Proceedings World Geothermal Congress 2026, Calgary, Canada, June 8—11, 2026

Next Generation Geothermal for large-scale district heating - a feasibility study for Germany

Medgyesi, N.,[1]*, Sidorova, A.[1], Uth, F.[1], Hamacher, T.[1]
Technical University of Munich[1]

INTRODUCTION

- 70 % of the energy demand of private households in Germany is used for heating purposes. Only 18 % of it is sourced from renewables, mainly from biomass[1]
- District heating systems supplied by renewable energy will play a key role in decarbonizing cities
- Deep geothermal as a source for district heating in Germany is currently limited by the geographic availability of hydrothermal resources
- Enhanced Geothermal Systems (EGS) with horizontal drilling and multi-stage stimulation (next-gen EGS) could be the first truly scalable geothermal technology
- Business model for heating differs from the electricity market
- Direct heat needs to be sourced locally. Transporting heat over longer distances is uneconomic, but how close can we get to city centers to minimize seismic risks?
- **Could next-gen EGS be the solution to the heating needs of cities in low-enthalpy regions?**
- This work analyzes factors, which affect the feasibility of next-gen EGS projects for direct heating, as a case-study in Germany

METHODS

- First, publicly available permitting, heat demand and geodata is compiled and standardized
- Subsequently, the data is combined within the four categories into a timeline prediction (short-term, medium-term, long-term or not feasible prospect) via a decision tree
- Classification is based on the minimum value for the given timeline category instead of averaging. This method therefore avoids balancing out red-flag criteria
- Finally, the four categories are combined to create a map showing a potential timeline for the EGS rollout

Permitting	Heat Demand	Stimulation potential based on regional geology	Local data availability and quality
Drinking Water Protection Zone	Heat Demand Density	Tectonics and Stress Field	Well Data
Healing Water Protection Zone	District Heating Networks (DHN)	Depth of Relevant Formation	2D/3D Seismic Data
Natural Parks & Monuments	Buffer Zones around DHN	Lithology and Rock Properties (Poro-Perm and Thermal Properties)	Gravimetry
Nature Protection Zones	Industrial sites with heat demand	Seismicity Risk	Bibliometric analysis index
Landscape Protection Zones	EGS Production Temperature >100°		
Earthquake Zones			

Local map value on the final map based on the lowest rating of the four categories
If all the categories are rated as short-term, the overall rating is short-term
If one category is rated long-term, the overall rating is long-term (even if all the others would be short-term)

RESULTS

Permitting

- Fracking for geothermal is forbidden in water protection zones, natural parks & monuments and nature protection zones (red colour)
- Permitting requires a full environmental impact assessment in Earthquake Zones and Landscape Protection areas, slowing down the development process by a year (yellow colour)
- Protection Zones complicate, but don't render site selection impossible, as they are fragmented throughout the area

Heat demand

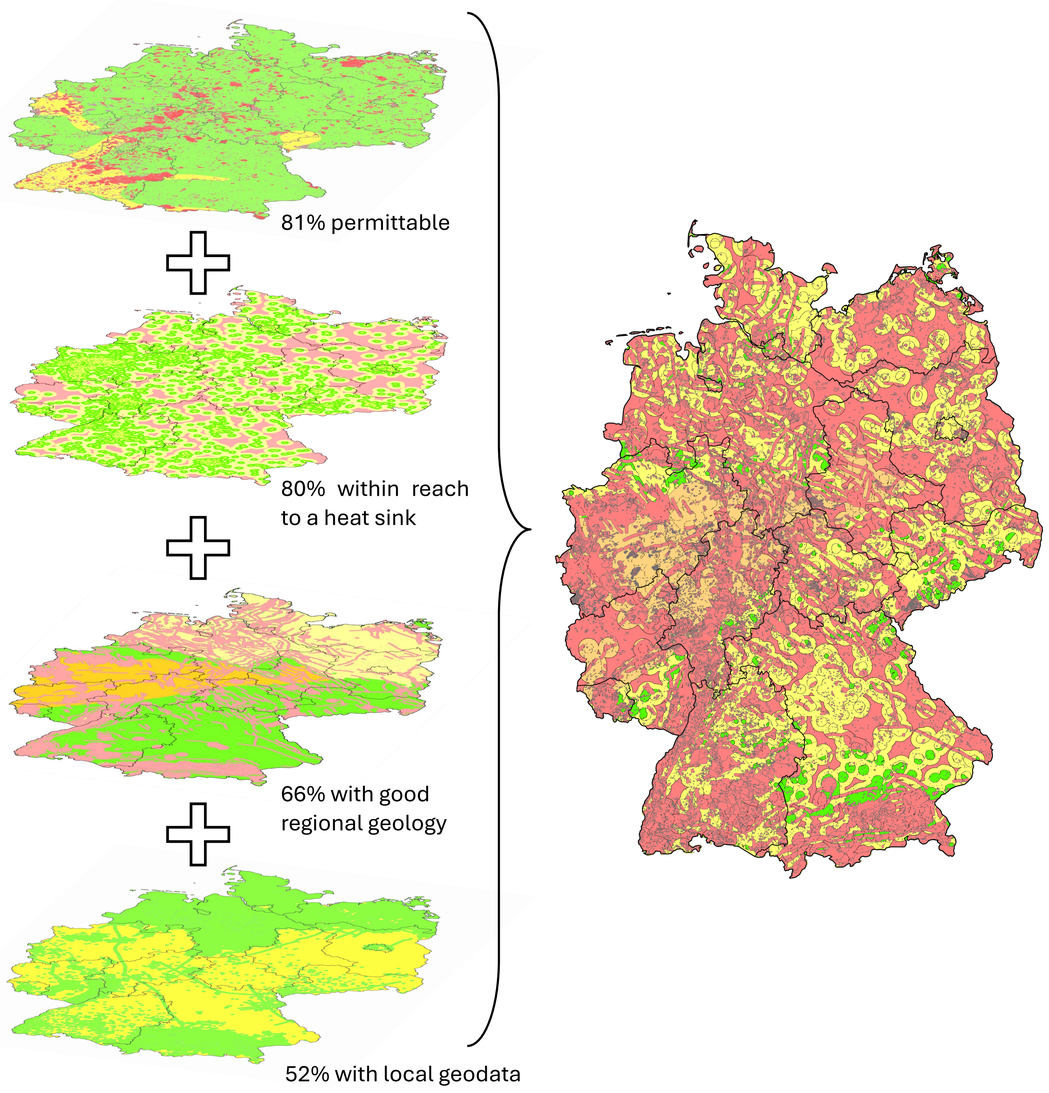
- Pilot next-gen EGS projects are considered economically viable if they are located within 5 km of the heat sink (green colour)
- From short-term prospects onwards, projects could be viable within 12 km of heat sinks. Construction of heat interconnectors with this length is realistic within 3 years (hydrogeothermal reference projects ongoing)
- Heat demand is especially low in the sparsely populated Northeast and in hilly regions. 20 % of the country is considered too remote to connect to a heat sink

Stimulation potential based on regional geology

- Regional lithologies are based on large-scale models of Germany [2,3,4]
- Stimulation potential is depth-dependent: for each location, the „best" lithology defines the classification. However, depths below 4500 m won't be classified as short-term prospects, even if the lithology would justify it
- Buffer around known fault zones and historic tectonic earthquakes limit prospects. Large faults with a buffer of 2 km restrict 27%, a buffer of 10 km around natural >M3 earthquakes 11%, however mostly overlapping, leading to one third of the area together
- Semi-optimal, slate dominated lithology in the Rehenohercynian domain is restricting the central-west for long-term development, unfortunately coinciding with high heat demand

Local data availability and quality

- For a reliable site assessment in a preliminary study, local data is crucial. However this study only considers data availability quantitatively
- Data availability coincides with hydrocarbon exploration in sedimentary basins with hydrogeothermal potential (green colour)
- Research activities at the KTB well, as well as regional seismic lines, supplement the database together with scientific publications on modelling local geology



Short-term prospect, possible demo site
Recommended for detailed feasibility study

Medium-Term prospect
Data or distribution grid needed

Long-term prospect
Challenging geological or economical conditions

Not feasible prospect
Reassessment after 10 years recommended

DISCUSSION

- Hydrothermal zones with >100°C are considered not feasible for EGS in the model. Hydrothermal zones with <100 °C partly coincide with suitable EGS demo sites in the South German Molasse Basin
- Contrary to popular belief, legal restrictions limit the development of EGS project the least from all examined factors. However, further non-publicly available protection zones might exist
- Leaving safety margins around fault zones and historic natural seismicity limits the development the most.
- For next-gen EGS project development to take up, the technology should be proven in different subsurface conditions. Besides basement granites and gneisses, tight sandstones and carbonates are abundant in the >100 °C subsurface.
- Pilots should fulfil three main criteria:
  - Supplying heat to a grid for competitive (operational) costs
  - Perceivable seismicity should not happen during construction and operation
  - Local subsurface conditions should be representative for a larger region (prevent statements like "the technology works because of that particularly optimal setting")

CONCLUSION

- The results offer a country-wide first analysis of the level of fulfilment of the necessary factors for local EGS development. The most promising geologic conditions rarely coincide with heat demand, regulatory restrictions, and data availability. Next-gen EGS development is expected to start in central-southern Germany
- The work should not be considered as a feasibility study for a given location
- The classification should guide stakeholders away from challenging locations until the industry gathers enough experience at the most promising locations, with matching heat demand to reliable subsurface conditions
- Simultaneously, the work identifies data and knowledge gaps, which should be addressed quickly. Severe knowledge gaps exist in the central part of the country, which coincides with magmatic and metamorphic formations, which could host next-gen EGS projects in
- Furthermore, the work serves as a basis for calculating the technical and economic potential for next-generation enhanced geothermal systems in the next step

Acknowledgements
This work was created within the Roadmap Next Generation Geothermie Project, funded by the Federal Ministry for Economic Affairs and Energy, Germany.
The project is supported by the Geothermal-Alliance Bavaria Project of the Bavarian State Ministry for Science and the Arts .

REFERENCES
1) Umweltbundesamt: Endenergieverbrauch nach Energieträgern und Sektoren (2025), https://www.umweltbundesamt.de/daten/energie/energieverbrauch-nach-energietraegern-sektoren#allgemeine-entwicklung-und-einflussfaktoren
2) Agemar, T., Schellschmidt, R. & Schulz, R. (2012): Subsurface Temperature Distribution of Germany. – Geothermics, 44: 65-77.
3) Anikiev, D., Lechel, A., Gomez Dacal, M. L., Bott, J., Cacace, M., Scheck-Wenderoth, M. (2019): A three-dimensional lithospheric-scale thermal model of Germany. - Advances in Geosciences, 49, 225-234.
4) Ahlers, S., Röckel, L., Hergert, T., Reiter, K., Heidbach, O., Henk, A., Müller, B., Morawietz, S., Scheck-Wenderoth, M., & Anikiev, D. (2022). The crustal stress field of Germany: a refined prediction. Geothermal Energy, 10(1), 10.