Strategic Energy Technology Plan

Implementation Working Group on Geothermal

Thematic Vision on Geothermal

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Executive Summary

Geothermal energy is key to European energy independence and climate neutrality. Geothermal energy includes supply of heating and cooling, with or without heat pumps; thermal energy storage that also bridges winter and summer seasons; dispatchable electricity production; and co-production of minerals, elements or compounds. These uses can often be combined in cascade, maximizing the value of the resource. European companies have long-standing expertise and are well positioned to deliver the full geothermal value chain, which is largely independent of critical raw materials. Developing geothermal is good for Europe's industry and jobs.

Geothermal energy offers a wealth of concepts and technologies, and there are many ways to match local geology and local demand by suitable technologies. While deeper drilling enables access to higher temperatures, it also increases costs. The main challenges for geothermal projects remain high upfront cost and the geological risk. Geothermal is proven technology, but technological advances will boost market development.

The Vision of IWG Geothermal is a significant acceleration by 2030 already: 3 times more heating and cooling supplied by geothermal; 2 times more electricity production; step up the uptake of geothermal storage, and co-production of geothermal minerals, elements or compounds in at least 3 European regions. The decade 2030-2040 shall see a steep market growth. In 2040, geothermal will supply 30% of Europe's space heating, 5% of industrial heat, and 20% of agricultural heating; geothermal storage will supply 10% of space heating; and geothermal will account for 10% of the total electricity generation; finally, 10 European regions will co-produce geothermal minerals, elements or compounds. The subsequent decade 2040-2050 shall see 5% expansion in all applications, and 5 more regions with co-production.

Current conditions favour acceleration of geothermal development. Key drivers are energy independence, grid congestion challenges, the need for renewable heat and to match seasonal demand patterns. Key enablers are policy, regulatory and technological advances, including advances on data availability. Many European governments have adopted geothermal strategies in recent years. The IWG will focus on advancing R&I in all parts of the value chain: exploration, resource development, and utilisation and integration into the energy system. Scale and size of the projects justify international collaboration. The IWG will also foster collaboration on policies and market support. A robust European market is the overarching aim.

At the request of the EC, the IWG recommends the following 3 technological areas for particular attention for R&I efforts in the next multiannual framework programme (2028-2034):

- Geothermal storage: developing viable concepts in various settings;
- Geothermal drilling and subsurface engineering: most important cost item for geothermal;
- Demonstrating innovative concepts: real projects are crucial for learning and inspiration.

The next step will be to translate this Vision into a Strategic Research and Innovation agenda. The ETIP-Geothermal, GEOTHERMICA Initiative, ETIP Renewable Heating and Cooling, EERA Geothermal, and the European Geothermal Energy Council (EGEC) will contribute to this work.

1. Introduction

1.1. Geothermal technologies in Europe

Europe needs to become climate neutral, competitive and resilient. Climate neutrality will largely be achieved by switching to renewable energy sources. The European energy system is changing rapidly. Europe needs to become less dependent on fossil fuels for heating, cooling, electricity and mobility and needs to consider its position when it comes to raw materials. Fostering European clean industries is a strategy that contributes to European resilience and jobs. Without competitive industries, Europe will not be able to prosper. Without the ability to take care of its own energy needs, Europe will fall prey to spiking fossil prices.

The transition of the energy system comes with challenges. While renewable electricity production covers nearly half of Europe's demand, the heating transition is lagging behind with about a quarter of the total heat demand supplied from renewable sources (Eurostat 2026a). The call for evidence for the renewed EU Strategy on heating and cooling reiterates that half of Europe's energy is used for heating purposes, in buildings, industry and agriculture (EC 2025a). The heating transition needs to accelerate to make the energy transition happen. In some countries, the electrification is slowing down because of electricity grid congestion, which can be alleviated by diversifying and using geothermal energy. Europe has a long-standing expertise in geothermal energy across the full temperature spectrum—from the lowest to the highest, from shallow surface layers to deep subsurface. These skills must be preserved and deployed.

Geothermal energy offers one of the few scalable, dispatchable and indigenous renewable solutions capable of replacing fossil fuels at scale in buildings, cities, industry and agriculture. Geothermal energy plays a critical system role by delivering renewable heat where it is needed, reducing peak electricity demand, alleviating grid congestion, and enabling cost-efficient sector coupling. Large-scale geothermal storage is crucial to address the winter peak for heating and the summer peak for cooling. Geothermal heating, cooling and thermal storage therefore deliver system value that extends well beyond individual projects and must be assessed against full system costs and benefits. Besides all of this, co-production of minerals, elements or compounds from geothermal brines supports the European energy transition and Critical raw materials position.

1.2. The SET Plan Implementation Working Group Geothermal

The SET Plan Implementation Working Group Geothermal (IWG Geothermal) will support the transition to a fair, resilient, competitive and climate-neutral Europe which utilizes geothermal energy to its full potential, in the future energy mix. It aligns the national and European ambitions on geothermal energy. The IWG Geothermal supports the SET Plan “Number 1 in renewables” target. The scale and size of the technology encourage international collaboration. The IWG Geothermal collaborates with other IWGs on renewable energy, and sector and system oriented IWGs.

The IWG Geothermal considers all technologies that use heating and cooling from below the earth's surface in all depth ranges as geothermal energy, in conformance with the REDIII definition (EC 2023a). This includes technologies that store heat under the earth's surface during the summer season for use in winter and vice versa. Throughout this Vision, geothermal *energy* refers to all energy services: heating, cooling, storage, and electricity generation. The Vision is very precise in referring to *electricity* when statements are relevant for electricity specifically.

1.3. Key developments

While the market for geothermal energy is steadily growing (EGEC 2023, 2024, 2025), it is not growing at the pace that will deliver the full benefits for Europe. The current challenges around climate change, European resilience, electrification, and sector coupling justify stronger efforts for geothermal. Interest in geothermal energy is increasing globally (IEA, 2024).

1.4. Objective of the Thematic Vision

This thematic Vision of the IWG Geothermal presents short term, mid-term and long-term goals for market development, the industrial base, and research, development and innovation (RD&I). These goals define what is needed to utilize geothermal energy to its full potential for a fair, climate neutral, competitive and resilient Europe.

The IWG Geothermal works on four key priorities:

- Geothermal heating and cooling
- Geothermal storage
- Geothermal electricity
- Co-production of minerals, elements or compounds

1.5. Focus areas

The work of the IWG is multi-faceted, and advances are needed for resource assessment, development, utilization and sustainable management. At the request of the EC, the IWG however recommends the following areas for R&I efforts in the next multiannual framework programme. These R&I topics offer particularly high benefits to the sector and the European energy transition:

- Geothermal storage
- Drilling and subsurface engineering
- Demonstrating innovative concepts

1.6. Non-technological focus areas

The guiding principles for the SET Plan IWGs and the work of the SET Plan cross-cutting task forces (EC, 2025b) will serve as a compass for the IWG Geothermal . In particular, the importance of access to market, skills, the potential and challenges of digitalisation, the affordable availability of sufficient data and the relation of geothermal energy to societal needs are in focus. The guiding principles also promote collaboration and complementarity among IWGs. IWG Geothermal is fully supportive of those aims.

Maintaining and expanding the position of the European geothermal industrial base is an important cornerstone. This implies a consistent market perspective and due attention to non-technological focus areas.

2. Vision and targets

2.1. Progress and recent developments in geothermal energy

The dependence of Europe on fossil fuel imports is still high. In 2024 nearly 60% of the EU's energy needs were met by net imports. The share of renewables in the EU's gross final energy consumption was 25% (Eurostat, 2026). Nearly 50% of the European *electricity* production is from renewables. In several Member States, further electrification of heating is increasingly constrained by grid capacity, reinforcement costs and seasonal peak demand (EC 2025c). Renewable heating and cooling technologies that rely primarily on thermal rather than electrical infrastructure—such as geothermal—offer critical alternatives for accelerating the energy transition without exacerbating grid bottlenecks.

At the system level, demand and supply need to be matched real-time. This requires smart solutions for grid stabilisation and storage, and sector coupling. It also requires solutions that help Europe through the winter peak for heating, and the summer peak for cooling. The future energy system needs to be robust and also capable of integrating emerging sectors, e.g. data centres. Geothermal heating and cooling, geothermal storage and geothermal electricity production are robust, dispatchable and in many ways suited to Europe's needs.

2.1.1. Relevant European and national policies

The political momentum for geothermal energy is increasing. The recent EU Communication Accelerate EU identifies the need to accelerate geothermal energy and identifies a set of concrete priorities: geological data, geothermal derisking instruments and international collaboration (EC 2026a). Earlier, in January 2024, the European Parliament adopted a resolution on geothermal energy (EP 2024). Following this, the publication of a European Geothermal Strategy is expected before summer 2026. The European Parliament resolution still provides a good analysis of the situation today, with statements such as: *"[..] the comprehensive policy conditions and frameworks needed to boost the development and use of geothermal energy in Europe are still absent at EU level; [..] advances in different policy areas at national level are also urgently needed so as to enable geothermal actors to boost deployment of projects through improved research, strengthening of the supply chain, efficient support schemes and increased public awareness [..]."*

Bespoke policies are needed to really unlock the potential of geothermal energy. Several national and European acts work in the right direction. However, to date they still insufficiently overcome the challenges in project development: high upfront investment, high subsurface risk, tedious permitting procedures, insufficient public awareness, and (still) cheap fossil-fuel fired alternatives. Policies that phase out fossil heating systems are needed, because they significantly improve the investment conditions for geothermal projects, particularly in the built environment. For large-scale geothermal projects, there is insufficient mass and multiplication today.

European policies that are supportive to the development of geothermal energy include:

- EU Solar Strategy, part of the REPowerEU package; boost the heat demand covered by geothermal by at least a factor three (EC 2023b).
- Renewable Energy Directive; binding annual increments for renewable heating and cooling (EC 2023a).

- Recast Energy Efficiency Directive; integrated energy planning in municipalities over 45.000 inhabitants and the decarbonisation of heating systems at local and regional levels (EC 2023c).
- Net-Zero Industry Act; strengthening the supply chain for net-zero technologies including geothermal, including permitting procedures for factories and businesses that are part of this supply chain (EC 2024a).
- Clean Industrial Deal; aligning decarbonisation with industrial competitiveness, relevant both for the geothermal value chain and for the energy supply of the European industry at large (EC 2025d).
- Critical Raw Materials Act; supporting strategic projects for extraction, processing, and recycling of critical raw materials within the EU; relevant for geothermal co-production projects; accelerated permitting procedures and access to financing (EC 2024b).
- AccelerateEU; Highlights value of home-grown energy and identifies issues which will be prioritised: geological data, risk mitigation and international collaboration (EC 2026a).

In recent years, an increasing number of European countries have national policies or national schemes directed towards geothermal energy. The table in Annex 1 summarises some main characteristics. The IWG will build on those European and national policies.

2.1.2. Market status

There are 2.43 million **geothermal heat pumps** operating in Europe in 2024. The total installed capacity is 38 GW. Over 90% of them are small heat pumps under 50 kW. The whole stock provided 85 TWh heat in 2024. In many cases these heat pumps are supplying both heating and cooling. However, unit sales decreased by 28% from 2023 to 2024 (EGEC, 2025) due to both macroeconomic factors and insufficient valuing of the system benefits.

The total installed capacity of **geothermal district heating and cooling** was more than 6 GW across 29 European countries by the end of 2024, including 21 EU Member States. It is estimated that their production is 24 TWh of thermal energy per year. There is a steady growth, but at a slow pace with some 3-5% per year. 412 geothermal DHC plants were in operation across Europe, including 308 in the EU Member States (EGEC, 2025).

Geothermal storage is an up-and-coming technology. While in the Netherlands seasonal thermal storage supplies 0,7 TWh heating and the same amount of cooling every year (CBS 2024), there are insufficient statistics to estimate Europe-wide benefits of thermal storage. Borehole Thermal Energy Storage continues to dominate the European market for geothermal storage with thousands of BTES installations in operation across Europe.

In 2024, Europe had over 3.5 GW of installed **geothermal electricity** capacity (1,7 GW in the EEA), generating around 20 TWh in 2024 (7 TWh in the EU). In 2024, three new geothermal electricity plants were inaugurated, of which two in Türkiye. They added 40 MW of additional baseload capacity (EGEC, 2025).

In terms of **co-production of geothermal minerals, elements or compounds,** projects are in operation in Germany and the UK (since 2026) and furthermore in the planning and construction phase in Germany, France, and Italy.

At European level, geothermal energy is still a small energy source. The total annual contribution of 120 TWh for heating and electricity generation is about 1% of the total final demand of Europe. However, lead countries, cities and regions show that geothermal can be the backbone of the supply of heating, cooling, and electricity generation, depending on local demand patterns and geology.

It is important to understand that geology is a crucial factor in geothermal energy, especially for deep geothermal projects. It determines opportunities for local geothermal development. Drilling cost, temperature level, and productivity are all influenced by geology. Data acquisition is essential to de-risk geothermal projects. Geothermal energy remains underdeveloped in Europe due to geological risks, which take time to mitigate. This remains an important focus for policies. Next generation geothermal systems look at solutions that are less dependent on geological setting. However, cost reductions are needed to make them economically viable. It should also be noted that the project development time for deeper geothermal resources is mostly years; exploration, permitting and realisation are all time-demanding. For shallow geothermal projects, the project development time is typically months.

2.1.3. European industrial base

Project development for geothermal – be it for heating, cooling, electricity generation, underground thermal energy storage or the extraction of critical raw materials – passes through three major stages: 1) Site investigation and exploration for resource assessment; 2) drilling and subsurface engineering for resource development; 3) utilisation, operation and management of the resource. After the end of life, the project needs to be decommissioned as well. The table below shows what equipment and which type of companies are typically needed.

Table 1 The geothermal value chain

	Equipment	**Skills / companies**
Resource assessment	Seismic equipment, advanced subsurface models	Engineering / service companies for shallow and deep geothermal; geothermal HP project designers
Resource development	Drilling rigs, drilling bits, drilling equipment, casing materials, pumps, probes for geothermal heat pumps, cements for wells, chemicals	Drilling contractors, drilling service companies, large operators with own drilling rigs
Utilisation and management	Valves, pipes, heat exchangers, turbines/generators for electricity, heat pumps, filters, inspection/remote control equipment etc.	Equipment manufacturers, turbine/generator manufacturers, heat pump manufacturers, geothermal operators and service companies

The European industry is present in the whole of this value chain, though there are also multinationals active. The European industry is well placed to expand its market in Europe (CETO, 2025). Europe has the whole value chain except for the electronics – in house. Europe has the excellence. Europe has the potential. However, for the potential to materialise, the European market also has to develop. The geothermal sector in Europe is open to collaboration with many different countries to support our companies and ensure competitive offers.

2.1.4. Research, development and innovation

In the past decade, significant progress was made in geothermal research and innovation (Kieling 2024) (ETIP-G, 2025) in Europe. However, annual public R&I support stagnated (CETO, 2025), while the European ambitions for geothermal energy increased. Geothermal technologies have proven their worth but their deployment remains too limited. Technological advances, innovations, and demonstrators in various regions and sectors are necessary to unlock the full geothermal potential. At a global level, interest in geothermal energy is increasing (IEA 2024; IEA 2026). Expectations around Enhanced and Advanced, and Superhot Geothermal Systems are high. Annex 2 explains these concepts briefly.

The strategic research and innovation agenda (SRIA) of the Geothermal ETIP that was published in 2023, offers a comprehensive description of the State of the Art and a wealth of 41 research priorities, that are organised in 5 main groups and 10 subgroups, see section 2.3.4 (ETIP-G 2023)

2.2. Vision summary

Table 2 Vision summary

	2030	2040	2050
Markets	- Triple geothermal heat production (base 2022) - Step up geothermal storage application - Double geothermal electricity production (base 2022) - ≥ 3 European regions co-produce geothermal minerals, elements or compounds	Geothermal supplies: - 30% space heating, 5% industrial heat, 20% agricultural heating - geothermal storage: 10% of space heating - 10% electricity generation - 10 European regions co-produce geothermal minerals, elements or compounds	Geothermal supplies: - 35% space heating, 10% industrial heat, 25% agricultural heating - geothermal storage: 15% of space heating - 15% electricity generation - 15 European regions co-produce geothermal minerals, elements or compounds
European geothermal industry	European geothermal value chain meets at least 40% of the EU's annual deployment needs. Step up the awareness about the European geothermal value chain and awareness of skills and jobs	European geothermal value chain meets at least 60% of the EU's annual deployment needs.	European geothermal value chain meets at least 60% of the EU's annual deployment needs.
Policies and society	Access to geological data; Access to geothermal research infrastructures; Smooth permitting; Promote active engagement of society Analyse transition societal value of various geothermal concepts	Unified European geodata accessibility act Foster geothermal concepts with high transition societal value	Self-propelling market for geothermal energy

R&I Goals	Increase the cost efficiency of geothermal concepts by 30% (base 2025) - across the whole value chain, from exploration and risk mitigation to extended project life	Increase the cost efficiency of geothermal concepts by 50% (base 2030) - across the whole value chain, from exploration and risk mitigation to extended project life	Increase the cost efficiency of selected geothermal concepts by 30% (base 2030) - across the whole value chain, from exploration and risk mitigation to extended project life

The IWG Geothermal defines a Vision for market development, the role of the European geothermal industry, Policies and society, and finally, the R&I Goals. These aspects are all crucial to accelerate the use of geothermal energy to its full potential in a resilient Europe. However, there is a difference between the aspects “Market development”; “European geothermal industry”; “Policies and society” and the R&I Goals. While the first three aspects list important and ambitious goals for the geothermal sector to which the IWG will contribute, they also require multi-faceted strategies that cannot be implemented by the IWG Geothermal alone. Not only are these challenges subject to partly unpredictable market forces, but the path towards full-scale implementation also requires concerted policies and democratic decision making at European, national and municipal level, which should have its course. The R&I Goals, however, are core to the IWG activities. IWG members will align funding and R&I efforts in line with the Vision of the IWG.

IWG Geothermal has defined a Vision for Policy and society to analyse the ‘transition societal value’ of geothermal concepts. This parameter will monitor the value of geothermal concepts for the European society. It includes system cost for both the geothermal energy concept and the competing climate-neutral system. This needs to factor in marginal grid expansion and electricity storage cost for many competing technologies, material cost and benefits in terms of jobs and resilience. Thermal storage technologies, that can absorb excess energy in summer to use for efficient heating in winter have a high transitional societal value.

2.3. Short-term (2030)

2.3.1 Markets

The short-term vision for geothermal heat including thermal energy storage coincides with the European objective in the EU Solar energy strategy (EC 2023b). It says that the energy demand covered by solar heat and geothermal should at least triple. Annual production of geothermal heat from all depth levels amounted to approximately 100 TWh in 2022. This translates into a target of 300 TWh for 2030. In 2024, we know that the annual production was approximately 110 TWh.

The short-term vision for geothermal electricity generation aligns with the short-term objective for geothermal heat. The target will be to double electricity production in EEA, from 12 TWh in 2022. This translates to a target of 25 TWh for 2030. Geothermal electricity generation will also be increasing in Türkiye, with already 8 TWh annual production now.

The short-term vision for co-production of geothermal minerals, elements or compounds is that 3 European regions would produce them. The lead time for geothermal projects does not realistically allow more ambitious aims.

2.3.2 European geothermal industry

The European geothermal industry should develop positively, along with a positive market development for geothermal energy in Europe. This industry which delivers all services and all equipment, should remain competitive at the international level. This includes maintaining 40% of production aim in full conformance with NZIA (EC 2024a). A short-term target for the IWG is also to step up the awareness about this industrial value chain, with policy makers and the European society at large. Also, the geothermal community should strengthen links with the value chain of the oil and gas industry for mutual benefit.

2.3.3 Policy and society

While cost efficiency will increase through R&I, there are also policies that will support the required strong market growth by reducing risks and elevate the overall probability of success for especially large-scale geothermal projects. The IWG will foster activities on improving:

- Access to geological data;
- Access to geothermal research infrastructures;
- Better permitting (quick but high-quality);
- Promote active engagement of society.

Then, the IWG Geothermal will foster analyses of the transition societal value of geothermal concepts, factoring in seasonal variations in heating and cooling demand, storage, grid reinforcement and resilience and European jobs and prosperity in defining energy policies. This task should be extended to energy models, that represent geothermal technologies at an insufficient level today.

2.3.4 Research and innovation

The short-term goal for research and innovation for geothermal energy is to improve cost efficiency of geothermal energy by 30% compared to 2025. This is an ambitious goal, that is nevertheless achievable if we look at recent advances in efficiency and drilling technologies. Also improved methods for assessing the subsurface to manage the geological risk, improved lifespan of investments and new concepts contribute to the aim. Heating, cooling and thermal storage is currently the most important sector for geothermal in Europe. Temperatures suitable for the production of electricity can mostly only be found very deep down (>3 km) on the European continent, while temperatures for heating and cooling and geothermal storage can be reached at lower depths and at lower cost.

As mentioned earlier, there is a significant challenge to transition the remaining 75% of the European heat demand to climate neutrality. The concepts we need are not a ‘one-size-fits-all'. Regional differences in heating and cooling demand patterns, availability of existing district heating and cooling networks, regional geothermal resource differences and regional differences in availability of excess heat, excess electricity and electric grid capacity will lead to different optimal solutions. At the same time, these concepts are united by a generic project chain: assessment of the subsurface, development of the geothermal installation, and integration of the installation in the energy system. This generic project chain is also valid for geothermal electricity generation and the co-production of geothermal minerals, elements or compounds.

Table 3 R&I thematic areas and subthemes

Main R&I theme	Subthemes
Resource assessment *Better methods for retrieving all useful information for underground energy extraction design*	a. Cost effective exploration and data sharing b. Exploration for specific targets c. Scaling up - portfolio exploration
Resource development *Better methods to drill and realise geothermal installations*	a. Drilling and well completion b. Improving productivity of wells
Resource utilization and management *Better concepts for use and energy system integration*	a. High-efficiency utilization in specific applications b. Optimal integration into the energy system
Resource sustainable management	a. Enhance environmental performance b. Promote market uptake in and for society
Data and knowledge sharing	a. Data and knowledge sharing

Technological advances in each of the three themes for the project chain will contribute to the cost efficiency of the suite of solutions that the various European regions need. Besides that, there are overarching R&I priorities. The themes 'Resource sustainable management' and 'Data and knowledge sharing' bring together those topics.

Cost efficiency improvements are envisaged for all themes along the project chain. The scaling effect of the envisaged market development will contribute as well. In terms of overarching priorities, AI and machine learning may be instrumental to accelerate learning for different concepts for the various regions and could create overarching cost efficiency improvements and accelerated learning. This means standardizing the process towards bespoke solutions. It can also mean more efficient operation.

Overarching to the project chain is research and innovation directed towards health, safety and circularity, and R&I to support market growth. Availability of suitable research infrastructures to support R&I is an important overarching short-term topic, too.

For the short term, the IWG recognizes that there is a need to demonstrate and share experiences with concepts and technologies that have been developed in the first half of the decade. Two recent reports (Kieling 2024) (ETIP-G 2025) provide excellent overviews of all advances, that need to prove their value and potential in the real world. The interaction with the real geothermal resource is a crucial phase in the development chain of any new geothermal technology or concept. Suitable support schemes to demonstrate the innovations in the real world at the real scale is crucial for the geothermal mass application, both for regional inspiration as well as for the final validation of the innovation.

The IWG considers that two important focal areas for RD&I will be geothermal storage and improved drilling. Both topics promise a step-change in financial viability of geothermal projects. The third focal areas should be demonstration of innovative technologies and concepts in the real world.

2.3.5 Progress towards the targets

The envisaged process to reach the targets after approval of the Vision is the following

- The ETIP Geothermal, GEOTHERMICA Initiative, ETIP Renewable Heating and Cooling, EERA Geothermal, and the European Geothermal Energy Council (EGEC) will be asked to update the existing SRIA to address the IWG Geothermal targets. The SRIA update needs to take into consideration short-term, medium-term and long-term targets. The focus evidently needs to be on the short-term and early medium-term.

- The ETIP Geothermal will also be asked to create a viable structure that can be used for commitments at the “Theme” or “subtheme” level, to generate the required resilience of the CIIP and promote alignment of activities.
- The IWG Geothermal will consider which activities need to be taken in separate fiches for short-term progress, including the activities in Policies and society where the IWG is a relevant network for mutual learning.
- ETIP and IWG will together create the monitoring framework, to follow up on KPIs. The backbone shall be in place before March 2027 so it will be part of CIIP.

2.4. Medium-term (2040)

The medium-term targets are crucial for the geothermal sector, since an acceleration of the pace of the energy transition in the built environment is expected during the years 2030-2040, and this is the most important sector for geothermal energy.

2.4.1. Markets

The medium-term Vision for the markets is that geothermal supplies:
- 30% space heating, 5% industrial heat, 20% agricultural heating
- storage for 10% of space heating
- 10% electricity generation
- minerals, elements or compounds in 10 European regions

This Vision is in line with the ETIP Vision and the IWG Geothermal 2023 Vision, where the background of the values is also briefly explained (ETIP-G 2024) (IWG-G 2023). Getting there requires stepping up R&I budgets and infrastructure support across Europe. Also, the investment risks should be addressed. Market conditions should be as stable and predictable as can be in this uncertain world. Better tools to address geological risks in a cost-effective way need to be implemented throughout Europe. The system value of (seasonal) geothermal storage may be beyond 10%, but there are no good estimates. Surely, heating dominates demand in winter (Victoria 2019). The system value of geothermal thermal storage is expected to become increasingly visible in the 2030–2040 period, as electricity system costs, grid reinforcement needs and seasonal imbalances intensify. Seasonal thermal storage is not included in many predictive energy models such as POTEnCIA, which also externalises the cost of grid reinforcement (CETO 2025b).

In terms of KPIs, a market growth of 20% for space heating applications, year on year on year is the most relevant parameter. Market data on geothermal storage should be improved first, and then a similar KPI should be established and monitored.

2.4.2. European geothermal industry

The European geothermal value chain meets at least 60% of the Europe's annual deployment needs in 2040. The geothermal industry is already in a good starting position with competing technologies and little dependence on critical raw materials. The IWG Geothermal aims for an ‘international trade’ scenario with 60% as the aim of European supply for the geothermal value chain.

In terms of KPIs, a first need is to establish clearer statistics on availability of the various parts of the value chain (EGEC 2024) and develop a method by which to estimate market shares supplied by European industry.

2.4.3. Policies and society

In the 2030-2040 decade, the IWG Geothermal will still foster analyses of the transition societal value of geothermal concepts. There should be large scale application of geothermal energy in all concepts, and this requires a system approach that prefers concepts with high system value. This requires bespoke policy instruments to tackle barriers for geothermal energy as well. Geodata availability is crucial for cost-efficient geothermal energy. A unified European Geodata Act would help access existing data all across Europe.

2.4.4. R&I Goals

The goal for 2040 is to have increased the cost efficiency of geothermal concepts by 50% compared to the 2030 baseline. This implies a similar rate of progress between 2025-2030, 2030-2035, and 2035-2040.

Advances can come from exploration, realising the geothermal wells with drilling and all equipment and materials and processing time needed for that, and the utilization of the geothermal wells. Also, advances can be on circularity, organisation of the work, and translating concepts for one region successfully to other European regions. AI possibilities that allow us to learn faster will be important. It is expected that cheaper drilling will facilitate access to deeper and hotter reservoirs and that bespoke technologies for geothermal from such reservoirs will be developed in this decade. At the same time, the need to support first-of-a-kind demonstrations will remain.

KPIs will build on the work done in GEOTHERM FORA (Cittadini 2025), (Kieling 2024), (ETIP-G 2025). The annual improvement rate to be achieved is about 5%. It is probably more important to identify step changes and assess their meaning than trying to find that 5%, which is very difficult to monitor as the prices of geothermal energy are very dependent on the local geology, and the local demand patterns.

2.4.5. Timeline

The implementation will be planned together with the implementation of the short-term priorities, as detailed in section 2.3.5.

2.5. Long-term (2050)

The ultimate long-term aim is to establish a self-propelling market for geothermal energy, starting in the built environment. The Geothermal IWG expects that the built environment and service sector will be largely carbon-neutral by 2040. Between 2040 and 2050, some additional industrial process heat will be sourced from geothermal. R&I will probably look at equipment for higher temperatures and optimisation of maintenance and lifetime productivity. Continuous improvements can be expected on exploration, resource development and operation and integration.

3. Conclusions and next steps

IWG Geothermal concludes that an ambitious R&I agenda for geothermal energy is timely and possible. This agenda will contribute to acceleration of the market for geothermal energy. A steep acceleration is anticipated. Key drivers are energy independence, grid congestion challenges, the need for renewable heat and the need to match seasonal demand patterns. Key enablers are policy, regulatory and technological advances.

The next step will be to translate this Vision into a Strategic Research and Innovation agenda. The ETIP-Geothermal, GEOTHERMICA Initiative, ETIP Renewable Heating and Cooling, EERA Geothermal, and the European Geothermal Energy Council (EGEC) will contribute to this work. The anticipated delivery date is 15 October 2026.

The IWG will forge links with the following IWGs where there is most synergy:

- IWG Energy efficiency in buildings; renewable heating and cooling for space conditioning
- IWG Energy efficiency in industry; renewable heat at industrial temperature levels
- IWG Solar thermal technologies; synergies on renewable energy – electricity and heat
- IWG CCS/CCU; synergies on type of value chain and subsurface challenges
- IWG Energy systems; synergies on role of various geothermal energy concepts including thermal storage in the energy system; sector coupling

The IWG will also work on KPIs and preparations for monitoring. As geological conditions may differ per project, a balanced approach is needed.

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Annexes

Annex 1. Overview on National Policies & Strategies

Country	General	Exploration	Feed in premium	R&I funding 2024 (M€)	Investment support
Bulgaria	Legal separation in regulation of shallow (Water Act) vs. deep (Natural Resources Act) geothermal resources; Publicly available online tool to serve as a centralized platform for geothermal data in Bulgaria (ME & WB).	First exploration concessions in South Bulgaria in 2026, as well as three submitted to ME prospecting applications around Sofia.	currently not offered		175 M€ in the National Recovery and Resilience Plan(NRRP); ME grant scheme under Modernization Fund in progress;
France	Risk mitigation in place since 1981. In 2025, France had 209000 shallow installations (4.82 TWh), 73 deep installations (2.28 TWh), 2 operations of electric generation (17.2 MW) and ongoing development for Lithium-geothermal co-generation. Increase of shallow geothermal energy expected to reach 10 TWh in 2030, and between 15 and 18 TWh in 2035. For deep geothermal energy the target is 6 TWh in 2030 and between 8 and 10 TWh in 2035.	Recent exploration has been funded through programs since 2022 of subsurface characterisation based on existing seismic and wells as well as newly acquired seismic (for a total of over 10 M€)	Individual feed in tariff for each electric geothermal project.	Heat focus R&D with at least 800 k€ from ADEME + over 4 M€ dedicated to geothermal energy research within the "PEPR sous-sol, bien commun"	The "fond chaleur" has been spending 166 M€ in support of the development of geothermal energy (both subsurface and heating network; both deep and shallow geothermal energy). France has also a warranty fund for drilling risks with a 37 M€ available for deep geothermal energy and ~3 M€ for shallow geothermal. There is also additional support from local authorities.
Germany	Risk mitigation in place since 12/25	~ 50 M€ (2024:76 M€) exploration campaign for underexplored areas)		23 M€, heat focus (storage included)	Federal funding for efficient heat networks (BEW) in explored areas
Hungary	National Geothermal Utilization Concept (accepted in 2024): increasing the domestic use of geothermal energy by 20% to 8 PJ by 2026, and to double the output to 12-13 PJ by 2030.	2023-2025 (SARA): complex geothermal research-exploration program to increase geothermal utilizations (including Special	–	Information is partially available (only dedicated EU or state financed project information). Dedicated funds for universities,	In 2025-2026 new geothermal subsidies, grants, subsidized loans are available to support new geothermal utilization developments from geothermal

	"Reducing Geothermal Drilling Risks" (KEHOP-Plus) started	geothermal data packages, geothermal data room, and geophysical surveys of underexplored areas). The program is to be continued until 2029.		research institutes can be estimated as 1.5-3 million EUR/year in the cc. past 5 years	drilling phase to building geothermal heating plants or geothermal power plants (42.3 billion HUF, cc. 110 million Eu). An additional 96 billion HUF (cc. 250 million Eu) for DH modernization, including geothermal energy.
Iceland	There are several state programs and state-owned actors which accelerate the advancement of geothermal: Climate and energy fund, investment subsidy programs, geothermal research institute (ÍSOR), a geothermal training program as part of development aid (GRÓ).	During 2023-2025 the Icelandic Climate and energy fund awarded approximately 9.7 M€ for geothermal exploration and drilling projects. In 2026, nearly 2,1 M€, is awarded to the IDDP3 project for deep drilling at Nesjavellir.		In 2025-2026 the Icelandic Climate and energy fund awarded approximately 4 M€ for geothermal energy innovation and technology development projects. At least 10 M€ was awarded in 2024 to consortia involving Icelandic entities by EU Horizon Europe.	The Icelandic government subsidizes investment for heat pumps in areas heated with electricity, energy efficiency as well as new district heating projects.
Italy	NECP foresees by 2030 an increase of 22%, 30% and 24% in electrical installed capacity and production and thermal production, respectively.	Risk mitigation scheme foreseen in the NECP but not active yet	FER2: 100€/MWh Traditional power plants + 200€/MWh zero-emissions power plants (30 MW to be auctioned by 2026)	About 0,5 M for optimising exploration and potential evaluation tools, heat pump and thermal storage technologies	238 M€ for DH, including geothermal technology. Conto Termico 3.0 support 30-65% of investment cost for GSHP installations. Geothermal INNOVATIVE investments compete with other renewable energy sources in regional tenders, often based on cohesion funds.
Netherlands	Many geothermal storage projects (aquifer thermal energy storage) First 'deep'geothermal in 2008; now > 30	Guarantee scheme, SCAN exploration campaign, Good public data	Heating only	8 M€, LT geothermal, HT storage	Only for innovative projects Scheme for investment support for

	operational doublets, mainly in horticulture				medium-depth geothermal being developed Support for new district heating networks
Poland	First geothermal district heating plant was opened in 1993, Podhale region. Ten municipal geothermal district heating plants commissioned by end-2025. Heating, recreation and other purposes (e.g. cosmetics). Geothermal project risk insurance scheme under analysis.	Increased pace of geothermal drillings since 2016. 56 geothermal wells supported by national funds in 2016–2023; 53 under implementation. Total funding: approx. PLN 919 million (ca. EUR 216 million). Further public support for new geothermal wells under analysis.	Formally possible, but in practice marginal. Geothermal energy exclusively for heat production, (one installation in CHP regime only in operation)	Polish Geological Survey: geothermal research tasks implemented in 2024 (approx. PLN 4.5 million / EUR 1.1 million); continuation of earlier projects.	Support for geothermal investments in Poland via the National Fund for Environmental Protection and Water Management (wells, geothermal heating plants, reinjection wells) and the National Centre for Research and Development (innovative projects).
Slovenia	First geothermal electricity research concession was awarded in 2025. Data is missing or not available (e.g. from test drilling by some oil companies in the past.)	Climate Fund for 2025–2028 includes 4 M€ for geophysical research including deep drilling.	New RES support scheme in pipeline after the new law on RES was adopted in 2025.		Ecofund subsidies for RES heating (HP)
Spain	First exploration concessions in the Canary Islands in 2024, followed by the drilling of deep wells during 2026 and 2027.	~ 90 M€ allocated to the investigation of potential areas of interest. Funded by the Ministry for the Ecological Transition.	Electricity production	tbd	Recovery, Transformation and Resilience Plan General Spanish Government

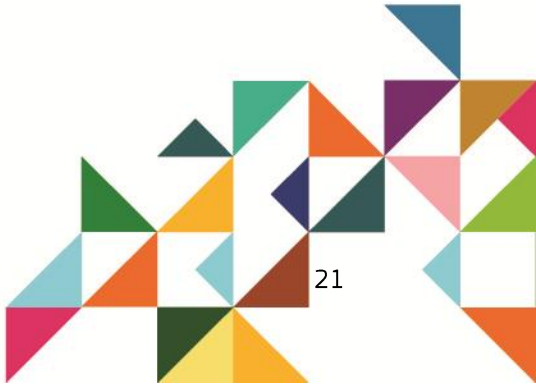
Sweden	Geoenergy/geothermal energy: ~580,000 facilities in Sweden Deep geothermal energy: only a few test and pilot facilities today (Lund, Malmö, Gothenburg)	~ 16 M€ allocated for heating and cooling inclusive geothermal projects in R&I Heating and Cooling Program Termo (2024-2028)	Heating production more than electricity production	5-6,5 M€ per geothermal project	Research and Innovation Fund for heating and cooling; Pilot and Demonstration Fund; The electricity system of the future fund
Switzerland	New federal law: guarantee for risks linked to investments in heating networks and long-term heat storage, covering up to CHF 5mio and max. of half of the financial loss incurred	Exploration subsidies for power (Max. ~ 50mio CHF/yr, until 2035, Energy-Act) and heat (Max. 30mio CHF/yr until 2034, CO2-Act) production: max. 60% of subsurface eligible costs (incl. planning cost up to 15% of project execution costs)	Feed-in tariff scheme for power production ended in 2022; three projects secured tariffs for future electricity fed into the grid	Approx. CHF 10.5mio in 2024 for R&I (fundamental and applied research, and market-oriented innovation)	Part of exploration subsidies and general subsidies

Annex 2. How do 'Next generation geothermal systems' work?

What is often called 'next generation geothermal systems' concerns a group of 'reservoir-independent' techniques. They focus on extracting heat from deep, low-permeability rocks at depths of 3-5 km or more, surpassing the constraints of conventional hydrothermal systems. Since these methods are not limited by location and help minimize geological uncertainties, they provide access to vast, previously untapped geothermal resources.

Enhanced Geothermal Systems (EGS) are artificially created reservoirs with improved rock permeability and underground flow, achieved through advanced borehole designs and reservoir stimulation techniques.

Advanced Geothermal Systems (AGS), also known as closed-loop geothermal systems (CLGSs) or deep borehole heat exchangers (DBHE), are closed underground systems with single or multilateral wells drilled at large depths, where a secondary fluid is circulated to extract heat through conduction at the borehole-rock interface.

Superhot rock (SHR) systems occur where temperatures exceed hundreds of degrees, producing supercritical fluids that contain more energy than conventional water- and steam-based systems. Although experiments are currently underway in magmatic zones a few kilometers deep, the aim is to drill ultra-deep wells (over 10 km) to access these conditions globally.

Next generation geothermal systems provide a very high technical potential but significant progress is needed for economic viability (IEA, 2024).