

Unlocking Europe's Geothermal Industrial Heat Potential

How 30 Priority Clusters Can Help Scale Geothermal Across Europe, Cut Energy Costs, and Strengthen European Energy Security



October 2026

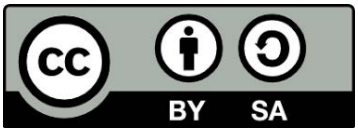
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Thanks to everyone doing great work on geothermal in the European Union. This report shows that Europe has a great opportunity in geothermal, and we hope it sparks new industrial projects.

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Published October 2026. The cluster analysis in this paper uses plant locations and fuel use from official registers (the EU Emissions Trading System and the European Environment Agency's industrial sites), calibrated to Eurostat 2023 national energy balances, with process heat split by temperature using European sector data. Each cluster's geothermal supply is matched to the temperature its demand needs, and plants that raise their heat from their own high-temperature processes, such as steam crackers, reformers, steel, cement, lime and glass, are not counted. The 30 priority clusters carry 2.00 gigawatts of industrial heat demand in 11 countries and could avoid about 4.3 million tonnes of carbon dioxide a year; a wider pool of 152 clusters in 14 countries could avoid 11.0 million tonnes. Given the scale and complexity of the analysis, minor errors or omissions may exist; any identified issues will be corrected in future updates. The full method is available in the appendix.

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Executive Summary

The subsurface below the EU-27 countries has an estimated 18,000 gigawatts-thermal[1] of geothermal heat at temperatures of 100°C or above.[2] And yet, EU factories for the most part still burn imported gas to create heat for their industrial processes—and about 90% of the natural gas those processes consume is imported.

Much of Europe's industrial heat demand is in temperature ranges that geothermal can serve directly—such as food and beverage processing, textiles, paper, and some chemical manufacturing—but geothermal energy is often overlooked in Europe because the energy source has historically held a niche role. The places that use geothermal power today almost all use conventional hydrothermal energy and are mostly found in Iceland, Italy, and Turkey.

Today, advances in geothermal systems mean developers can access subsurface heat in a wide variety of subsurface conditions, far beyond the hydrologic limitations of conventional geothermal systems. And a geothermal well supplies heat around the clock, regardless of weather or grid congestion.

This report examines both what is needed for industrial geothermal to scale across Europe and where deployment can begin now. It sets out the broader policy and market conditions needed for growth, then links geothermal resources with industrial heat demand to identify 30 priority clusters in 11 countries that could form an initial project pipeline. The 30 clusters are not an estimate of the full European opportunity; they are the locations where this analysis finds the strongest near-term case for further development.

Taken together, those sites could displace more than €850 million per year in fuel spending and avoid about 4.3 million tonnes of carbon dioxide emissions each year, roughly 1% of all EU industrial-heat emissions from just 30 locations. The opportunity extends well beyond that short list: A wider pool of 152 candidate clusters in 14 countries could avoid 11.0 million tonnes of carbon emissions each year, while individual industrial facilities can also develop geothermal projects outside the cluster model, as projects in France and Hungary already show. Additional opportunities will emerge as subsurface data, technology, and project economics improve.

Several policy tools already in place in Europe could support the expansion of industrial geothermal. France and Germany have developed programmes that cover part of the loss if a deep well fails to find enough heat or water. Germany has also declared geothermal an energy source of "overriding public interest," which means authorities must give geothermal projects high priority

when weighing them against other interests, such as environmental protection, in permitting decisions. The Netherlands makes subsurface data public, which in turn helps each project learn from the wells drilled before it. Denmark has measures in place to protect geothermal heat contracts from price regulation. But all of these measures were developed separately, often for single projects and conventional geothermal resources—in other words, they may not cover new geothermal technologies. Expanding the use of geothermal heat for industry will require programmes, tools, and measures that can work at the member state level and at the EU level. The EU Geothermal Action Plan, originally expected in early 2026, remains unpublished. Publishing that plan, with priority industrial clusters and a quantified trajectory for geothermal in industrial heat, would be a clear first step in this process. Alongside the identification of the European Union's first and best geothermal opportunities, this report also identifies eight policy changes to organise the first projects, reduce early-stage risk and unlock investment, and create the conditions for geothermal to scale across Europe (see **Figure ES.4**).

The cost of relying on imported gas became clear in 2022. When gas prices spiked, Germany's energy-intensive industries lost 20% of their output, and the nation didn't recover. Scaling the use of geothermal resources for industrial heat would reduce exposure to gas-price volatility and supply risk while strengthening the competitiveness of European industry.

WHERE TO START: THE 30 PRIORITY INDUSTRIAL CLUSTERS

When several industrial users can share wells and other infrastructure, the economics will improve. Having several buyers also spreads risk and reduces off-take risk. If one customer leaves, the remaining contracts continue to provide revenue, making the project easier to finance. In 2017, in the Westland region of the Netherlands, 49 greenhouse growers formed the Trias Westland Project, which went on to serve 54 growers, the Royal FloraHolland flower auction, and 345 homes.

Together, the 30 priority clusters carry 2 gigawatts of industrial heat demand and would displace more than €850 million per year in fuel spending (see **Figure ES.1**). Twenty-seven of the 30 clusters include facilities covered by the EU Emissions Trading System, and in 23 of them, facilities emit more than their free allocation; at €65 per tonne, buying those extra allowances costs about €150 million per year.

Italy, Germany, France, Spain, and the Netherlands hold four clusters each; the short list allows at most four clusters per country, so the 30 clusters span 11 countries. Priolo Gargallo in Italy, Süßenbrunn in Austria, and Wesseling in Germany lead the list. (See "The 30 Priority Clusters: Screening and Results.")

The eight policy recommendations fall into three groups that reflect what is needed to move the first clusters toward development, then scale geothermal more broadly across Europe.

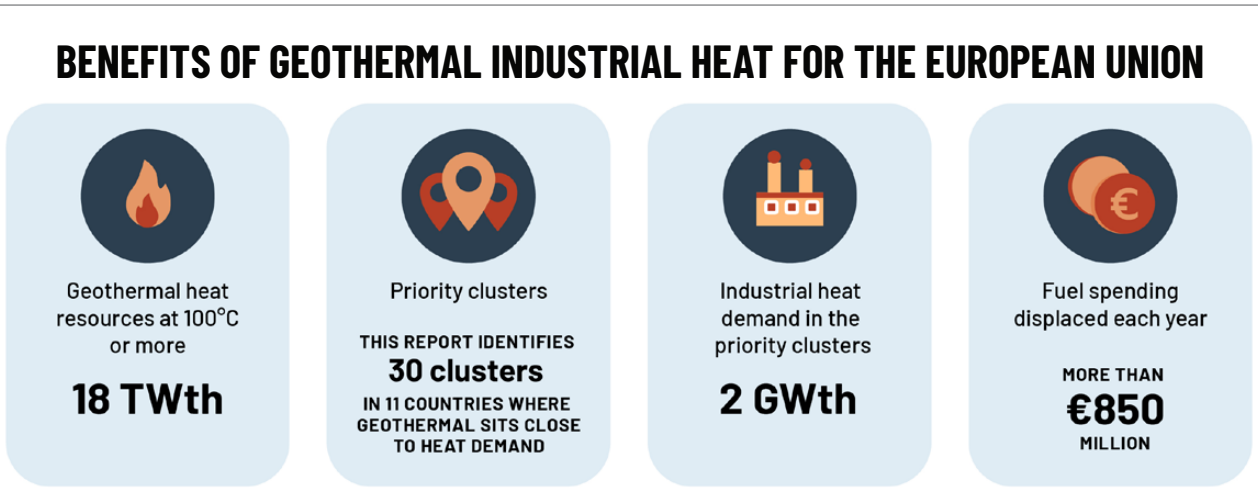
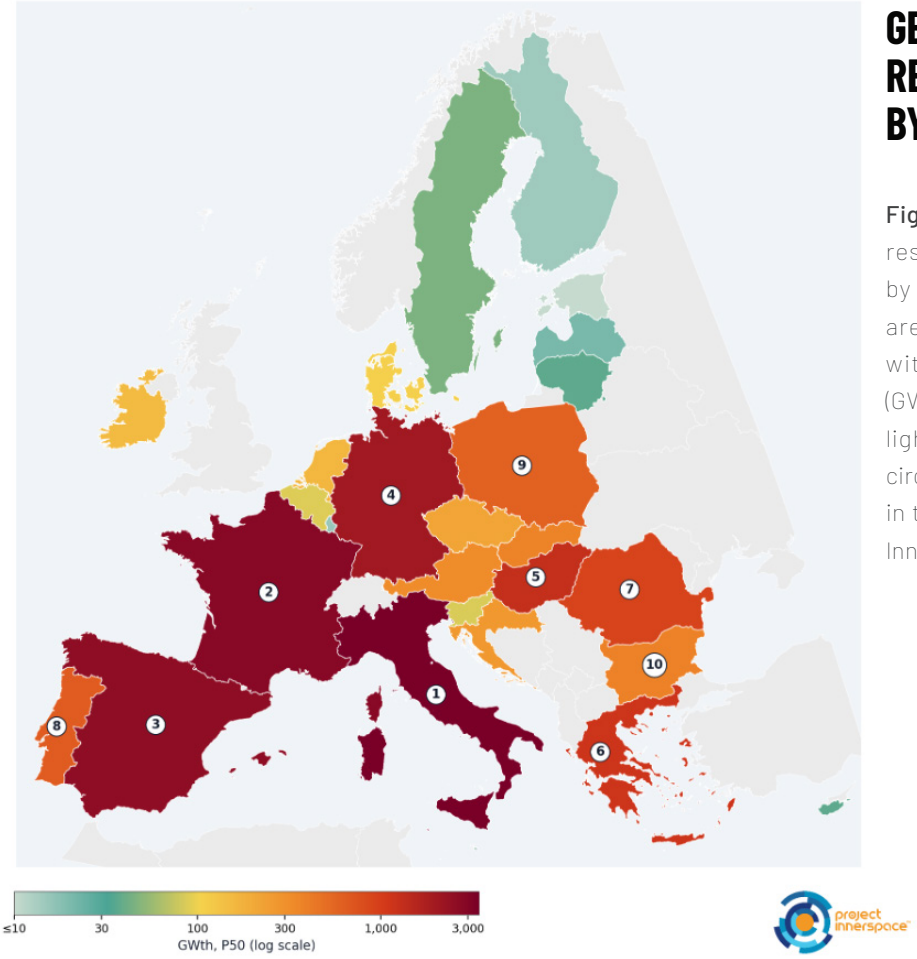
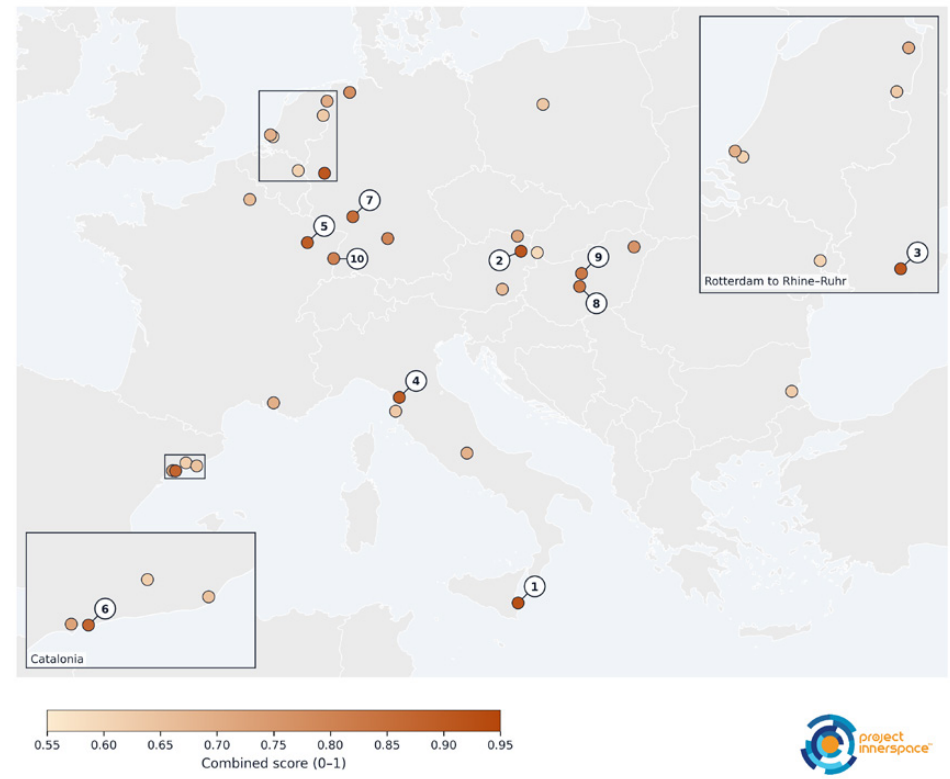


Figure ES.1: Key figures related to EU industrial heat demand, its reliance on imported natural gas, and the geothermal heat resource beneath EU-27 countries. GWth = gigawatts-thermal; TWth = terawatts-thermal. Source: Project InnerSpace.



GEOTHERMAL HEAT RESOURCE AT 100°C, BY EU-27 COUNTRY

Figure ES.2: Geothermal heat resource at 100°C or above, by EU-27 country. Countries are shaded on a log scale, with 10 gigawatts-thermal (GWth) and below sharing the lightest colour. Numbers in circles represent areas ranked in the top 10. Source: Project InnerSpace.



COMBINED SCORE

Figure ES.3: The 30 priority clusters by combined score. See **Table 5** for details for all 30 clusters. Source: Project InnerSpace.

The first group identifies and organises the first projects. It calls for making industrial geothermal a policy priority, identifying where geothermal resources overlap with concentrated industrial heat demand, funding the project preparation needed to turn those opportunities into clusters, and establishing an operator that can own shared wells and infrastructure and serve multiple customers.

The second group reduces early-stage risk and unlocks investment. It includes drilling-risk programs for first wells, support for first-of-a-kind next-generation geothermal, and tools to make projects financeable, including heat purchase agreements and public guarantees that reduce off-take and buyer risk.

The third group creates the conditions for geothermal to scale. It calls for faster and more predictable permitting, secure geothermal rights, better public subsurface data, and clear safeguards for induced seismicity.

The forthcoming European Geothermal Strategy and Action Plan and the Geothermal Stakeholder Partnership could tie all of these measures together by identifying priority clusters and setting a quantified trajectory for geothermal in industrial heat. Additionally, in their own national energy and climate plans, member states could reinforce how geothermal will help meet rising renewable energy use targets.

The 30 clusters highlighted in this report provide a practical starting point, while the broader policy changes can help make geothermal industrial heat easier to develop and replicate across Europe.

POLICY RECOMMENDATIONS FOR EU GEOTHERMAL INDUSTRIAL CLUSTERS

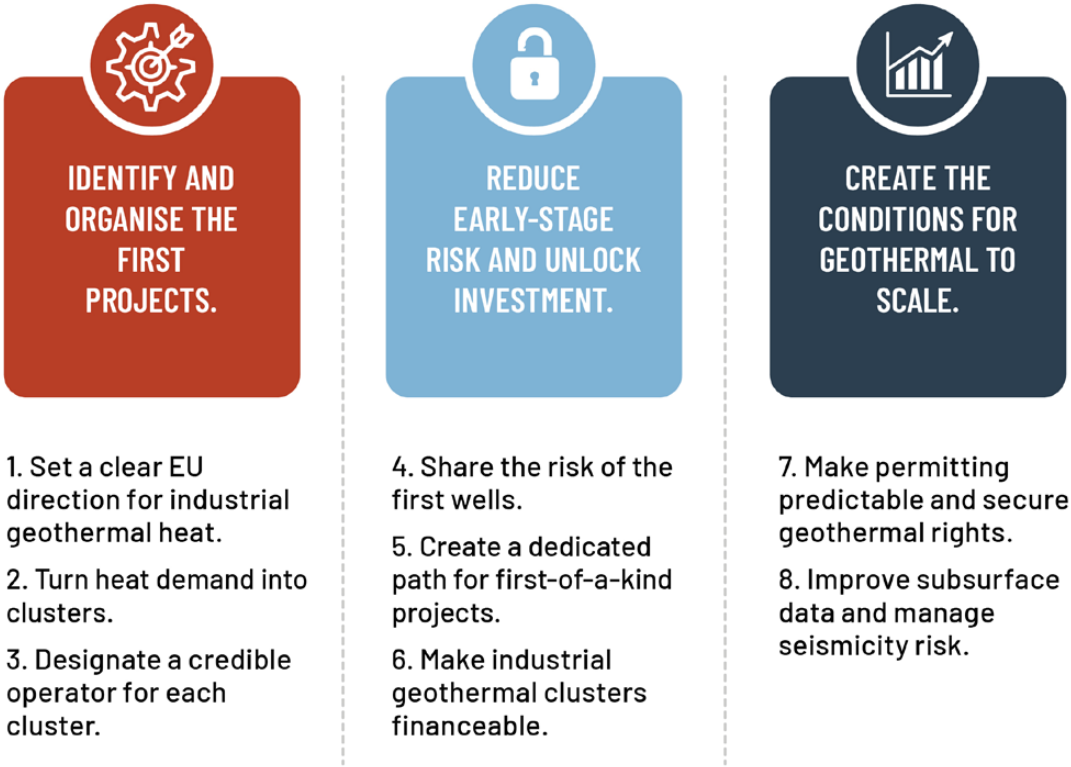


Figure ES.4: Eight policy recommendations organised around three areas for action: identifying and organising the first projects, reducing early-stage risk and unlocking investment, and creating the conditions for geothermal to scale. Recommendations include actions for both the European Union and member states. Source: Project InnerSpace and Future Cleantech Architects.



Geothermal for Industrial Heat

For most of its history, the geothermal industry has accessed heat—for industrial use, warming buildings, and more—by drilling a well to reach hot water underground, then bringing the water to the surface. This approach works well in regions where volcanic activity brings heat close enough to the surface, but those conditions show up reliably in only a few tectonically active regions in Europe.[3,4] Installed geothermal power generation in Europe is concentrated almost entirely in places such as Iceland, Italy, and Turkey via conventional hydrothermal drilling.[5]

Yet, heat is everywhere underground. A new generation of engineering advances now make that heat resource reachable in places far from conventional hydrothermal geology.

GEOTHERMAL TECHNOLOGY SYSTEMS

Geothermal heat can now be delivered to the surface straight from hot rocks, for various uses and via a few methods. Key to these various systems are the temperatures of the subsurface geology. This report focuses on direct-use industrial heat: geothermal heat delivered straight to industrial processes.

Power Generation: Temperatures of 150°C or Above

The accessible subsurface for power generation needs to be 150°C or above. A plant can operate at 90% capacity factors.[6] Systems that use these temperatures to spin turbines to produce electricity include the following:

- **Engineered geothermal systems (EGS):** With EGS, operators target hot rock with low natural permeability. They drill down to between 3 kilometres and 6 kilometres and stimulate the rock to open flow paths, building an artificial reservoir.

- **Advanced geothermal systems (AGS):** In AGS, also known as closed-loop systems, engineers drill wells into the subsurface, then circulate fluid through sealed underground pipes rather than through the rock itself, picking up heat by conduction. No reservoir is needed.[7]

DIRECT-USE INDUSTRIAL HEAT: TEMPERATURES OF ABOUT 100°C AND ABOVE

At these temperatures in both AGS and EGS, circulated fluid could still produce some electricity, but that fluid is used more efficiently in what is called direct-use geothermal as heat for industrial processes.

Many direct-use projects use a doublet: a pair of wells, with one bringing hot water up and the other sending it back down once its heat is used. This setup covers both conventional sedimentary-aquifer wells and EGS. At the surface, a heat exchanger transfers the heat from the production well's water to a separate working fluid, which delivers it to the process or building that needs it. The cooled water then returns to the reservoir through the injection well. In a closed-loop system (AGS), fluid circulates through sealed pipes underground and picks up heat by conduction, so no water is drawn from the rock . Because nothing is converted into power along the way, a direct-use system retains far more of the energy that a well produces than a power plant does, and that system remains viable at temperatures well below the threshold for commercial power generation.

Proximity of the resource to the demand governs direct-use projects more than temperature. In other words, direct-use development depends less on finding the hottest rock than on identifying where usable subsurface temperatures coincide with steady, year-round thermal demand, such as industrial parks and facilities. (See **Figure 1**.)

DIRECT-USE GEOTHERMAL FOR INDUSTRIAL STEAM PROCESSES

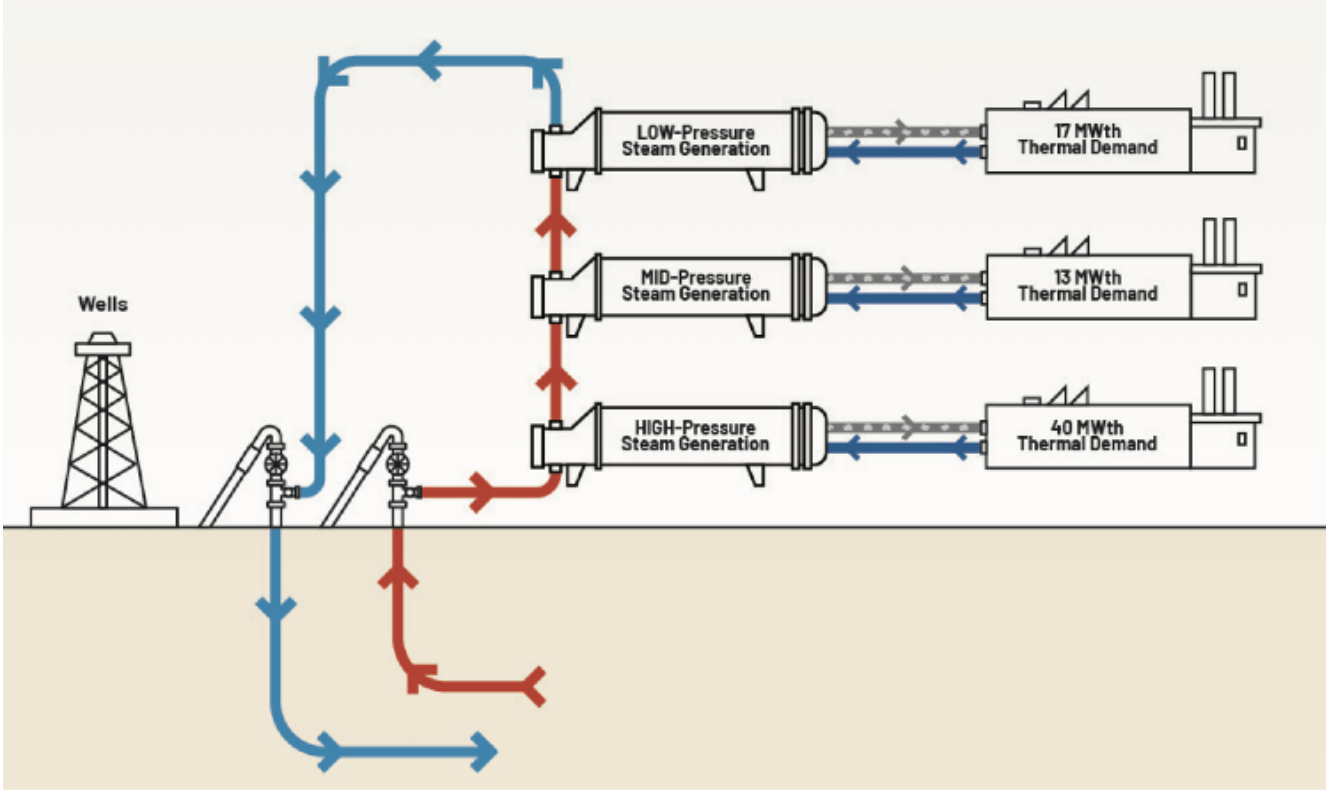


Figure 1: Direct use of geothermal resources to provide steam of different qualities to three facilities. MWth = megawatts-thermal. Source: Project InnerSpace.

Direct-Use Building Heating and Cooling: Temperatures of Between 60°C and 100°C

At these temperatures, fluid is best suited to heating and cooling networked buildings, though some lower-temperature industrial processes can also use it. A thermal energy network carries that fluid from a wellhead through insulated pipe and distributes it across a campus, a district, or an entire city. Each connected building uses what it needs through its own heat exchanger. Europe has run networks on this model for the better part of a century, and several hundred of these networks are in service across the continent today.

Direct-Use Building Heating and Cooling: Temperatures Below 60°C

The ground within a few hundred metres of the surface holds a steady temperature through the year that is cooler than summer air and warmer than winter air. Ground source heat pumps and low-temperature thermal energy networks draw warmth out of the ground in winter, return the heat in summer, and can heat and cool individual buildings. No part of this process depends on unusual geology. Shallow ground works almost anywhere, which makes this geothermal application open to nearly every site in Europe.[8]

GEOTHERMAL APPLICATIONS AND TEMPERATURE REQUIREMENTS

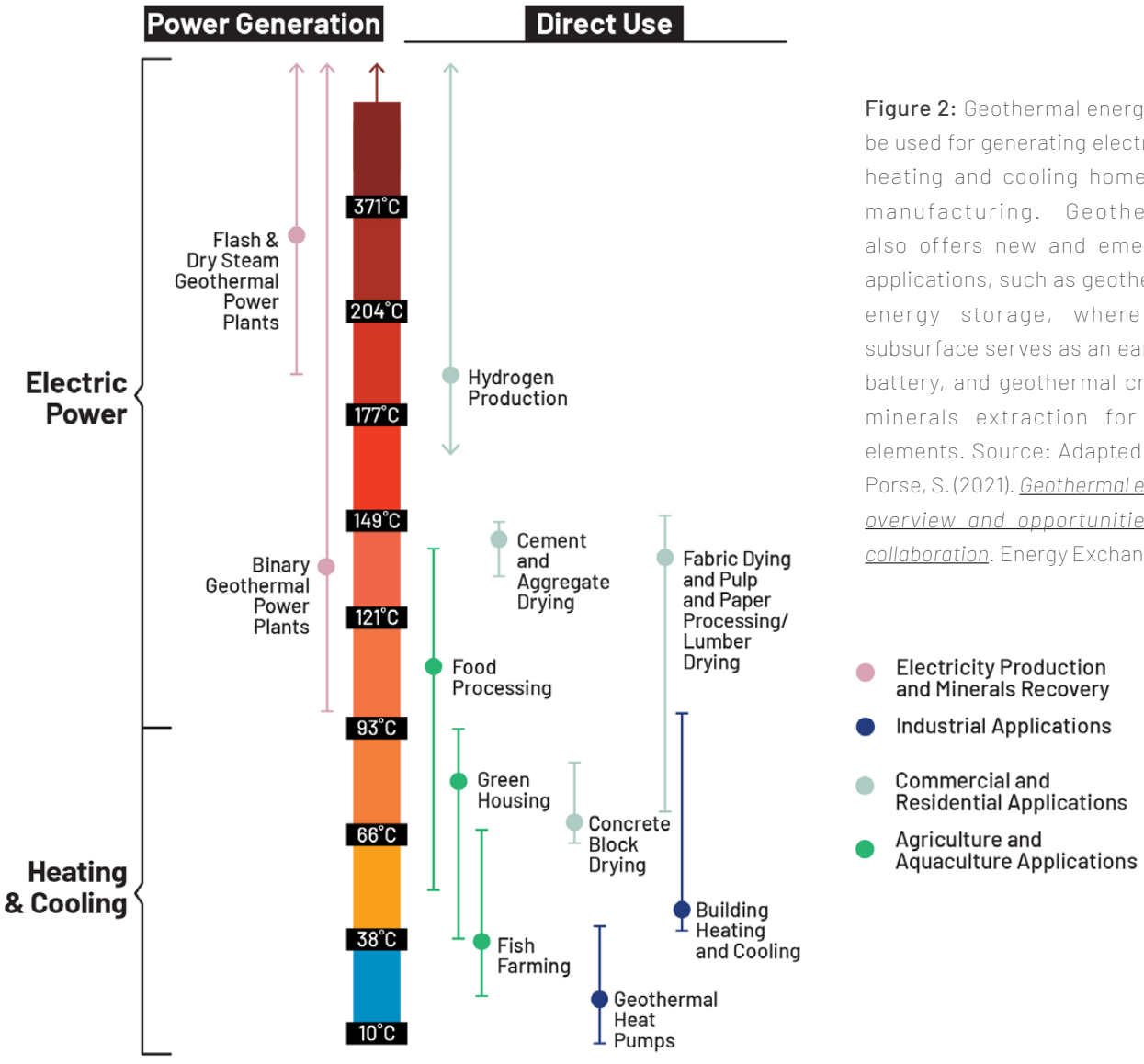


Figure 2: Geothermal energy can be used for generating electricity, heating and cooling homes, or manufacturing. Geothermal also offers new and emerging applications, such as geothermal energy storage, where the subsurface serves as an earthen battery, and geothermal critical minerals extraction for rare elements. Source: Adapted from Porse, S. (2021). *Geothermal energy overview and opportunities for collaboration*. Energy Exchange.

INDUSTRIAL APPLICATIONS AND NEW MARKETS

Most of Europe's industrial heat demand uses temperatures achievable by direct-use geothermal systems (see **Figure 2**). Food and beverage processing, textiles, paper, and some chemical manufacturing run on process heat below 200°C. Pasteurising, washing, and evaporation do not need blast-furnace conditions.[9,10] Drying paper requires temperatures as low as 150°C, reachable at between 3 kilometres and 5 kilometres in Europe's warmest basins.[11]

Conventional geothermal resources are concentrated in a few basins, including those around Paris, Munich, and the Pannonian Basin. Next-generation technologies could extend geothermal heat to industrial regions beyond them. Perhaps the strongest case for geothermal is that a geothermal well, once drilled, runs continuously regardless of weather or grid congestion, delivering clean baseload heat 24 hours a day, seven days a week.[12]

Existing Precedent and Future Potential

According to the European Commission's Joint Research Centre, geothermal already supplies competitive, stable heat at temperatures up to 200°C for agri-food, paper, and plastics manufacturers. In Iceland's HS Orka Resource Park, waste streams from a single (conventional) geothermal facility feed a cluster of 10 businesses, including fish-drying operations, a methanol plant that captures the facility's own carbon dioxide, an algae-cultivation venture, and an aquaculture operation.[13] In France, the Rittershoffen geothermal plant piped 170°C fluid from a nearby geothermal well field directly into the Roquette Frères bio-refinery in Beinheim. For 10 years, this system supplied about one-quarter of the site's process-heat demand. In Hungary, Procter & Gamble is developing a deep geothermal system at its Csömör manufacturing site that is expected to replace about 90% of the facility's natural gas use for heating and manufacturing processes by mid-2027.[14]

Outside Europe, New Zealand has one of the world's longest industrial geothermal track records: Geothermal heat is used for pulp and paper production, timber drying, and dairy processing via the Kawerau and Taupō geothermal fields.[15] The Miraka dairy plant uses geothermal steam for process heat; the company Essity has converted tissue-paper production to run on geothermal steam.[16] The United States also has a long history of direct geothermal use in industrial applications for processes such as food dehydration and mineral processing.[17] In other words, there are multiple precedents globally for geothermal industrial heat, but they have been confined to traditional geothermal areas. That is poised to change.

Globally, the International Energy Agency (IEA) estimates that hot sedimentary aquifers with temperatures above 200°C hold roughly 15,000 exajoules of technical geothermal heat potential, equivalent to almost 500 years of current global industrial heat demand below 200°C.[18] In a low-cost case, next-generation geothermal could economically displace about 3 exajoules of fossil-fuel industrial heat by 2035, avoiding roughly 230 million tonnes of carbon dioxide per year. By 2050, next-generation geothermal could supply about 35% of global industrial heat demand below 200°C and avoid about 750 million tonnes of carbon dioxide per year, roughly equivalent to Canada's annual emissions.[19] The IEA also points to the 100°C–200°C resource range as particularly promising for industries such as paper, chemicals, food processing, and auxiliary processes in cement production.

Europe's geothermal resource for industrial heat is large, but unevenly distributed. Project InnerSpace's Heat-in-Place model estimates roughly 18,000 gigawatts-thermal of geothermal heat resources across the 27 countries in the European Union (EU-27) at temperatures of at least 100°C and depths of between 0.5 kilometres and 3.5 kilometres. Six countries—Italy, France, Spain, Germany, Hungary, and Greece—account for about 75% of the total resources, with Italy alone holding an estimated 3,400 gigawatts-thermal. Significant resources also appear in Romania, Portugal, Poland, and other parts of Central and Southern Europe (**Table 1**).

INDUSTRIAL HEAT RANKING AND SHARE OF RESOURCES FOR EU-27 COUNTRIES

Rank	Country	GWth (P50)	Share of EU-27 Resource (%)
1	Italy	3,400	19
2	France	2,800	16
3	Spain	2,600	14
4	Germany	2,100	12
5	Hungary	1,300	7
6	Greece	1,200	7
7	Romania	930	5
8	Portugal	660	4
9	Poland	600	3
10	Bulgaria	380	2
11	Slovakia	380	2
12	Austria	330	2
13	Croatia	270	2
14	Czech Republic	220	1
15	Netherlands	160	<1
16	Ireland	150	<1
17	Denmark	110	<1
18	Belgium	88	<1
19	Slovenia	87	<1
20	Sweden	46	<1
21	Cyprus	37	<1
22	Lithuania	37	<1
23	Latvia	21	<1
24	Luxembourg	15	<1
25	Finland	15	<1
26	Malta	11	<1
27	Estonia	5	<1
	EU-27 total	**17,952**	**100**

Table 1: Geothermal heat resource at 100°C in EU-27 countries. Recoverable heat (gigawatts-thermal [GWth], P50 of 2,000 Monte Carlo runs) from the Project InnerSpace Heat-in-Place model, 100°C cutoff, all rock types, 0.5 kilometres–3.5 kilometres deep, summed by country. The EU-27 total is about 18,000 GWth, and the top six countries (Italy, France, Spain, Germany, Hungary, Greece) hold about 75%. Values show resource in place over 30 years, before surface constraints and demand matching; not installed or installable capacity. Source: Project InnerSpace Heat-in-Place model.



The 100°C threshold provides a useful indicator of where geothermal could contribute to industrial heat, either directly for lower-temperature processes or with heat pumps or supplementary heating where higher temperatures are required. These estimates represent heat in place before accounting for surface constraints, project economics, or whether industrial demand is located close enough to use the resource. They should therefore be read as an indication of the scale and geographic distribution of the opportunity, not as installed or immediately developable capacity. That distinction is critical. Geothermal heat is only commercially useful for industry where an accessible resource sits close to sufficient, steady heat demand. The challenge is therefore not simply to identify where Europe has geothermal heat, but to identify where that heat overlaps with industrial users that can share wells, pipelines, and other infrastructure. For Europe's industrial regions, the next step is to identify where the resources sit and how many nearby industrial users a single well could serve.



Europe's Industrial Heat Challenge and Why Geothermal Matters

Across Europe, manufacturing represents a significant portion of the European Union's economy: The sector employs about 30 million people (18.5% of the total business economy) and generates €2.5 trillion of value added (23.1% of everything that European Union businesses create).[20,21] But the processes required in the European

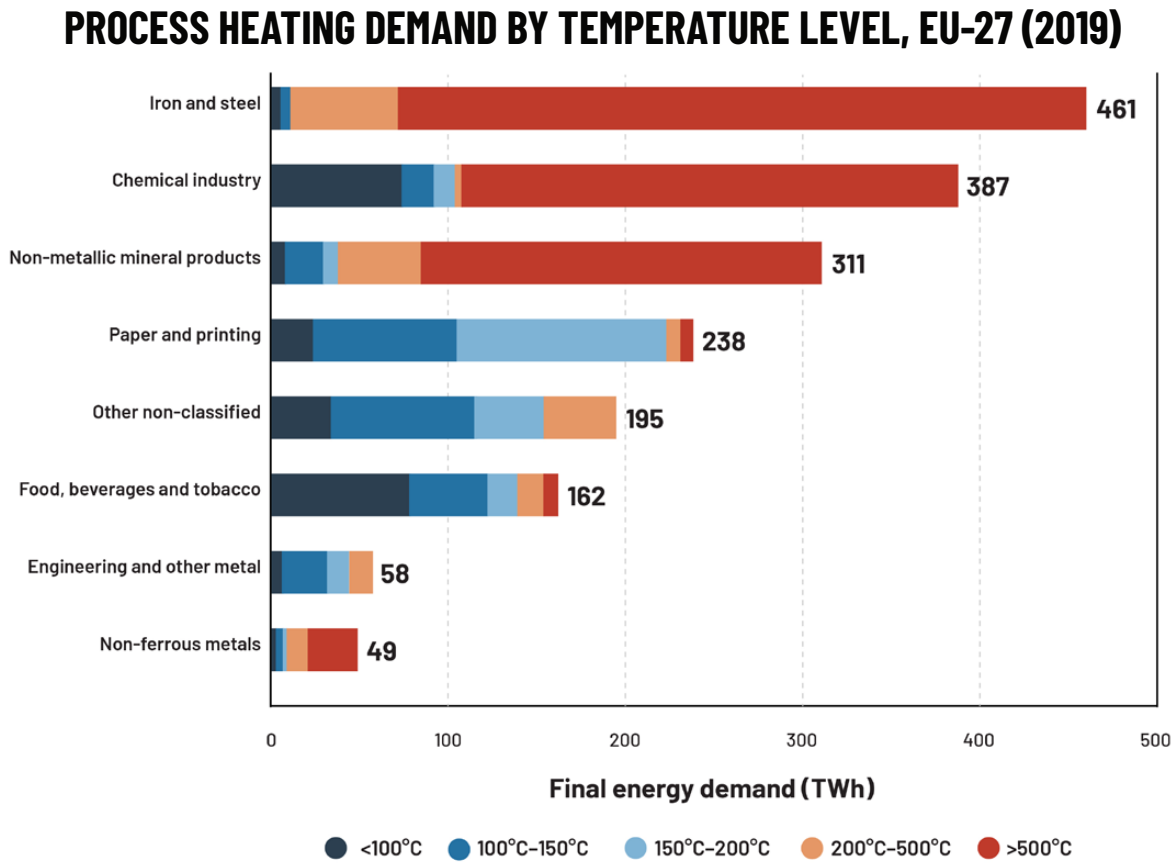


Figure 3: Final energy demand for process heating in the 27 European Union countries in 2019, by temperature and sector. TWh = terawatt-hours. Source: Fraunhofer ISI. (2024). *Direct electrification of industrial process heat: An assessment of technologies, potentials and future prospects for the EU*. Agora Industry.

Union's manufacturing industry use vast amounts of energy—2,500 terawatt-hours or about one-quarter of the European Union's final energy consumption.[22] About one-third of this energy is delivered in the form of electricity, but most of the rest is delivered as heat.

Heat is a key input for industrial processes and spans a diverse range of applications, each with its own particular operating temperatures (see **Figure 3**). At the lowest end, industries such as paper and food mostly use heat at temperatures below 200°C, predominantly as steam. At the high end of the temperature spectrum, metal and chemical production uses energy above 500°C, typically as hot air or radiative heat transfer.

Today, the heat required for the manufacturing industry is mainly supplied through the combustion of fossil fuels. Natural gas alone represents nearly one-third of total energy consumed by European industry (in other words, half of industrial heat).[23] The share of industrial energy consumption powered by natural gas is even greater when considering that, indirectly, natural gas contributes 17% of electricity production in the European Union.[24] As a result, the European Union emits around 400 million tonnes of carbon dioxide because of its industrial heat demand.[25]

But this dependence on natural gas is at odds with the region's energy security concerns. Only 10% of EU consumption is covered by domestic production; the European Union overwhelmingly depends on foreign imports to meet its gas needs. Most imports come from Norway (30%), the United States (26%), North Africa (12.7%), and Russia (12.5%).[26] This dependence exposes Europe to price volatility from global markets. For example, when gas prices spiked by 120% following the war in Ukraine in 2022, Germany's energy-intensive industries lost 20% of their output. Not only that, this decline did not reverse when prices stabilised, which illustrates the long-term sensitivity of energy-intensive industries to even short-term fossil-fuel price volatility. Switching to cleaner, homegrown sources of energy for industrial heat is essential to not only meet climate goals but also ensure long-term industrial competitiveness and energy security for Europe.

Europe already has useful geothermal policy tools, including drilling-risk programmes, public subsurface data, heat-contract protections, and permitting reforms. But these measures are fragmented and mostly designed for individual projects. Industrial geothermal therefore faces two sets of barriers: general ones (such as drilling risk, data, permitting, and geothermal rights) and cluster-specific ones (such as customer aggregation, project preparation, heat contracts, shared infrastructure, and buyer risk). The cluster model addresses the second set of barriers by turning locations where geothermal resources and industrial heat demand overlap into financeable projects.

PRODUCTION INDEX INDUSTRY AND ENERGY-INTENSIVE INDUSTRIES IN GERMANY

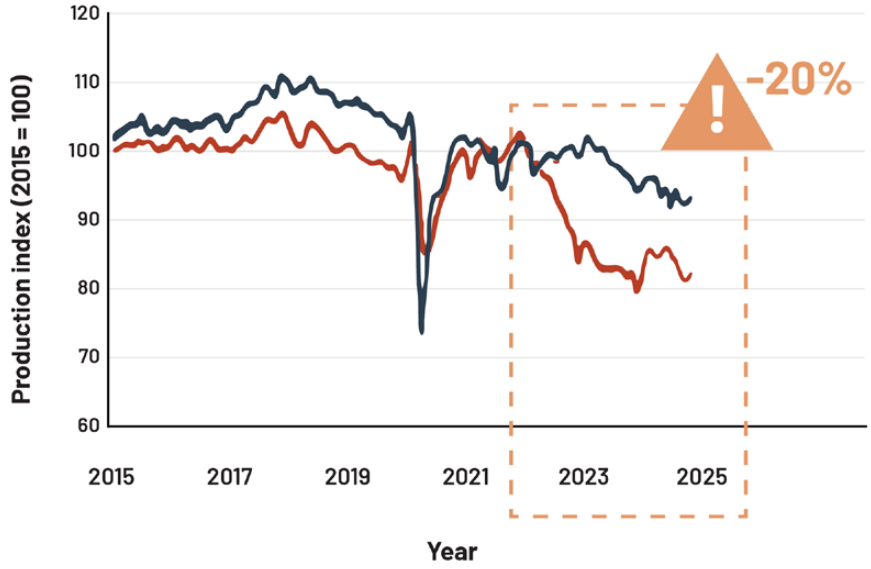


Figure 4: Industrial production in Germany, all industry and energy-intensive industries, 2015–25 (index, 2015 = 100). Energy-intensive industries are the five branches that Destatis defines by their high energy demand relative to value added. Source: Federal Statistical Office (Destatis). (n.d.). *GENESIS Online: The database of the Federal Statistical Office*.



The Geothermal Cluster Model

According to the IEA, the costs of drilling wells often make up as much as 80% of a geothermal project's total cost.[27] That means a geothermal heat project spends most of its money before it sells its first megawatt-hour. But the price of geothermal heat depends less on what wells cost than on how much of the output finds a buyer. Importantly, Europe's existing wells could deliver far more heat than they sell today.

How a Geothermal Cluster Operates

A geothermal cluster is a group of heat users that share one well field, one heat network, and one operator that sells heat to all users in the cluster. A cluster needs one trunk pipeline. Its heat pumps, storage, and backup boilers are sized once to cover the members' combined demand.

The system starts with an anchor customer, such as a paper mill or chemical plant, whose large, steady demand for heat justifies the building of initial wells. In many locations, however, neighbouring companies can use the heat that the anchor does not need. These companies may be greenhouses, district heating networks, aquaculture, and drying operations that can take lower-temperature heat or use it at different times of year.

The Kawerau geothermal field in New Zealand has supplied steam to pulp, paper, and timber mills since 1957. The system ranks among the world's largest uses of geothermal heat at a single location.[28]

In 2017, 49 greenhouse growers in the Netherlands' Westland region built a European version, the Trias Westland project. The project's first pair of wells began delivering heat to 26 growers, from 2,300 metres down, in 2019.[29] A second well pair came online in 2021 and lifted capacity above 40 megawatts-thermal. When Trias Westland commissioned the second doublets, it linked the two sources into one circuit so heat supply continued without interruption.[30] Soon the project was serving 54 growers, the Royal FloraHolland flower auction, and 345 homes.[31]

Engineers are now evaluating a large cluster on the Upper Rhine. In November 2024, the multinational chemical company BASF and Vulcan Energy signed a letter of intent to assess deep geothermal heat for BASF's Ludwigshafen complex.[32] A 2025 two-dimensional seismic survey confirmed promising geothermal structures in the region. That survey is the basis for a planned three-dimensional seismic survey and preparation of an appraisal well.[33] Additionally, Vulcan's 2026 pre-feasibility study for its broader Project Ludwig in the Ludwigshafen region envisions up to 3,125 gigawatt-hours of renewable heat per year. A final investment decision will be made after production begins at the company's first project, Lionheart.[34]

About 70 companies operate at Germany's Chempark sites in Leverkusen, Dormagen, and Krefeld-Uerdingen. The site operator, Currenta, runs energy supply and a shared infrastructure. The company also keeps a digital

HOW HEAT CASCADES THROUGH A GEOTHERMAL CLUSTER

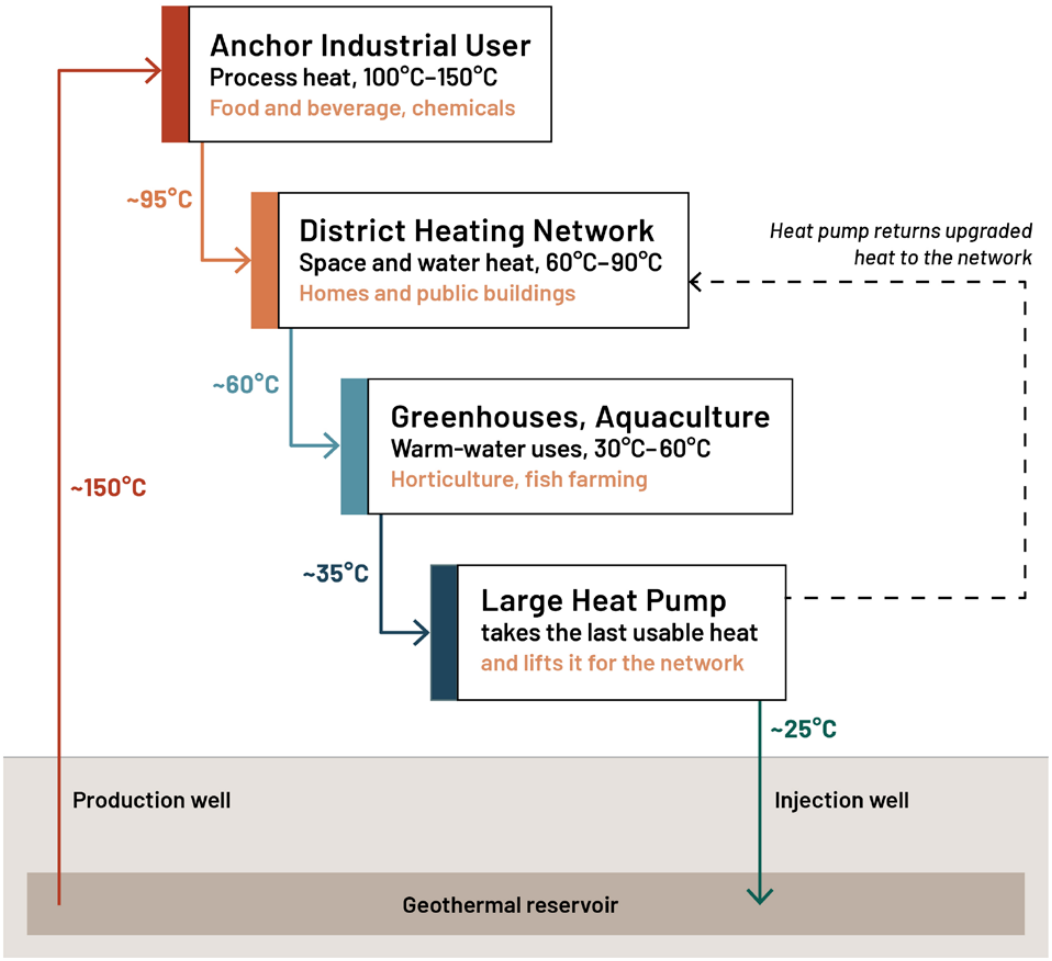


Figure 5: Cascaded use in a geothermal cluster. An anchor user takes the hottest fluid, and successive users take heat at falling temperatures before reinjection. Source: Project InnerSpace.

heat register that maps heat sources and heat sinks across the area to identify projects for a sustainable heat supply.[35] A geothermal source would join an arrangement that is already in place. (See "Industrial Applications and New Markets" for two other examples already deployed, including Iceland's HS Orka Resource Park and the Rittershoffen supply to Roquette Frères.)

Where the Savings Come From

The costs of building geothermal systems can be extensive—and, as mentioned, many of those costs come before any heat is delivered to customers. The drilling of wells is often the biggest expense, but other up-front costs can include amassing the research, exploration data, and other information (such as seismic data) that developers must have before starting a project.

In Ludwigshafen, BASF and Vulcan Energy are collaborating on seismic surveys that will determine where wells are drilled. The Netherlands does the same. Since 2018, the country's energy company, EBN, and the national geological survey TNO (Netherlands Organisation for Applied Scientific Research) have run SCAN, a campaign to map the country's geothermal potential. The group publishes its results through NLOG, the government's subsurface data portal. [36]

A cluster also gets more use out of each well. Using 2015 operating data, researchers at the University of Bayreuth calculated that a plant near Munich ran the equivalent of 4,115 full-load hours—less than half the number of hours there are in a year.[37] Some industrial processes do run year-round, but researchers found that demand for heat at the plant rose and fell with the weather.

Because capital for a geothermal plant is largely spent up front, every hour the plant delivers energy lowers the cost of each megawatt-hour. European geothermal power plants ran at an average 79% capacity factor in 2022, or about 6,900 hours of the full output.[38] If the Munich-area plant was running at that level, it would sell about two-thirds more heat, and the capital cost carried by each megawatt-hour would fall by about 40%.

The Trias Westland project in the Netherlands has built a market for this. Its regional network operator runs a trading platform that puts surplus heat to use by making it possible for growers to sell contracted geothermal heat they do not need to neighbours who need more.[39]

Additionally, plants can get more out of geothermal projects by putting different fluid temperatures to use as they cycle through industrial processes. For example, the Munich-area network returns water back to the plant at an average temperature of 58°C. The plant's fluid goes back underground at an average temperature of 68°C. These varied temperatures can be used by various companies if the system is set up right. The European Commission's Joint Research Centre notes that plants producing both electricity and heat get more out of a geothermal project by using a larger temperature range of the fluid before it is reinjected into the subsurface.[40] In other words, in a cluster, there is often a company—such as a greenhouse or a low-temperature building network—that can put to work the fluid that is output from a previous user (see **Figure 5**).

Lower Risk, Cheaper Capital, Room to Grow

Once a project has drilled its wells, it risks losing buyers. If the project sells to a single factory and that factory closes or moves, the wells are left producing heat that no one is paying for. When a cluster has several buyers, losing one hurts but does not sink the project. The others keep paying, and the spare heat can go to a neighbour. (This is why the screening discussed in "The 30 Priority Clusters: Screening and Results" counts only clusters with at least two facilities.)

Steadier income also makes borrowing easier. A project with several paying customers gives banks more confidence to lend more, for longer, and on better terms.[41] Trias Westland borrowed against its own revenue alone, then received loans from Rabobank and BNG Bank for its second pair of wells. Several growers—energy buyers—also put their own money into the project's financing.[42]

A cluster can also start small and grow. Once wells and pipes are in place, a new buyer can join a network that already has customers. In Westland, a regional network continues to link the area's geothermal sources one at a time, with a target of about 500 megawatts-thermal by 2030.[43]

When Clustering Pays

As this section points out, clustering pays best where a usable resource sits within pipeline distance of demand, as proximity governs direct use more than temperature does. A cluster needs an anchor that can sign a contract that is both long-term and large enough to justify building the first wells. A cluster also needs an operator that can contract with many buyers at once, such as a municipal utility or chemical park operator. Having many buyers also helps ensure the pipe between users costs less than the heat it carries.

The system works most efficiently when the other members' heat requirements differ from the anchor in season or temperature, allowing the wells to run for more hours and using the same heated fluid for multiple processes as it decreases in temperature. When a cluster has these strong conditions, fixed capital gets spread out, driving gains in levelised cost of heat.

Europe already runs the institutions this model needs, in locations with hot-enough resources and with industries in need of heat. Westland and Currenta—sharing wells and supplying multiple companies at one site—are examples that can be replicated across the continent.



The 30 Priority Clusters: Screening and Results

This analysis turns the broader European geothermal opportunity into a location-specific project screen. It combines geothermal resource, industrial heat demand, infrastructure, and commercial factors to identify where cluster development should be tested first. The analysis grouped industrial plants into 313 potential clusters. Of those, 152 passed the eligibility requirements described in this section and were scored on a technical track and a commercial track. The 30 highest-ranked clusters, with at most four per country, form the short list across 11 countries.

Eligibility Filters

Cluster Formation

Every industrial plant has an annual fuel demand, from verified emissions and reported energy calibrated to Eurostat, split into process-heat bands (below 100°C, 100°C–200°C, and 200°C–500°C). A plant enters a band if its demand there exceeds 5,000 megawatt-hours per year. Within each band, clusters grow outwards from the plant with the highest demand. Plants are added as long as every member stays within 7 kilometres of the cluster's centre point,[44] which the method recalculates each time a plant joins. Any cluster that ends up with less than 10 megawatts of heat demand is dropped. Clusters in different temperature bands whose centre points lie within 7 kilometres of each other are then merged and take on the highest band because one resource can cascade heat down to lower-temperature users. Only EU-27 plants are included, and plants that raise heat from their own high-temperature processes—such as steam crackers, reformers, steel and cement—are not counted.

Before being scored, each cluster must pass five requirements: It has to have at least two participating facilities; it has to have at least 10 megawatts of heat demand, below which a pair of wells is unlikely to be economical; it has to have a heat resource score of at least 0.02 (see "Heat Resource"); the rock within 7 kilometres has to reach its band's lower temperature (50°C, 100°C, or 200°C) by 5 kilometres deep; and it has to be located within the study scope. Romania, which ranks seventh in geothermal resource (**Table 1**), falls outside the scope of this analysis and remains a candidate for future screening.

Heat Resource

The heat resource is the mean recoverable heat per model cell within 7 kilometres of the cluster centre, counted above the temperature the cluster needs: above 50°C or 100°C to 3.5 kilometres deep for clusters below 100°C and at 100°C–200°C, and above 200°C to 5 kilometres for 200°C–500°C clusters. It uses the same Heat-in-Place model as **Table 1** and **Figure ES.2**. Each cell covers between about 20 and 25 square kilometres, so the score measures how rich the resource is around a cluster, not the total heat beneath it.

Infrastructure Readiness

A project scores higher when it sits close to two existing networks: (i) gas transmission or distribution pipelines and (ii) high-voltage power lines. The power-line score is full within 3 kilometres and reaches zero at 20 kilometres; the gas score reaches zero at 30 kilometres. Together, these capture the infrastructure already in the ground, which bears on construction cost; a gas network also gives heat pipes a corridor to follow.

Heat Demand and Network Viability

Whether there is a group of industrial companies with heat requirements worth serving and whether a network can economically reach that group will determine network viability. These data combine the cluster's net heat demand, the carbon intensity of the heat those sites currently purchase, and their emissions trends and fuel-cost exposure; temperature is handled by the heat resource and the eligibility test. Network compactness, measured as megawatts of demand per kilometre of pipe, is also taken into consideration, as a dispersed cluster costs more to connect for the same delivered heat.

Decarbonisation Potential and Cost Exposure

This data point looks at the gross annual fuel cost displaced, the carbon dioxide avoided relative to the cluster's current fuel mix, and the EU Emissions Trading System's allowance position of facilities that are net buyers at the prevailing carbon price if a developer switched to geothermal. In other words, it is the commercial and climate prize on offer.

Two-Track Ranking

Each track is scored on its own and normalised to a 0 to 1 range before the two tracks are combined (see the combined ranking in **Table 5**). Track 1 (technical viability) is a weighted sum whose weights total 1—namely, heat resource 0.80, high-voltage proximity 0.10, and gas pipeline proximity 0.10. Track 2 (the industrial business case) uses a multiplicative core of demand, carbon intensity, and an urgency factor (all temperature bands weighted equally) and carries up to 1.30.

PRIORITY CLUSTERS WITH THE LARGEST HEAT RESOURCES

Combined Rank	Location	Temperature requirements (°C)	Demand (MWth)	Heat resource above 100 °C within 7 km (MWth)
24	Rosignano Solvay, Italy	Below 100	15	683
13	Nyíregyháza, Hungary	100–200	44	372
2	Süßenbrunn, Austria	100–200	66	336
1	Priolo Gargallo, Italy	100–200	99	310
11	Aalen, Germany	100–200	55	287
5	Varangéville, France	100–200	75	278
4	Padule, Italy	100–200	187	253
8	Dunaújváros, Hungary	100–200	62	253

Table 2: The eight priority clusters with the richest geothermal heat resources, with their place in the combined ranking. Resource refers to the mean recoverable heat above 100°C per model cell (0.5 kilometres–3.5 kilometres deep) within 7 kilometres of each cluster's centre, from the Project InnerSpace Heat-in-Place (HiP) model, for every cluster whatever its temperature band. EGS = engineered geothermal system; MWth = megawatts-thermal. Source: Project InnerSpace.

ACCESSIBLE GEOTHERMAL HEAT RESOURCE

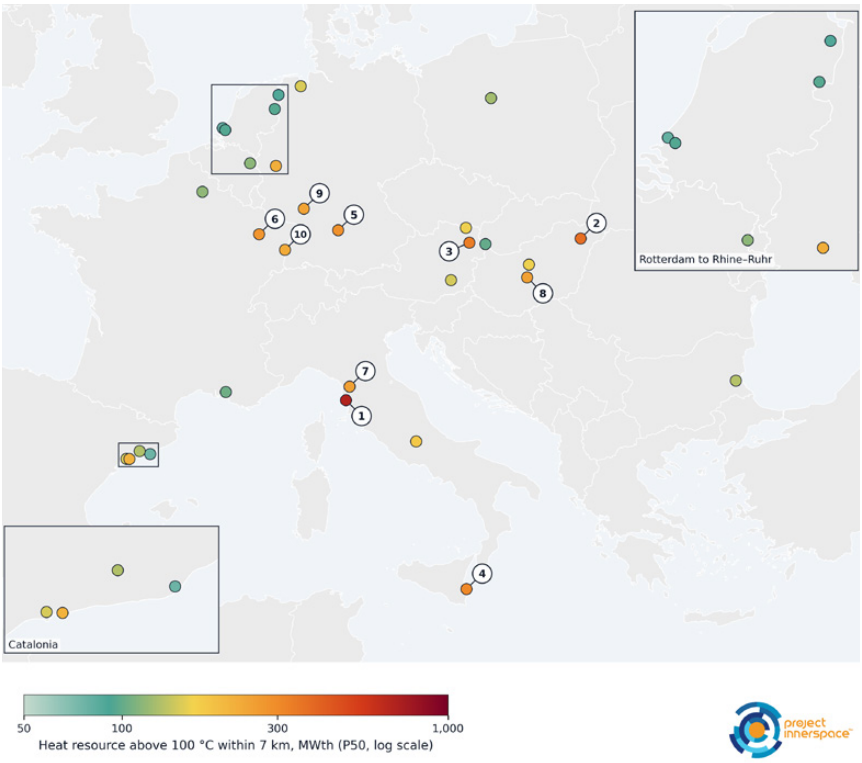


Figure 6: The 30 priority clusters in Europe, by accessible geothermal resource. The numbers indicate the top 10 on this measure. Heat above 100°C within 7 kilometres of each cluster. MWth = megawatts-thermal. Source: Project InnerSpace.

GRID AND GAS PIPELINE PROXIMITY

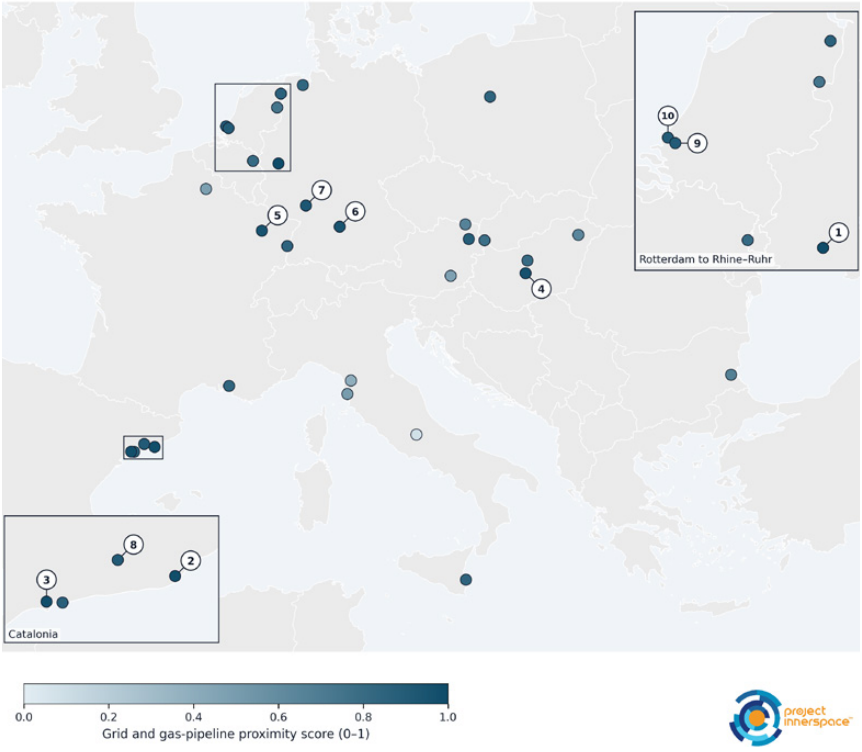


Figure 7: The 30 priority clusters in Europe by grid and pipeline proximity. The numbers indicate the top 10 on this measure. Source: Project InnerSpace.

TOP 30 CLUSTERS BY TECHNICAL VIABILITY (TRACK 1)

Rank	Location	Temperature Requirements (°C)	Demand (MWth)	Technical Viability (T1)	Industrial Business Case (T2)	Combined Score
1	Gerdt, Germany	Below 100	11	1.0	0.098	0.0
2	Schwabenheimer Hof, Germany	Below 100	12	0.999	0.118	0.0
3	Kelsterbach, Germany	Below 100	15	0.997	0.084	0.0
4	Longeville-lès-Saint-Avold, France	Below 100	11	0.996	0.06	0.235
5	Chalampé, France	Below 100	11	0.996	0.156	0.464
6	Wörth am Rhein, Germany	100–200	36	0.996	0.311	0.616
7	Helkijn, Belgium	Below 100	11	0.995	0.108	0.488
8	Rózinowo, Poland	Below 100	12	0.995	0.075	0.486
9	Seneffe, Belgium	Below 100	10	0.994	0.099	0.462
10	Dobrzelin, Poland	Below 100	10	0.985	0.101	0.536
11	Chépy, France	Below 100	10	0.978	0.151	0.439
12	Mengeš, Slovenia	100–200	12	0.977	0.091	0.521
13	Bruxelles - Brussel, Belgium	Below 100	11	0.966	0.054	0.368
14	Süßenbrunn, Austria	100–200	66	0.96	0.689	0.911
15	Aulnat, France	100–200	27	0.959	0.215	0.537
16	Zaandam, Netherlands	Below 100	15	0.957	0.1	0.444
17	Gasselterboerveenschemond, Netherlands	Below 100	13	0.943	0.133	0.508
18	Nyíregyháza, Hungary	100–200	44	0.927	0.352	0.761
19	Priolo Gargallo, Italy	100–200	99	0.92	0.772	0.926
20	Cassino, Italy	100–200	10	0.915	0.086	0.391
21	Rosignano Solvay, Italy	Below 100	15	0.9	0.263	0.631
22	Salerno, Italy	100–200	10	0.9	0.062	0.293
23	Olek, Poland	Below 100	11	0.863	0.079	0.462
24	Dunaújváros, Hungary	100–200	62	0.861	0.5	0.829
25	Tarragona, Spain	100–200	82	0.783	0.699	0.874
26	Ulmerfeld, Austria	100–200	13	0.692	0.075	0.419
27	Lorquí, Spain	100–200	22	0.678	0.179	0.471
28	Fischdorf, Austria	100–200	28	0.674	0.2	0.548
29	Vila-seca, Spain	100–200	41	0.654	0.35	0.725
30	Dunaharaszti, Hungary	100–200	82	0.653	0.641	0.824

Table 3: The 30 clusters with the highest technical viability scores (Track 1), ranked by T1. Industrial business case (T2) and combined scores are shown for comparison. Not every cluster on this list appears in the final 30 because the final ranking combines both tracks. Source: Project InnerSpace.

Four additional data points are then added: fuel cost savings up to 0.25; network compactness up to 0.10; carbon dioxide displacement up to 0.10; and EU Emissions Trading System exposure up to 0.10.

Clusters whose dominant fuel is assumed rather than confirmed are reduced for viability by 10%. The theoretical ceiling is 1.85, and the raw total is divided by 1.80 (acknowledging that 1.85 is never achieved). The score is then normalised to 1 to put the track on the same scale as Track 1.

The two normalised tracks are then combined as a geometric mean, the square root of their product: They count equally, and because the mean is geometric rather than arithmetic, a cluster cannot offset a weak resource with a strong commercial case. Clusters that rank in the top 50 of both tracks receive a 0.10 bonus. A country penalty then applies from each country's third cluster onward, rising by 5% with each additional cluster (in Germany, 5% for Aalen and 10% for Varel), so that the rankings do not collapse in the two or three countries with the largest industrial base. The result is divided by 1.10, the highest score possible after the bonus, and its square root gives the final score. The short list then takes the 30 highest-ranked clusters with at most four per country; no two of them lie within 7 kilometres of each other. (The appendix tests the two assumptions most likely to move the result—the cluster radius and the resource estimate—and checks how deep the clusters must drill to reach their target temperatures.)

Sensitivity of the Ranking to Dimension Weights

The ranking reflects the weighting chosen for these dimensions. Different weighting assumptions would lead to different ranking results. Raising the weight on any dimension raises the relative importance of the criteria within it and reorders clusters whose scores are close together. The weights applied in this paper express the judgement that resource availability is a binding physical constraint and that displaced fuel cost is the clearest commercial signal. These should be read as an assumption of the analysis rather than a property of the data.

Track 1: Technical Viability

Clusters Ranked by Heat Resource

A cluster's heat resource varies widely across the 30 priority clusters, and on its own it does not carry a cluster into the top ranks. The richest, at Rosignano Solvay in Italy, is more than twice the fifth richest. Three of the five richest sit outside the top 10 because the demand for industrial heat in their area is small (see **Table 2**). Italy holds two of the five richest resources, at Rosignano Solvay and Priolo Gargallo (see **Table 6**).

The scoring samples an all-rock layer, which counts heat in sediment and in basement resources alike, so a strong resource score can mean either a conventional sedimentary pair of wells or a basement project requiring stimulation. Comparing that layer against the sediment-only layer from the same model gives a first look: 18 of the 30 come out sedimentary, five mixed, and seven either basement-leaning or basement-only. This is a proxy, and it is generous, because the two layers are cut at different temperatures. The appendix reports two other counts that answer different questions. Only two clusters reach 150°C while still in sedimentary rock, because reaching that temperature usually means drilling into the basement below. Separately, a classification of each area's thermal setting places 14 clusters in sedimentary settings (see "Target Depth and the Rock Where Heat Is Found").

Clusters Ranked by Infrastructure Readiness

Most of the ranked clusters sit close to the two networks a project requires. Eight of the 30 clusters are within 3 kilometres of a high-voltage line; the median distance is 5.5 kilometres to a high-voltage line and 3.4 kilometres to a gas pipeline. Eleven clusters are within about 6 kilometres of both a high-voltage line and a gas pipeline. The weakest grid access is at Borgo Incile in Italy (34 kilometres from a high-voltage line and 25 kilometres from a gas pipeline), Homblières in France (25 kilometres from high-voltage line; 1 kilometre to gas pipeline), and Gratkorn in Austria (19 kilometres to a high-voltage line; 4 kilometres to gas pipeline).

TOP 30 CLUSTERS BY INDUSTRIAL BUSINESS CASE (TRACK 2)

Rank	Location	Temperature Requirements (°C)	Demand (MWth)	Technical Viability (T1)	Industrial Business Case (T2)	Combined Score
1	Varel, Germany	100–200	108	0.633	0.84	0.772
2	Padule, Italy	100–200	187	0.748	0.813	0.894
3	Wesseling, Germany	100–200	101	0.822	0.789	0.907
4	Martigues, France	100–200	116	0.336	0.787	0.631
5	Priolo Gargallo, Italy	100–200	99	0.92	0.772	0.926
6	Brunshausen, Germany	100–200	98	0.63	0.739	0.726
7	Herten, Germany	100–200	67	0.452	0.724	0.645
8	Kruiningergors, Netherlands	100–200	77	0.392	0.706	0.692
9	Tarragona, Spain	100–200	82	0.783	0.699	0.874
10	Nieuwe Pekela, Netherlands	100–200	91	0.421	0.694	0.701
11	Quillebeuf-sur-Seine, France	100–200	85	0.34	0.69	0.594
12	Süßenbrunn, Austria	100–200	66	0.96	0.689	0.911
13	Varangéville, France	100–200	75	0.897	0.674	0.893
14	La Fare-les-Oliviers, France	100–200	76	0.484	0.645	0.695
15	Dunaharaszti, Hungary	100–200	82	0.653	0.641	0.824
16	el Prat de Llobregat, Spain	100–200	65	0.395	0.592	0.647
17	Borgo Incile, Italy	100–200	51	0.552	0.547	0.689
18	Hadres, Austria	100–200	56	0.625	0.51	0.716
19	Beerse, Belgium	100–200	44	0.233	0.501	0.528
20	Dunaújváros, Hungary	100–200	62	0.861	0.5	0.829
21	Coevorden, Netherlands	100–200	58	0.432	0.486	0.629
22	Gratkorn, Austria	100–200	43	0.551	0.474	0.665
23	Hoogvliet, Netherlands	100–200	59	0.459	0.45	0.61
24	Zaidín / Saidí, Spain	100–200	59	0.217	0.447	0.376
25	Sant Martí Sarroca, Spain	100–200	46	0.589	0.373	0.619
26	Janikowo, Poland	100–200	30	0.559	0.355	0.636
27	Tienen, Belgium	100–200	39	0.333	0.354	0.544
28	Nyíregyháza, Hungary	100–200	44	0.927	0.352	0.761
29	Burgas, Bulgaria	100–200	39	0.546	0.336	0.624
30	Petržalka, Slovakia	100–200	35	0.455	0.329	0.593

Table 4: The 30 clusters with the highest industrial business case scores (Track 2), ranked by T2. Technical viability (T1) and combined scores are shown for comparison. Not every cluster on this list appears in the final 30 because the final ranking combines both tracks. MWth = megawatts-thermal. Source: Project InnerSpace.

NET INDUSTRIAL HEAT DEMAND

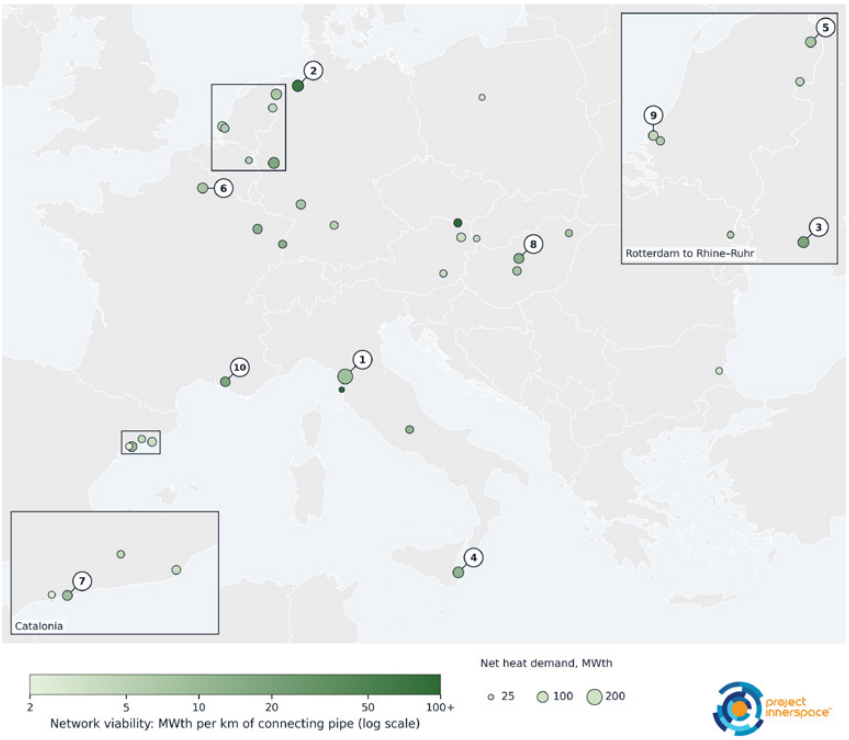


Figure 8: The 30 priority clusters by net industrial heat demand (circle size) and network viability (colour: megawatts of demand per kilometre of pipe). MW = megawatts. Source: Project InnerSpace.

ANNUAL CO_2 DISPLACEMENT

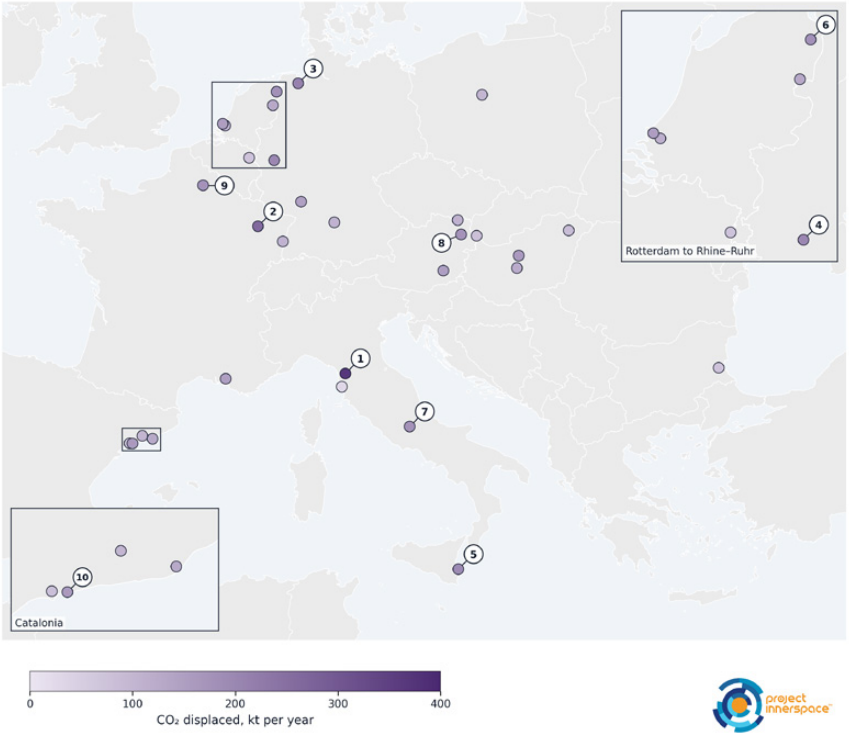


Figure 9: The 30 priority clusters by annual carbon dioxide (CO_2) displacement. Source: Project InnerSpace.

Track 2: Industrial Business Case

Clusters Ranked by Heat Demand and Network Viability

The 30 priority clusters in these findings carry 2,010 megawatts-thermal of net industrial heat demand, a median of 50 megawatts-thermal each, ranging from 11 megawatts-thermal to 210 megawatts-thermal. Twenty-two of the 30 fall in the 150°C–250°C range, where most medium-temperature process heat sits, and the remaining eight are in the 80°C–150°C range, which includes food, pharmaceutical, and consumer goods sites. The networks are compact. The median radius of the 30 priority clusters is 6.0 kilometres, and the median cluster has five facilities. Linking each cluster's facilities along the shortest possible route takes a median of 21.0 kilometres of pipe.

Clusters Ranked by Decarbonisation Potential and Cost Exposure

Together, the 30 priority clusters would cut about 4.3 million tonnes of carbon dioxide per year and more than €850 million per year in fuel spending. The median would be about 138,000 tonnes of carbon dioxide and €19 million in fuel per cluster. Twenty-seven of the 30 clusters include facilities covered by the EU Emissions

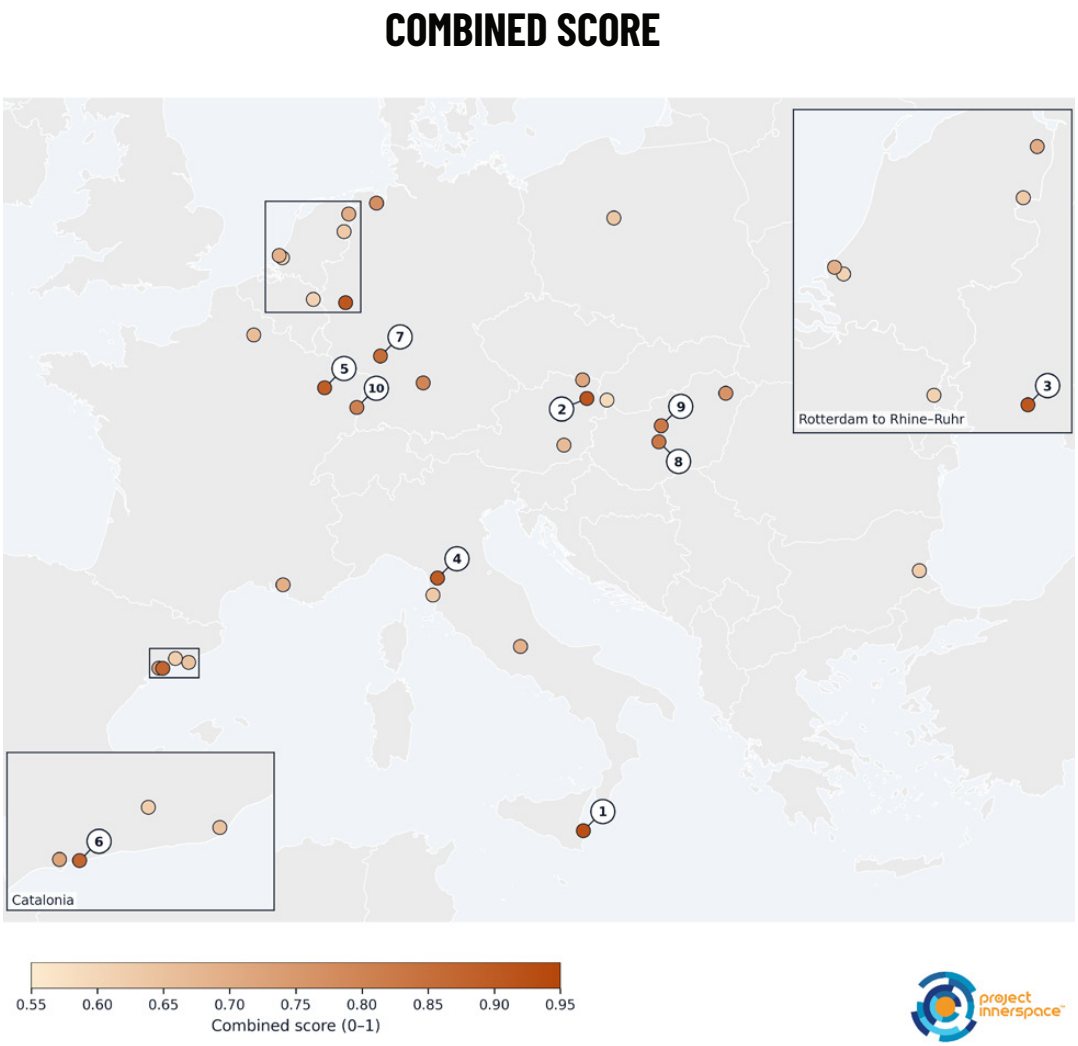


Figure 10: The 30 priority clusters by combined score. Source: Project InnerSpace.

COMBINED RANKING

Rank	Location	Temperature Requirements (°C)	Demand (MWth)	Technical Viability (T1)	Industrial Business Case (T2)	Combined Score
1	Priolo Gargallo, Italy	100–200	99	0.92	0.772	0.926
2	Süßenbrunn, Austria	100–200	66	0.96	0.689	0.911
3	Wesseling, Germany	100–200	101	0.822	0.789	0.907
4	Padule, Italy	100–200	187	0.748	0.813	0.894
5	Varangéville, France	100–200	75	0.897	0.674	0.893
6	Tarragona, Spain	100–200	82	0.783	0.699	0.874
7	Ormsheimer Hof, Germany	100–200	74	0.848	0.581	0.854
8	Dunaújváros, Hungary	100–200	62	0.861	0.5	0.829
9	Dunaharaszti, Hungary	100–200	82	0.653	0.641	0.824
10	Marckolsheim, France	100–200	54	0.808	0.464	0.805
11	Aalen, Germany	100–200	55	0.909	0.441	0.796
12	Varel, Germany	100–200	108	0.633	0.84	0.772
13	Nyíregyháza, Hungary	100–200	44	0.927	0.352	0.761
14	Vila-seca, Spain	100–200	41	0.654	0.35	0.725
15	Hadres, Austria	100–200	56	0.625	0.51	0.716
16	Nieuwe Pekela, Netherlands	100–200	91	0.421	0.694	0.701
17	La Fare-les-Oliviers, France	100–200	76	0.484	0.645	0.695
18	Kruiningergors, Netherlands	100–200	77	0.392	0.706	0.692
19	Borgo Incile, Italy	100–200	51	0.552	0.547	0.689
20	Gratkorn, Austria	100–200	43	0.551	0.474	0.665
21	Homblières, France	100–200	87	0.46	0.63	0.664
22	el Prat de Llobregat, Spain	100–200	65	0.395	0.592	0.647
23	Janikowo, Poland	100–200	30	0.559	0.355	0.636
24	Rosignano Solvay, Italy	Below 100	15	0.9	0.263	0.631
25	Coevorden, Netherlands	100–200	58	0.432	0.486	0.629
26	Burgas, Bulgaria	100–200	39	0.546	0.336	0.624
27	Sant Martí Sarroca, Spain	100–200	46	0.589	0.373	0.619
28	Lanaken, Belgium	100–200	39	0.52	0.326	0.612
29	Hoogvliet, Netherlands	100–200	59	0.459	0.45	0.61
30	Petržalka, Slovakia	100–200	35	0.455	0.329	0.593

Table 5: The 30 priority clusters for geothermal industrial heat in Europe, ranked by combined score. Temperature requirement is the process heat the cluster's facilities require, and demand is the cluster's net industrial heat demand. T1 is the technical viability score, T2 is the industrial business case score, and the combined score combines the two, as described in "Two-Track Ranking." MW = megawatts. Source: Project InnerSpace.

Trading System, and in 23 of them, facilities emit more than their free allocation; at €65 per tonne, buying those extra allowances costs about €150 million a year. This provides a financial incentive to switch to geothermal heat. At 25 of the 30 locations, reported data confirm which fuel the facilities mainly burn today; the other five carry a 10% reduction on the commercial track. For the other five clusters, the analysis estimates the fuel as a blend of natural gas and coal, weighted by how close the cluster is to a gas pipeline, and reduces their commercial score by 10%.

Combined Ranking

As shown in **Table 5**, the combined scores for the 30 priority clusters run from 0.593 to 0.926, with Priolo Gargallo in Italy ranked at the top of the list. Thirteen of the 30 clusters appear in the top 50 of both tracks, meaning they have a strong-enough resource and a strong-enough business case to be selected independently.

Characteristics of the Strongest Opportunities

Each of the top 10 locations reaches its position through a different balance of the two tracks. Süßenbrunn, Priolo Gargallo, and Varangéville are resource-led, scoring 0.960, 0.920, and 0.897 on the technical track. Padule, Wesseling, and Tarragona are demand-led, carrying 187 megawatts, 101 megawatts, and 82 megawatts, respectively, with commercial scores of 0.813, 0.789, and 0.699 against technical scores between 0.748 and 0.822. Varel in Germany (12th overall) has the strongest commercial case in the ranking at 0.840 on 108 megawatts. It ranks 12th mainly because Germany already holds three places

STRONG OPPORTUNITIES

Country	Clusters	Demand (MWth)	CO_2 Avoided (Mt/yr)	Highest-ranked cluster
Italy	4	352	0.77	Priolo Gargallo, Italy
Germany	4	338	0.67	Wesseling, Germany
France	4	292	0.7	Varangéville, France
Netherlands	4	285	0.58	Nieuwe Pekela, Netherlands
Spain	4	234	0.48	Tarragona, Spain
Hungary	3	188	0.37	Dunaújváros, Hungary
Austria	3	165	0.44	Süßenbrunn, Austria
Bulgaria	1	39	0.08	Burgas, Bulgaria
Belgium	1	39	0.08	Lanaken, Belgium
Slovakia	1	35	0.08	Petržalka, Slovakia
Poland	1	30	0.1	Janikowo, Poland

Table 6: CO2 = carbon dioxide; Mt/year = million tonnes per year; MW = megawatts; MWth = megawatts-thermal. Source: Project

above it, which brings a 10% country penalty. Rosignano Solvay in Italy remains the purest resource case, with 683 megawatts-thermal beneath only 15 megawatts of demand—the richest resource in the ranking.

Countries and Regions That Represent Strong Opportunities

Countries are listed in **Table 6** according to their highest-placed cluster. The resource column shows the average resource across each country's clusters, in megawatts-thermal per model cell, and the demand is the net of waste heat already available on site.

What the Ranking Shows

The ranking in these charts points to a compact set of near-term opportunities rather than a continent-wide programme. Twelve of the 30 clusters are in Germany, France, and Spain, and the top 10 alone account for 0.88 gigawatts of the 2 gigawatts total. The ranking is a screening tool, not a feasibility study. Each of the 30 locations still requires borehole-specific resource confirmation, engineering, heat off-take agreements, permitting review, and financing before a project can move forward. The short list should therefore be read as a pipeline for further project development, not as 30 construction-ready projects.

The IEA puts the full technical potential for electrifying low-temperature heat and steam across the European Union's industrial sectors at about 190 million tonnes of carbon dioxide per year, equal to 8% of total EU greenhouse gas emissions, by replacing roughly 3,000 petajoules of fossil fuel use.[45] That estimate assumes electrification, but it measures the same low-temperature fossil heat that geothermal could replace. The 30 clusters here would displace about 4.3 million tonnes of carbon dioxide per year, about 2.3% of the addressable potential. The full set of 152 eligible clusters would avoid 11.0 million tonnes, or 5.8% of the 190 million tonne potential identified by the IEA.

The short list is deliberately small against the continental total. Its job is not to summarise what geothermal could eventually serve, but rather to name the 30 places where a geothermal heat network is most likely to be built first—sites that have a resource, demand, and sufficient facilities and where the case is strong enough to start development now. Each cluster developed does more than displace its own emissions. It also proves the model to a neighbouring cluster, helps take the risk out of the next drilling campaign, and turns a share of the 190 million tonnes from a technical estimate into real projects.



Barriers and Policy Recommendations

Barriers

Geothermal can provide clean, firm heat for industrial processes, including where demand is continuous. The development of geothermal heat delivery systems for industrial clusters faces four main categories of barriers: awareness, technology, financing, and permitting. Geothermal tends to be overlooked due to its historically niche role, a lack of political visibility, and the difficulty in identifying suitable locations. The hydrothermal energy industry is relatively bespoke, and scaling it would require a standardised approach that works from one site to the next.

This is where next-generation geothermal technologies can make a real difference and make projects more repeatable. But because their commercial maturity is still low, they need to have risk removed. Financing and off-taker commitments are closely linked. Next-generation technologies face high up-front costs, and buyers may be reluctant to commit to long-term heat contracts before technology is proven and costs fall. Yet, meaningful cost reductions depend on deployment at scale, with multiple wells per site and projects reaching tens of megawatts. This leads to a classic chicken-and-egg problem: Costs will fall as projects scale, but reaching that scale requires off-takers willing to commit before cost reductions materialise. Finally, permitting can be a barrier, particularly where local and regional authorities lack familiarity with geothermal, standard procedures are fragmented, or administrative capacity is limited. These challenges could become more pronounced as the sector expands.

The private sector and public policy can address barriers in complementary ways. Next-generation technologies can make geothermal projects more repeatable. Heat-as-a-service contracts—in which a provider builds and operates the system and the customer pays only for the heat it uses—can offer industrial buyers a standard way to procure geothermal heat and help structure long-term demand. Public policy can reinforce these efforts by improving permitting procedures, building familiarity among local and regional authorities, and providing early-stage financial support to reduce risks that private investors and off-takers are not yet willing to bear alone.

These barriers often overlap in practice. The eight recommendations are grouped into three areas for action: identifying and organising the first projects, reducing early-stage risk and unlocking investment, and creating the conditions for geothermal to scale more broadly across Europe (**Figure 11**).

Who Can Do What

Energy is a shared issue in the European Union, but article 194(2) of the Treaty on the Functioning of the European Union reserves to member states the right to determine the conditions for using their energy resources.[46] This means that licensing, mining law, geological surveys, heat networks, and liability for induced seismicity are national, or often regional, matters.

The European Union holds three levers that can support all of its members:

1. The organisation can fund projects through a few pathways: Horizon Europe, the Innovation Fund, InvestEU, and the European Investment Bank. There will also soon be another Multiannual Financial Framework that could fund projects.

2. The European Union assesses the compatibility of national state aid with EU law.

3. The European Union sets rules via directives such as the Renewable Energy Directive III (RED III) and the Energy Efficiency Directive (EED), which include parts of the permitting framework.

The European Union cannot licence a well directly, but it can pay for it, lower its risk, and set deadlines for the authorities that approve it. The hurdle is that the existing instruments for geothermal development were largely designed for conventional geothermal projects. Those instruments provide useful policy models, but they need to be adapted with new approaches to risk, data, and licensing to support both conventional and next-generation geothermal across a much wider range of geologies.

The European Union also holds a lot of useful knowledge that can propel an expanded geothermal industry. France and Germany understand drilling risk. The Netherlands publishes its subsurface data. Denmark protects geothermal heat contracts from price regulation. Germany has declared geothermal development to be in the public interest. The European Union funds industrial heat through the Innovation Fund. But these instruments were designed one at a time, mostly for single projects, and again, mostly for conventional geothermal resources in specific places.

Scaling geothermal industrial heat in Europe will require a more strategic and comprehensive policy approach that reduces early-stage risk, turns promising resource and demand into bankable clusters, creates clearer permitting and subsurface rules, and provides the financing and commercial structures needed to move projects from exploration to construction. These eight recommendations aim to address those barriers and create a clearer pathway for geothermal industrial heat projects to scale across Europe.

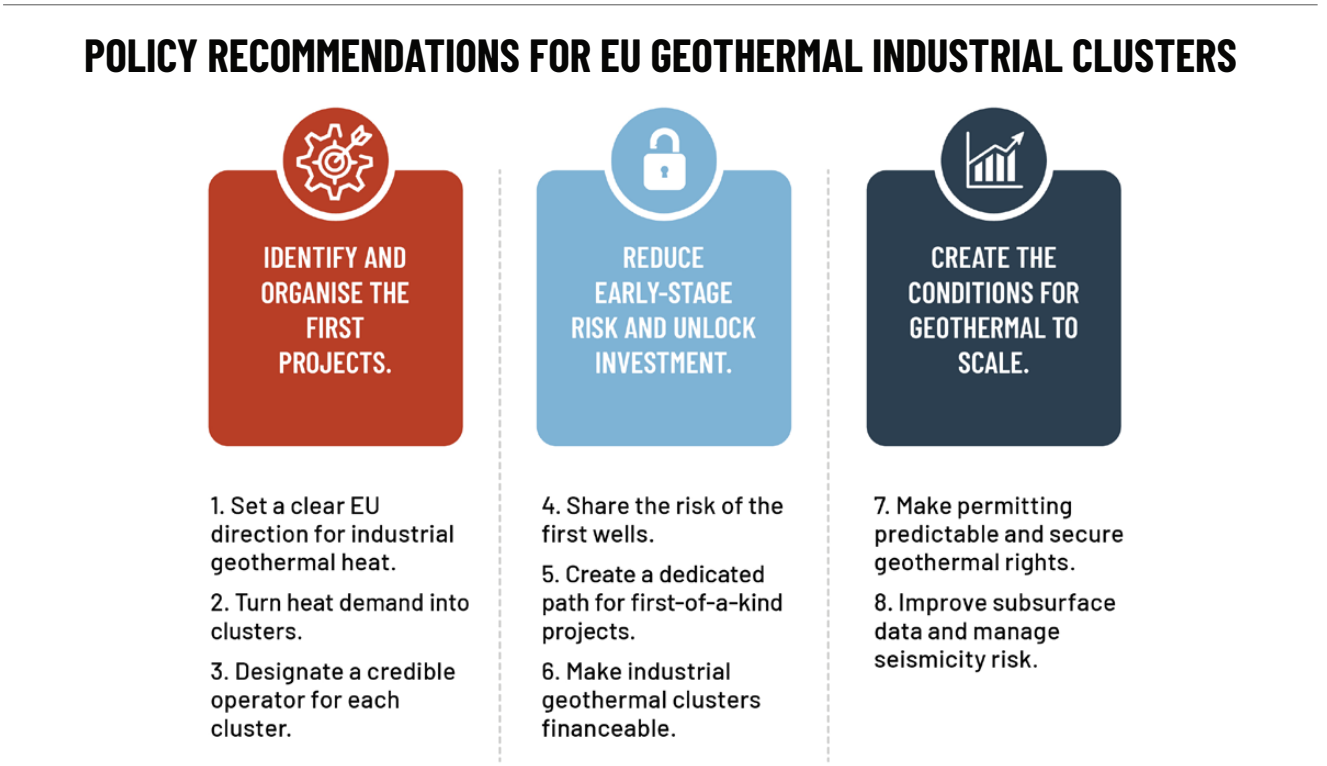


Figure 11: Eight policy recommendations organised into three areas for action: identifying and organising the first projects, reducing early-stage risk and unlocking investment, and creating the conditions for geothermal to scale. Source: Project InnerSpace and Future Cleantech Architects.

Identify and Organise the First Projects

These three recommendations focus on turning a promising resource and demand into an initial project pipeline by setting priorities, organising customers, and establishing credible project operators.

1. Set a clear EU direction for industrial geothermal heat.

Several EU initiatives already point in the right direction. AccelerateEU sets out general orientations for next-generation geothermal, and the Electrification Action Plan included a Geothermal Stakeholder Partnership for early 2027 focused on data, financing, and permitting.

EU Action

The upcoming EU Geothermal Action Plan, initially announced as being released in early 2026, is still unpublished at the time of the writing of this paper. The Action Plan and the upcoming Stakeholder Partnership (by the first quarter of 2027) should take the following actions:

- Help identify priority industrial clusters (as done in this report) and next-generation geothermal potential.
- Develop models for heat purchase agreements.
- Design the EU risk facility (see Recommendation 4), and explore geothermal de-risking and insurance schemes.
- Create a quantified trajectory for geothermal in industrial heat.

Member States Action

In their own national energy and climate plans, member states should identify how geothermal industrial heat can contribute to the RED III target of increasing renewable energy use in industry by at least 1.6 percentage points per year. Without such a commitment, geothermal will remain what it has been so far: a niche player that everyone agrees is promising yet nobody plans for.

2. Turn heat demand into clusters.

No specific instrument finances the key step that would turn several potential users into one bankable project. Before a cluster can attract construction finance, developers must pay for geological data, seismic surveys, resource confirmation, engineering, permitting, customer aggregation, legal structuring, and heat purchase agreements. In Ludwigshafen, BASF and Vulcan Energy got positive two-dimensional seismic results. That survey is the basis for a planned three-dimensional seismic survey and preparation of an appraisal well.[47]

EU Action

- Use the Geothermal Stakeholder Partnership and EU geothermal data initiatives to identify priority industrial areas where geothermal resources overlap with concentrated heat demand. Provide a framework for bringing developers, industrial off-takers, utilities, and public authorities together around those opportunities.
- Fund the project preparation those partners need, potentially through a facility for geothermal industrial heat modelled on the European Investment Bank's European Local Energy Assistance (ELENA) programme. That support would carry promising clusters far enough to qualify for existing drilling-risk programmes, which cover failed wells, and for deployment instruments that help pay to build and run projects.

Member States Action

- Systematically assess the overlap between industrial heat demand and geothermal resources (as identified in this paper) when preparing local heating and cooling plans according to the EU's Energy Efficiency Directive.[48] These plans should go beyond buildings and district heating to explicitly include industrial process heat demand. Member states should use this assessment to designate priority industrial clusters where geothermal resources and concentrated heat demand coincide. In this way, heat planning can turn geological and demand data into concrete opportunities for shared wells and heat infrastructure.

- Designate areas around priority clusters for permitting acceleration, ideally with a single lead authority for subsurface, environmental, and heat network approvals.

- Co-fund project preparation for designated clusters.

3. Designate a credible operator for each cluster.

A shared project needs an operator entity that can own and control the wells and the network, sign contracts with several customers, meter and dispatch heat, maintain backup capacity, and add users over time. Industrial users may be unwilling to manage shared infrastructure outside their core business, and developers and utilities may hesitate to invest before several customers have committed to long-term heat purchases. The operator can coordinate these interests and allocate risks, owning the shared wells and network, and each industrial user would still remain responsible for the costs of connecting its own plant, including heat exchangers, piping, changes to steam systems, and (where higher temperatures are needed) heat pumps. Depending on the context, this operator could be a municipal utility, industrial park operator, dedicated project company, or specialist geothermal operator.

EU Action

- Explicitly accommodate that in EU funding and state aid rules, operators that serve several industrial sites, as Currenta does in Germany (see "How a Geothermal Cluster Operates" earlier in this paper). That would create support for the shared well and related infrastructure, not only for individual installations.

- Confirm that geothermal clusters fall within the Clean Industrial Deal State Aid Framework, which allows grants, loans, and guarantees for industrial decarbonisation and shared infrastructure.

- Extend existing industrial decarbonisation and efficiency programmes to cover geothermal industrial clusters.

Reduce Early-Stage Risk and Unlock Investment

These three recommendations address the resource, technology, and commercial risks that make first projects difficult to finance.

4. Share the risk of the first wells.

One of the main barriers to next-generation geothermal is the high cost and uncertainty of exploratory drilling and building the first wells. Insurance can play a key role in taking the risk out of these early steps.[49] Several individual European countries already have policy mechanisms in place to share that risk between the public and private sectors, but these are often limited to conventional geothermal. France has run a geothermal guarantee fund for deep aquifers since the 1980s.[50] Until 2023, developers in the Netherlands paid a premium under the RNES guarantee scheme, and the state covered part of the loss if drilling underperformed.[51] Switzerland goes further, covering up to 60% of exploration costs.[52]

A German exploration-risk instrument that launched in December 2025 is a notable example of a public-private risk-sharing scheme for next-generation geothermal: KfW, Germany's state-owned development bank, offers loans of up to €25 million for wells deeper than 400 metres. Before drilling, Munich Re, a German reinsurer, insures between 30% and 70% of the loan, while KfW covers the remaining share if the well underperforms. Together, they can protect up to 100% of the loan.[53]

The problem is that existing risk-sharing schemes are largely country-specific, with no dedicated EU-wide mechanism to de-risk early next-generation geothermal development, unlike some other clean energy technologies. Today's GEODEEP programme in France, for instance, is capped at a handful of projects.[54] At the EU level, the Innovation Fund Heat Auction demonstrates that renewable heat technologies, including geothermal and solar thermal, can receive support across countries. This support rewards verified heat production over five years but does not cover the up-front risk of drilling an unsuccessful well. Coverage of next-generation technologies therefore remains uneven, particularly for closed-loop systems that may not fit schemes designed around conventional resource-success metrics.

Member States Action

Member states should design drilling-risk schemes to cover next-generation geothermal technologies, including closed-loop systems and engineered reservoirs.

- Insure projects before drilling begins; cover the risk of insufficient temperature or, where relevant, flow rates; and provide predictable coverage of eligible drilling costs.
- Define transparent risk-sharing arrangements, capped public exposure, and reimbursement conditions, with independent technical assessment to verify project risks and results.
- Coordinate scheme design where possible, and share geological and drilling data to improve risk assessment and avoid fragmented national approaches.

EU Action

The European Union should help extend financial support programmes both geographically and in scope to cover next-generation technologies. To do so, the European Union should take the following actions:

- Encourage best practices between member states to ensure they set up similar financial backing programmes.
- Use InvestEU and the European Investment Bank to back an EU geothermal risk fund that co-finances or reinsures national schemes and pools geological risk across several basins, which no single national programme can do.
- Explicitly confirm, through the European Commission, that such programmes are compatible with the Clean Industrial Deal State Aid Framework to avoid legal uncertainty that might deter ministries before the programmes are even designed.
- Use the current revision of the General Block Exemption Regulation, which expires at the end of 2026, to let member states run drilling-risk programmes without first seeking the European Commission's approval for each one.[55]

5. Create a dedicated path for first-of-a-kind projects.

The EU Innovation Fund's Heat Auction is a useful deployment route for geothermal, but it does not address the early resource confirmation and project-development risks that are particularly important for next-generation geothermal.[56] Next-generation geothermal projects that are not mature often cannot compete against electric boilers and heat pumps in terms of euros per tonne of carbon dioxide. Boilers and heat pumps are cheaper up front and quicker to build. Add to that, the requirement in the Heat Auction to reach financial close within 2 to 2 1/2 years of grant signature can also be incompatible with the timelines required for geothermal resource exploration.

EU Action

Ensure that the Innovation Fund's general decarbonisation and pilot calls, along with other relevant EU instruments, can support first-of-a-kind next-generation geothermal projects at each stage of development: feasibility work, resource confirmation, demonstration drilling, and first commercial deployment. Use the European Investment Bank's Project Development Assistance to help promising projects reach the maturity needed to compete for funding. Where exploration and resource-confirmation risks fall outside these instruments, pair Innovation Fund support with the geothermal risk-sharing mechanisms in Recommendation 4. Once costs fall and funding criteria better reflect their system value, next-generation geothermal projects will be able to compete on an equal footing with other low-carbon heat technologies or innovative renewable technologies, offering reliable, around-the-clock heat with limited additional demand on the electricity grid.

Member States Action

Extend long-term operating support, building on the Dutch SDE++, to industrial next-generation geothermal heat projects in more countries, including shared heat production where several industrial users can provide a stable demand base. Complement this with investment and project-development support,[57] following the French Fonds Chaleur model,[58] to help finance feasibility studies, shared wells, and heat infrastructure connecting multiple industrial users.

6. Make industrial geothermal clusters financeable.

Ensuring firm long-term heat off-take can be difficult before the resource has been proven, and for next-generation projects, this can be difficult before the technology has been proven at commercial scale. Yet, financing additional drilling and infrastructure can also depend on having committed customers in place. Eavor's first commercial plant, in Geretsried, Bavaria, illustrates one approach to assembling long-term heat off-take and project financing. Eavor signed a heat contract with a subsidiary of the town's municipal utilities and assembled financing that included a €91.6 million EU Innovation Fund grant and a European Investment Bank loan of close to €45 million, backed by InvestEU.[59] The first of four planned loops began operating in December 2025; the remainder await further commercial certainty before proceeding.[60,61]

Denmark shows how price regulation can take the risk out of geothermal investment. Danish heating companies, including municipally owned ones, normally cannot charge consumers more than the cheapest available alternative. Geothermal contracts are exempt from that rule if five conditions are met: (i) Geothermal was the lowest-cost option for the heating company at signing; (ii) the producer and buyer are independent; (iii) the contract meets set terms; (iv) the delivery must have started after March 2023; and (v) the municipal council approves it. Investors are thus protected against cheaper heat entering the market after the wells are drilled.

EU Action

- Develop a model heat purchase agreement for 10 to 15 years,[62] through the Stakeholder Partnership, with indexation rules.
- Support further heat-as-a-service contracts.[63]
- Provide public counter-guarantee programmes that would cover a buyer's credit risk. The latter is mentioned in the Affordable Energy Action Plan for a European Investment Bank pilot initiative for power purchase agreements, and nothing prevents this idea from being extended to heat.[64,65]
- Create demand by having municipal utilities serve as buyers.[66]
- Provide public guarantees by national promotional banks—the state-owned development banks such as Germany's KfW that guarantee part of a cluster's revenue if a buyer unexpectedly leaves its contract, until a replacement is found.
- Under the Critical Raw Materials Act, leverage a project's status in locations where geothermal fluids contain lithium that can be extracted to give permitting priority and access to finance.

Create the Conditions for Geothermal To Scale

These two recommendations focus on the permitting, rights, data, and regulatory framework needed to make geothermal development more predictable and repeatable across Europe.

7. Make permitting predictable, and secure geothermal rights.

The RED III programme created renewable acceleration areas, binding permitting deadlines, and a presumption of overriding public interest. Member states can limit that presumption to certain areas or technologies, so geothermal may not benefit from it everywhere. Add to that, exploration licences often fall under national mining law, which may sit outside RED III's permitting deadlines. National rules can also change sharply with depth. In the Netherlands,[67] wells shallower than 500 metres follow the general environmental permitting regime, while deeper wells—where the real potential can be found—fall under the Mining Act and its much heavier procedures.[68]

Developers and lenders also need to have clear rights for geothermal development, including exclusive exploration rights, a predictable path from successful exploration to production, licences that cover an extensive time period and are transferable, and clear rules for a shared reservoir where several wells or projects may interact. Croatia offers two practices worth considering: First, the process starts with consultation of local and regional authorities, and no response after 30 days counts as consent. Second, a single competitive bidding round then awards the winning bidder an exploration permit of up to five years. Following

exploration, the Ministry of Economy decides on extraction within 30 days of the application, and the developer can receive a production contract of up to 25 years.[69,70]

EU Action

The European Union should make sure that member states fully apply the permitting rules already in RED III. It should also clarify how far those rules reach for next-generation geothermal exploration and production licences that fall under a national mining law.

Member States Action

Member states should emulate Germany's December 2025 geothermal acceleration law,[71] which recognises geothermal as being of overriding public interest until climate neutrality is reached in 2045, introduces mandatory deadlines in mining law procedures, and allows installations in rural areas without prior land-use planning. This action should not remove the need to comply with applicable environmental safeguards. States should also ensure geothermal licences are continuous from exploration through production and, where necessary, manage a shared reservoir at the field level rather than permit by permit.

8. Improve subsurface data and manage seismicity risk.

Better subsurface data can help developers identify suitable sites and assess resource potential before drilling. Having data also enables regulators to establish local seismic baselines, assess geological stresses, and set proportionate monitoring thresholds to manage the risk of induced seismicity.

After earthquakes were induced in France in 2019 and 2020, the Vendenheim geothermal project near Strasbourg was halted,[72] and deep geothermal development in the area stalled. A similar case in Basel, Switzerland, also stopped the sector's progress for years.[73] Managing this risk adequately, with stakeholder engagement, is crucial.

Most seismic and well data remain confidential, especially from past oil and gas exploration. The Dutch RNES guarantee programme, which insured developers against failed wells until 2023, is a valuable example of mandatory data disclosure. Developers who joined the programme had to release certain data after completing their wells, so each well that the programme backed added to knowledge of the subsurface for the next project.

EU Action

- Build the European geothermal subsurface database announced in the AccelerateEU Communication.
- Mandate the release of data after a fixed confidentiality period,[74] or make data-sharing a condition of public funding for geothermal projects.
- Issue EU guidance on induced-seismicity management and reservoir stimulation based on established international protocols and best practices.[75]

Member States Action

- Extend public funding to drilling that collects data where needed, with results made public, including data on temperature and rock stress in basement rock.
- Provide a specific regulatory framework for engineered geothermal system technology with safeguards for induced seismicity, such as traffic-light monitoring protocols and clear operator liability.[76]

BEYOND THE FIRST 30

The 30 priority clusters represent a starting point, not the limit of the opportunity. A wider pool has 152 candidate clusters in 14 countries that already meet the screening criteria, and additional locations can be reassessed as subsurface and facility data improve, drilling costs fall, and project economics strengthen.

The policy needs should evolve with that pipeline. The first projects will require intensive project preparation, resource confirmation, customer coordination, and targeted risk support. As those projects establish repeatable contracts, operator models, and drilling experience, policy can shift toward standardised approaches that support broader deployment.



Conclusion

The European industrial sector uses about one-quarter of the energy produced for the European Union. Most of that use is in the form of heat. Today, natural gas supplies about half of that heat, yet beneath the EU-27 countries sits about 18,000 gigawatts-thermal of geothermal heat at temperatures of 100°C or above. Those temperatures are well suited to lower-temperature industrial processes and, with heat pumps, to much of the remaining industrial heat demand.

The opportunity is concrete and concentrated. This paper identifies 30 priority clusters in 11 countries where geothermal resources sit close to industrial demand.

BY THE NUMBERS

- ***Together, those sites have about 2 gigawatts of heat demand.***
- ***Switching these sites to geothermal would avoid about 4.3 million tonnes of carbon dioxide emissions each year.***
- ***Switching would also displace more than €850 million in fuel spending each year.***
- ***The top 10 sites account for about 0.88 gigawatts of heat demand.***
- ***In 23 of the 30 clusters, facilities emit more than their free EU carbon allowances; buying the extra allowances costs about €150 million a year.***

There is a longer list of 152 clusters that could help the European Union avoid 11.0 million tonnes of carbon dioxide each year.

About Clusters

When several buyers share one set of wells, the wells sell heat for more hours, the cost of each megawatt-hour falls, and the loss of one buyer no longer sinks the project. A geothermal plant near Munich ran the equivalent of less than half the hours in a year, because demand for its heat rose and fell with the weather. If it ran 79% of the time (the average for European geothermal power plants), it would sell about two-thirds more heat from the same wells, and the capital cost per megawatt-hour would fall by about 40% (see "Where the Savings Come From").

There are systems already taking these actions in the European Union. Trias Westland in the Netherlands supplies geothermal heat to 54 growers; in Chempark in Germany, the site operator Currenta operates shared energy infrastructure for about 70 companies.

Barriers

Early-stage risk, financing, and permitting are not only barriers but also the areas where public policy can make an outsize difference. Europe already has many of the tools needed, but they were developed country by country, mostly for single conventional geothermal projects. The recommendations in this paper can make those tools work together more effectively.



An EU risk fund that reinsures national drilling-risk schemes, together with funding for project preparation, would help promising industrial geothermal heat clusters acquire construction financing. Model heat purchase agreements and public guarantees would make cluster contracts bankable. Durable licencing rights and permitting deadlines that cover mining-law licences would give developers and lenders a predictable path from exploration to production. Germany's December 2025 Geothermal Energy Acceleration Act, which declared geothermal to be of overriding public interest until 2045 and sets deadlines in mining law procedures, can be a model for other countries.

Those changes would help each of the 30 clusters identified in this report get developed, prove the model to their neighbours, and take the risk out of the next drilling campaign. In these 30 places, the case is strong enough to move now. Getting the first projects built would lead to the growth of geothermal across Europe, increasing energy security, reducing fuel-price exposure, and strengthening industrial competitiveness.



Appendix: Methodology

Sensitivity to the Cluster Radius

The 7 kilometre radius is calibrated to a road-distance constraint, as "The 30 Priority Clusters: Screening and Results" sets out. As a sensitivity to ensure critical clusters are not left behind by this restriction, the clustering was rebuilt at 10 kilometres and scored through the same path.

Relaxing the radius captures 1.0 gigawatt more industrial demand across Europe, lifts the eligible pool from 152 clusters to 177, and takes the top-30 total from 2.00 gigawatts to 2.25 gigawatts and the carbon displaced from 4.33 megatonnes to 4.84 megatonnes per year. Of the 30 clusters in the 10 kilometre ranking, five are new locations. Because the list stays at 30 clusters, five clusters from the 7 kilometre list fall out of the top 30 to make room.

CLUSTERING RESULTS AT A RADIUS OF 7 KILOMETRES AND 10 KILOMETRES

	7 Kilometres (published)	10 Kilometres
Clusters formed	313	325
Demand captured	13.3 gigawatts	14.3 gigawatts
Median cluster radius	3.2 kilometres	6.9 kilometres
Scored pool	152	177
Top-30 demand	2.00 gigawatts	2.25 gigawatts
Top-30 carbon dioxide	4.33 megatonnes per year	4.84 megatonnes per year
Score range	0.593 to 0.926	0.581 to 0.911

Table A.1: Clustering results at the 7 kilometre radius used in this paper's "The 30 Priority Clusters: Screening and Results" section and at a 10 kilometre radius tested for sensitivity. Source: Project InnerSpace analysis.

Where those new places land is the question that determines whether the radius matters. None of the five clusters enters the top 10. The highest, Heist in Germany, is 14th on 107 megawatts, and Martigues in France is 18th on 118 megawatts. The other three—Windpassing in Austria, Kaczory in Poland, and Goetsenhoven in Belgium—sit between 25th and 29th. Between them, the five new locations carry 0.37 gigawatts, about one-sixth of the 10 kilometre total. The top of the ranking barely changes. The Wesseling cluster in Germany grows from 101 megawatts to 109 megawatts and moves from third to first, just ahead of Priolo Gargallo in Italy, and the next three places all go to clusters already in the top 10 at 7 kilometres. Kaczory gives Poland a second cluster. The case for the wider radius therefore rests on more demand at places already on the list rather than on new top-ranked opportunities.

Most of the five clusters that fall out of the top 30 remain as opportunities. Two are taken into larger neighbours that stay on the list. At 10 kilometres, the Vila-seca sites join the Tarragona cluster, which grows from 82 megawatts to 129 megawatts and ranks 10th, and the Hoogvliet sites join the Kruiningergors cluster, which grows from 77 megawatts to 127 megawatts and ranks 13th, so those opportunities are still there under a different name. Two more still exist as scored clusters at the same spot, Varel in Germany (16th of 177) and Homblières in France (26th of 177). They drop only because Germany and France already hold four places above them, and the cap allows no more than four clusters per country. Only Lanaken in Belgium has no eligible 10 kilometre cluster anywhere near it.

The wider radius also changes the clusters that appear in both rankings. Of the 25 locations included in both the 7 kilometre and 10 kilometre lists, 13 take in more heat demand and none lose any demand. Tarragona increases from 82 megawatts to 129 megawatts, Kruiningergors from 77 megawatts to 127 megawatts, Padule from 187 megawatts to 224 megawatts, and Nieuwe Pekela from 91 megawatts to 115 megawatts. Using 7 kilometres in the main analysis therefore keeps the estimates on the low side. It undercounts demand at sites where industry is spread across 7 kilometres to 10 kilometres, which is common in large chemical and industrial corridors.

Sensitivity to the Resource Estimate

The heat-in-place layer ships a P10, P50, and P90 mosaic from the same Monte Carlo run, so the whole pipeline was scored three times to see how much of the ranking depends on which percentile is read. Twenty-nine of the 30 clusters

LOCATIONS ADDED TO THE TOP 30 FOR THE 10 KILOMETRE RADIUS

Rank	Location	Band (°C)	Demand (megawatts)	Technical Score (T1)	Business Case Score (T2)	Score
14	Heist, Germany	100–200	107	0.647	0.76	0.758
18	Martigues, France	100–200	118	0.335	0.909	0.69
25	Windpassing, Austria	100–200	44	0.708	0.313	0.621
28	Kaczory, Poland	100–200	44	0.415	0.388	0.604
29	Goetsenhoven, Belgium	100–200	56	0.332	0.448	0.592

Table A.2: The five locations that enter the top 30 when the cluster radius widens from 7 kilometres to 10 kilometres, with their rank in the 10 kilometre list. T1 is the technical viability score, T2 is the industrial business case score, and the score column combines the two. Source: Project InnerSpace analysis.

DEPTH TO TARGET TEMPERATURES ACROSS THE 30 PRIORITY CLUSTERS

Target	Median Depth (kilometres)	Within 4 Kilometres	Within 5 Kilometres	Not Reached
100°C	2.69	30 of 30	30 of 30	0
150°C	4.31	9 of 30	29 of 30	1
250°C	Beyond 5	0 of 30	0 of 30	30

Table A.3: Median depth at which the 30 priority clusters reach 100°C, 150°C, and 250°C, as well as the number of clusters that reach each temperature within 4 kilometres and 5 kilometres. Not reached = clusters where the 7 kilometre average does not reach the temperature within 5 kilometres, the depth range of the data. Source: Project InnerSpace temperature model.

appear in all three rankings, and the median cluster moves by one place. Twenty-five of those 29 clusters are classified as stable, moving two places or fewer.

Only four clusters move more than two places between the P10 and P90 runs: Dunaharaszti in Hungary (13th and 9th), Rosignano Solvay in Italy (21st and 30th), and two Spanish clusters, Sant Martí Sarroca and el Prat de Llobregat (three and five places, respectively). Petržalka in Slovakia, 30th overall, drops out at P90. The order of the top 30 depends on demand, infrastructure, and commercial terms more than on uncertainty in the resource estimate. That uncertainty is wide in absolute terms but close to uniform across the clusters.

Target Depth and the Rock Where Heat Is Found

A resource score says heat is present; it does not say how far down the heat is or what has to be drilled through to reach the heat. Those details determine whether a project requires a conventional doublet or an engineered geothermal system. Sampling the depth-to-isotherm grids over the same 7 kilometre disc, alongside the sediment thickness grid, shows where the sedimentary rock ends and the basement rock begins and provides this information.

The 100°C basis for the resource score is realistic for all the clusters. The median cluster reaches 100°C at 2.69 kilometres, and all 30 clusters reach this temperature within 4 kilometres. The picture is different at higher temperatures. A temperature of 150°C sits at a median of 4.31 kilometres and is within 4 kilometres for nine clusters and within 5 kilometres for 29. A temperature of 250°C is not reached within 5 kilometres at any of the 30 clusters, the deepest level these temperature data cover.

This matters because 29 of the 30 clusters need heat at temperatures between 100°C and 200°C and one needs heat below 100°C. That band describes the temperature the processes need, not the temperature a well at that location would deliver. Each cluster's supply is therefore measured as heat above the lower temperature of its band: above 100°C to 3.5 kilometres for the 100°C–200°C band, and above 50°C to 3.5 kilometres below 100°C.

Using the evidence available, most of these clusters are candidates for geothermal at around 100°C, with a heat pump or a supplementary boiler to lift the last step, rather than for direct high-temperature supply. Reaching 150°C means drilling to more than 4 kilometres at 21 of the 30 clusters. Where that depth lies below the sediment, reaching the heat means drilling and

HOW DEEP THE 30 PRIORITY CLUSTERS MUST DRILL TO REACH 150°C

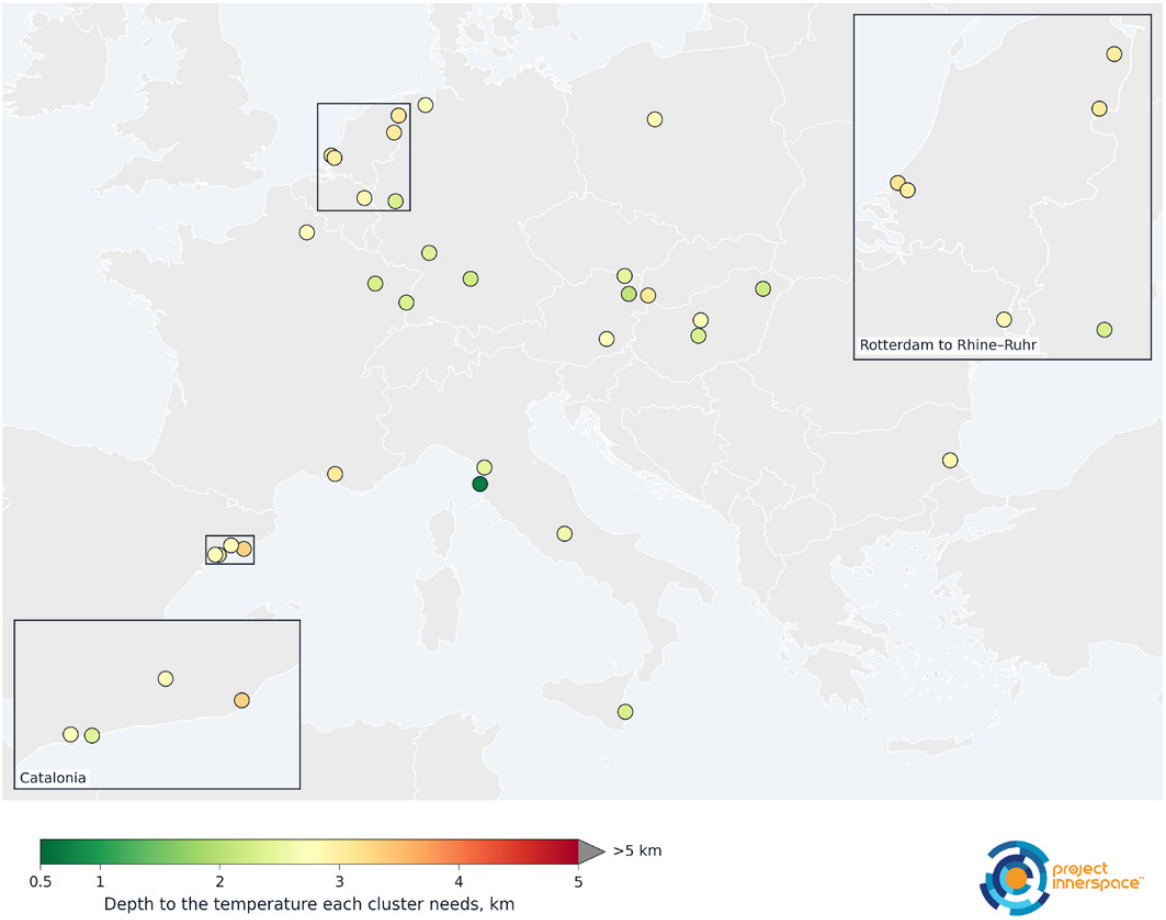


Figure A.1: Depth to the 150°C isotherm. Heavy green rings mark the two clusters where that isotherm lies inside sediment. Source: Project InnerSpace.

stimulating crystalline rock, with the induced-seismicity and permitting questions that doing so carries in Europe, and beyond the depth to which most current direct-use heat projects drill. The independent thermal-domain classification read over the same points places 14 of the 30 clusters in an advection-dominated setting, 14 in a sedimentary setting, and two in crystalline basement.

One caveat on provenance: These depth grids are a global 0.05 degree product built on the sediment thickness model, and the resource layer used for scoring is a separate EU-27 heat-in-place mosaic. They were not built together, so the two should be read as independent lines of evidence rather than as one consistent model.

METHODOLOGY FOR CALCULATING GEOTHERMAL POTENTIAL

The Heat-in-Place (HiP) method utilises the calculations from Pocasangre and Fujimitsu, as described in their 2018 paper, computing the thermal energy stored in each grid cell as a function of depth, temperature, rock and fluid properties, and recovery efficiency. The assessment divides the subsurface into 500 metre depth slices (from 500 metres to 5,000 metres; current technology for electricity generation) or 7,000 metres (future potential electricity generation) and 3,500 metres for heat applications (current technology) and 5,000 metres (future potential).

For each grid cell at each depth slice, the calculation proceeds as follows:

1. Temperature estimation: T(z) is computed using the domain-specific temperature-depth curves, incorporating the local geothermal gradient, surface temperature, and nonlinear corrections for sedimentary compaction and advective heat transport.

2. Porosity calculation: Porosity is modeled using Athy's compaction law, $\varphi(z) = \varphi 0 \cdot \exp(-c \cdot z)$, calibrated to Ehrenberg and Nadeau using more than 40,000 global reservoir measurements.

3. Thermal energy: The heat stored per unit volume is calculated as:

$$Q_{rock} = V \times \rho_r \times C_r \times (1 - \varphi) \times \Delta T$$

$$Q_{water} = V \times \rho_w \times C_w \times \varphi \times \Delta T$$

4. Recoverable energy: The electrical potential is computed as:

$$GWe = Q \cdot R_f \cdot \eta(T) / (plant_life \cdot seconds_per_year)$$

where R_f is the recovery factor (20%), $\eta(T)$ is the temperature-dependent conversion efficiency used in the electricity model, and $plant_life$ is 30 years.

The deterministic calculation is augmented by a 2,000 iteration Monte Carlo simulation that perturbs key input parameters within their empirically calibrated uncertainty ranges. This produces probability distributions (P2, P10, P50, P90) of the geothermal potential for each grid cell and country.

The following parameters are perturbed in each Monte Carlo iteration:

- **Geothermal gradient:** Gaussian perturbation with category-specific standard deviations.
- **Surface temperature:** Triangular distribution with bounds ([-3, 0, +3]°C).
- **Temperature at depth:** Depth-dependent sigma values calibrated from well P10–P90 spreads, ranging from ±8°C to 11°C at 0.5 kilometres to ±24°C to 35°C at 5 kilometres, depending on geological domain.
- **Rock density (ρ_r):** Gaussian perturbation around 156.07 pounds per cubic foot (2,500 kilograms per cubic metres) with ρ_r–C_r correlation of –0.2.
- **Recovery factor (R_f):** Perturbation around 20% with R_f–C_e correlation of 0.1.
- **Porosity:** Depth-dependent sigma from Ehrenberg & Nadeau's analysis.

Marginal sigma scaling is applied to ensure that uncertainty decreases with proximity to well control points, providing spatially varying confidence levels. The Monte Carlo results converge well at 2,000 iterations, with coefficient-of-variation for global totals below 1%.

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