally, section 7 outlines the political areas of action that are essential if geothermal energy is to be able to make a well integrated, beneficial contribution to the energy system's transition.

Series editor: acatech – National Academy of Science and Engineering, 2025

Munich Office
Karolinenplatz 4
80333 Munich | Germany
T +49 (0)89/52 03 09-0

Berlin Office
Georgenstraße 25
10117 Berlin | Germany
T +49 (0)30/2 06 30 96-0

Brussels Office
Rue d'Egmont/Egmontstraat 13
1000 Brussels | Belgium
T +32 (0)2/2 13 81-80

www.acatech.de
info@acatech.de
acatech @ X | LinkedIn | Instagram

This summary is based on: Emmermann, R./Schulz, R./Stober, I./Wenzel, F./Lauterjung, J./Bracke, R./Henning, H.-M./Chur, C./ Müller-Ruhe, W./Sass, I./ Reinicke, K. M./Knapek, E./Krawczyk, Ch./Huenges, E.: *Geothermische Technologien in Ballungsräumen. Ein Beitrag zur Wärmewende und zum Klimaschutz* (acatech STUDIE), München 2024. DOI: https://doi.org/10.48669/aca_2024-6.