European Geothermal heating and cooling technology Roadmap: status and implementation

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ABSTRACT

Among the technological challenges for an accelerated deployment of geothermal heating & cooling and electricity across Europe, new and innovative solutions in different areas are needed.

Firstly, it is especially important to develop solutions for refurbishing existing buildings, but also for zero and plus energy buildings, whereby systems need to be easier to install and more efficient at low temperature for both heating & cooling.

Secondly, to develop geothermal District Heating (DH) systems in dense urban areas and other direct uses, as for agro-industry, at low temperature is identified as a key issue amongst our sector. The objective is to contribute to the decarbonisation of DH and industry by providing competitive solutions for heating & cooling.

Finally, a third important goal is to contribute to the decarbonisation of electricity by ensuring security of supply, affordability and flexibility in the grid.

One objective is to keep the European industrial competitiveness in this sector:

With 1.2 million units of GSHP installed, Europe is the world leader in the shallow geothermal market and also a forerunner in innovation in areas such as underground thermal energy storage (UTES). Main competitors are heat pump manufacturers in China and the USA.

With more than 200 geothermal DH systems in operation, Europe is also the global leader for geoDH. Global competition exists mainly for heat exchangers and pipes. Also direct uses of geothermal started in Europe, although China is now leading the market due to the large demand there.

EGS plants are only in operation in Europe up to now. Projects are ongoing in the USA and Australia.

A next generation of geothermal technologies are needed to remain number one:

- GSHP for retrofit buildings
- Smart thermal grids with geoDH
- UTES with high temperature storage
- EGS for cogeneration and high temperature process heat

The European Geothermal Technology Roadmap 2013-2020, a result of the common effort of many stakeholders in our sector coordinated within the Geothermal Panel, presented a concept for developing these research projects. The first RD&I geothermal projects following its implementation started in 2014.

Our paper will present the roadmap and the status of the implementation with a monitoring of the first project results.

1. INTRODUCTION

The quantitative development of the European geothermal heating & cooling market in the next ten years is expected to be fuelled mainly through the introduction and consolidation of shallow geothermal systems, with a quite mature market in Sweden and Switzerland and well developed markets in Austria, Norway, Germany and France. In other emerging European markets, high growth is possible and is expected over the next years (Italy, Spain, the United Kingdom, Hungary, Romania, Poland, and the Baltic states). The aforementioned mature markets will see a steady increase, mainly stimulated by sales in the renovation sector, while in all other countries, a significant growth is to be expected. Fast development for geothermal heat pumps illustrates how shallow geothermal energy resources, previously often neglected, have become very significant, and should be taken into account in any energy development scenario.

Promising areas are the development of smart thermal grids (1st generation) with the building of new district heating & cooling networks (Geothermal District Heating & Cooling, with ca. 5 €-cent/kWh, is one of the most competitive energy technologies), optimisation of existing networks, and the increase of new and innovative geothermal applications in transport, industry and agriculture. The first regions to develop will be those possessing the most accessible resources (for example the Pannonian, Tuscan or Parisian basins) as well as higher grade resources where combined heat and power projects will be developed (e.g. the Bavarian Malm reservoir and the Upper Rhine Graben).

During the next 10 years, new geothermal combined heat and power plants with low temperature installations and Enhanced Geothermal Systems will be developed. The sector is forecasted to reach an installed capacity for geothermal electricity of 3-4 GWe in the EU-28.

2. THE ESTABLISHMENT OF THE GEOTHERMAL PANEL

The European Technology and Innovation Platform on Renewable Heating and Cooling (RHC-Platform), officially launched in 2010, today brings together over 800 stakeholders representing all renewable energy technologies for heating and cooling from industry, research, and the public sector from all over Europe. The RHC-Platform is recognized by the European Commission as one of the European Technology and Innovation Platforms (ETIP). The RHC-Platform brings together stakeholders from the biomass, geothermal, solar thermal sectors, heat pumps, district heating and cooling, thermal storage and hybrid systems.

The RHC-Platform consists of five Technology Panels which include all renewable heating and cooling sources and technologies. Acting under the guidance of the respective Steering Committees, each Panel is responsible for collecting and developing stakeholders' inputs from the respective sectors.

2.1 History 2009/2016

The geothermal panel was established in 2009, following the initiative of EGEC, and it became integrated to the RHC-Platform from 2010.

The report "Vision for the Geothermal Heating and Cooling Sector in Europe" was the first official publication of the geothermal panel. Published in 2011, the study identifies major technological and non-technological challenges to the uptake of the geothermal H&C systems and assesses the potential of geothermal energy sources to contribute to the European and national energy needs and targets. The "Common Vision for the Renewable Heating and Cooling Sector in Europe" was published in May 2011 by the RHC-Platform, integrating the four technology specific vision documents (geothermal, solar thermal, biomass and cross-cutting).

After the publication of the "Vision", the geothermal panel launched the work on the definition of Strategic Research Priorities. The definition of research priorities was a first important step towards the production of the Shared Strategic Research Agenda of the whole RHC-Platform. In 2013 the panel launched the Strategic Research Agenda for geothermal Heating and Cooling, first of its kind for the geothermal HC sector, a milestone publication which summarized the research priorities of the panel and, for the first time, provided a comprehensive overview of the short, medium and longer term R&D needs of geothermal HC technology. The research agenda identified the state-of-the-art, the research objectives and the critical targets (e.g. in terms of performance increase / cost reduction) required to realise the potential of geothermal HC technologies defined in the Vision's document. It also offers recommendations for research, development and demonstration funding in the timeframe of 'Horizon 2020' and in line with the wider EU 2030 Energy and Climate Framework. In April 2013 the RHC-Platform launched the Strategic Research and Innovation Agenda for Renewable Heating and Cooling (RHC-SRIA). It provides stakeholders with a structured and comprehensive view of the research, development and demonstration activities able to meet diverse profiles of demand in the short (by 2020), medium (by 2030) and long term (after 2030).

Finally, the geothermal panel worked on the implementation roadmap to plan research priorities and investigate ways of funding. It also further defined key performance indicators (KPIs), presented in the last chapter and major milestones, which are discussed in chapter two. The Geothermal technology roadmap was published in March 2014.

Furthermore, the Common Implementation Roadmap, published in June 2014, takes over from the work done by the four individual Technology Roadmaps and explores the interconnectivity between the different RHC technologies.

From 2014, the geothermal R&D plan is being implemented. First geothermal research projects have been launched by the European Programme Horizon 2020 in the framework of this implementation plan and first research results are expected by 2020.

2.2 Composition and activities

The geothermal panel was established in 2009, with more than 60 participants at the kick-off meeting. The panel is now composed by more than 300 members coming from all over Europe and some third countries.

The stakeholders represent all geothermal heating and cooling technologies. They have been divided in several working groups. The structure adopted by the steering committee of the geothermal panel was the following:

- Focus Group 1: Shallow Geothermal Heat Pump Systems:

WG 1.a: Underground

WG 1.b: System installation components (HP, HE, valves…)

WG 1.c: Integrated system design

WG 1.d: Exploitation, LCA, sustainability

- Focus Group 2: Deep Geothermal:

WG 2.a: Resource assessment, exploration

WG 2.b: Deep drilling

WG 2.c: production technologies

WG 2.d: surface systems: Direct uses & cascade uses, District Heating & cooling, CHP

WG 2.e: EGS

- Focus Group 3: non-technical issues

WG3a : shallow > Market and Policies (regulations, financing and economics) Communication

WG3b : deep > Market and Policies (regulations, financing and economics) Communication

WG3c : Education & Training (common, for shallow, for deep)

Moreover several geothermal representatives were active in the Cross cutting panel: District Heating, Hybrid Systems, Storage, Integration in Building and Industrial Processes.

To produce the Vision, the Strategic Research Agenda and the technology roadmap, sixteen meetings have been organised in total during 2009 to 2016.

The Steering committee was in charge of reviewing and validating these three documents before their publication.

From 2014, the main activities of the geothermal panel have been to implement the geothermal technology roadmap by promoting the key research priorities in the research programmes such as Horizon2020, by supporting the establishment of national TPs in the geothermal area and of by-side measures: e.g. GEOTRAINET, REGEOCITIES, etc.., and by diversifying the sources of funding for these research activities.

For the implementation of the roadmap, the geothermal panel has notably organised a series of brokerage events: workshops, b-2-b meetings, webinars. Moreover, dedicated technical seminars have been organised: on induced seismicity, on EGS…

New Activities have been proposed for the near future:

- Monitor research results: EU and national projects
- Update the implementation roadmap
- Assess competitiveness of the European geothermal industry: global competition, supply chain, business models…

3. THE CONTENT OF THE ROADMAP: PRIORITIES AND INDICATORS

The Geothermal H&C implementation plan 2013-2020 follows the timeline of the Horizon 2020 EU programme for RD&D, and presents a plan for developing different research priorities and areas. It departs from the need to establish a European Industrial Action. The Geothermal Section is structured in the following way:

- Shallow geothermal:

A) Ground Coupling Technologies Area

B) Resources, new systems & integration Area

- Deep geothermal

A) Resources

B) Drilling

C) Production

D) EGS flagship programme

3.1 Ground source heat pump systems

GSHP technology is suitable for small, individual houses as well as larger multi-family houses or groups of houses, with capacities ranging from under 10 kWth to over 500 KWth. The depths of geothermal heat exchange range from a few meters to more than 200 m, depending upon technology used, geological situation, demand profile, and other design considerations. For space cooling, in certain regions with moderate climate, direct cooling from the ground via cooling ceilings etc. is possible, allowing for space cooling with minimum energy input. In warmer regions with higher cooling demand, the heat pump can be used in cooling mode.

One major non-technical issue concerns the lack of awareness about shallow geothermal. Knowledge about this technology is still very limited. In particular, many project developers in the residential, tertiary and industry sector are not sufficiently aware of solutions provided by shallow geothermal. A large communication campaign should be launched to complement research activities presented in this roadmap. For well-insulated houses with a forced ventilation system, geothermal energy can contribute to pre-heating or pre-cooling ventilation air while it passes through intake pipes buried in the ground. Another geothermal technology useful for industrial applications and for the heating and cooling of larger buildings is underground thermal energy storage (UTES). In particular UTES at 40-90 °C can directly supply heat for low temperature industrial needs such as batch processes or seasonal industries (e.g. sugar refineries), where periods of heat (and/or cold) demand are followed by phases of inactivity. Whilst the number of geothermal heat pumps with a capacity below 50 kW crossed the threshold of 1 million units in 2010, further R&D and practical experience is crucial to fully exploit the advantages of geothermal heat pumps in supplying heat and cold from one single installation.

Main Key Performance Indicators (KPI) for GSHP

• The performance of geothermal heat pump systems improved substantially since their introduction in Europe in the 1970s. The first plants were installed in Sweden, Germany, and Switzerland, and used for heating only. In these regions the typical efficiency, expressed as Seasonal Performance Factor, increased from below 3 in the 1980s to well above 4 today, and with continued R&D, average values in the order of 5 seem feasible for 2020.

• Component efficiency improvement: The most popular ground-coupling technology is the borehole heat exchanger (BHE); a good efficiency of a BHE results in a small temperature loss between the ground and the fluid inside the BHE. This temperature loss is controlled by the borehole thermal resistance, Rb. This Performance Indicator has been reduced by more than 40% over the last ten years. The overall impact of this value to a defined shallow geothermal system is given by the Hellström efficiency, which has increased from below 60% to about 75% in state-of-the-art installations over the past 10 years. There is still room for improvement, so provided the technology progress is continued, efficiencies of about 80% in 2020 seem achievable.

• The cost shows a steady reduction in the last decades. A study of the Swiss Heat Pump Association (Fördergemeinschaft Wärmepumpen Schweiz, FWS) calculated the cost for a BHE-system (drilling, heat exchanger, and heat pump) for a small house, and found a reduction of 27.5% over 12 years, from 1992 to 2004. Whilst the initial cost of a BHE system has decreased slightly, improvements in efficiency, which result in less energy being used to operate the system, have led to a substantial cost reduction overall.

Need for R&D for GSHP technologies

Shallow geothermal systems consist of the integration of the devices for exchanging heat with the underground, with the components to make this heat available for use in the building, such as heat pumps, conventional heating, and HVAC (Heating, Ventilation & Air-Conditioning) equipment. The heat pump as such is covered in the Cross Cutting research priorities. Any progress in HVAC components (better efficiency, lower cost, adaptation to temperatures delivered by geothermal systems) will also benefit geothermal systems overall.

Specific R&D for geothermal heating and cooling in the residential sector thus mainly concerns ground coupling technologies. On the other hand, as most of the buildings which will exist in 2020 are already built, the development and testing of underground coupling systems suitable for retrofitting or adapting into old/historical buildings is crucial to substantially increase the penetration of GSHP technologies.

3.2 Geothermal direct uses and high temperature cogeneration

Deep geothermal energy production is the relevant technology in sectors which demand electricity and heat in the medium temperature range (80-250°C), which includes many industrial processes, DH systems, and large individual buildings in the service sector as well as other applications such as agriculture and balneology. The heat supply is achieved mainly with direct heat supply by thermal water production and reinjection, but also using other technologies like deep borehole heat exchangers (BHE) or heat from geothermal CHP plants. The capacity of such installations can start from about 0,5 MWth (in particular deep BHE) and may achieve values in excess of 10 MWth. The heat may be fed directly into a district heating system if production temperature matches the required supply temperature, or be used as a heat source for large heat pumps (including absorption heat pumps, engine-driven compression heat pumps, etc.). Also cold production is possible with absorption chillers driven by geothermal heat. Taking advantage of further development in DHC technologies (including cascading and storage) will make it possible to use geothermal heat even more efficiently. Geothermal energy can provide heat above 80°C from deep geothermal resources and from high-enthalpy geothermal resources. High enthalpy resources, some of which have temperatures over 250 °C, are used almost exclusively for electric power production, though its utilisation for industrial purposes (energy intensive industry) is also feasible. R&D will be required to provide the right matching and adaptation of the geothermal heat source to the specific characteristics of the industrial process concerned. For the heat source as such, most R&D needs are the same as for deep geothermal in DHC, as long as temperatures below about 120 °C are considered. As the temperature of the geothermal fluid increases, other problems need to be solved, like degassing of the fluid (pressure control), corrosion, and insufficient pump technology. Finally, geothermal electricity from CHP can bring many advantages for our future electricity mix: 1) as a proven base load renewable resource (can run >8000 h/ year); 2) because of its flexibility and scalability (right response for grid stability); 3) due to its easy integration into existing power systems; and 4) because of its local character, limiting new infrastructure and reducing system costs. The aim should be to have a step between centralised and completely decentralised systems with regional security of supply. In this aspect, geothermal CHP production is key. Moreover, the largest source of flexibility in power systems is the ability of dispatchable power plants such as geothermal plants to ramp output up and down on demand. Geothermal plants can be dispatchable as they are able to respond to commands from a system operator, at any time, within certain availability parameters, and to increase or decrease output over a defined period. Geothermal plants are 'base load', designed for operating 24h per day throughout the year. They could be also flexible because plants should be ready to respond with at least six-hours notice. The decarbonisation of the electricity sector will only be possible with a large additional contribution from the flexible renewable energy sources in order to replace base load production from coal, gas, and nuclear. A high penetration of geothermal CHP-plants could play a positive role on the operation of distribution networks and the ancillary services these units could provide to the electricity system, under consideration of the different operating modes e.g. heat/ power driven, with/without storage, afforded by their operational flexibility.

Main Key Performance Indicators (KPI) for deep geothermal

• Improved exploration of geothermal resources and creation of a European geothermal resource database. Presently, technology is mainly based on extrapolation of products tailored for hydrocarbon industry (e.g., geophysical software, logging tools, etc.) into the geothermal sector. A drilling campaign of slimholes should be launched in Europe for getting more geological data. In the future, not a single project should need to be abandoned after the decision to go ahead with drilling.

• Deep drilling cost reduction. The drilling of boreholes is a major share of the necessary investment. Hence, reductions in drilling cost can substantially influence the overall economics of a deep geothermal plant. R&D should focus both on novel drilling concepts and on improvements to current drilling technology, as well as for other ways to optimise the economics of drilling operations (horizontal, multiwells etc.). Nowadays, drilling for deep geothermal energy is done using equipment originally intended for the hydrocarbon industry. The target is to reduce cost for drilling and underground installations by at least 25% compared to the situation today.

• Novel production technologies to improve efficiency, reliability and cost of heat production (including well design and completion, definition of suitable materials, reservoir stimulation, prevention of formation-damage, high temperature-high pressure tools etc.). Geothermal well design has reached a good standard, and specifically-designed components like pipes and pumps are available. Production pumps cause high power consumption. However, there is room to reduce operation and maintenance cost by at least 25%, improve system reliability and energy efficiency of operation, in particular by decreasing energy consumption of production pumps by at least 50%.

• Surface systems for heat uses in DHC (including CHP) and industrial processes. The use of geothermal heat for DHC, process heat or large buildings requires specific technologies to transfer the geothermal energy into useful heat inside a network, a building or an industrial plant. The basic technologies to exchange heat between the geothermal source and the heat transfer fluid in the system in the network still offer a wide range of possible improvements, both in energy efficiency and resistance to corrosion, e.g. new materials or innovative geometries. Any further development in DHC technologies (including cascading and storage), also has the potential for improving the efficiency and performance of geothermal district heating. Standard heat exchange and heat/cold distribution systems for conventional heat and cold sources are applied; the characteristics of geothermal heat (steady supply, mostly limited temperature, mineralised waters) are addressed by design, but not with innovative solutions and components. The target is to provide optimum heat transfer from the ground system to the distribution system, increase heat exchange efficiency by 25% and component longevity in the thermal water circuit by 40%.

• Enhanced Geothermal Systems (EGS). EGS is a technology for accessing the heat in hot but impermeable basement rock. Once fully developed, it will provide a major increase in the geothermal resource base, both for heat and electric power. In spite of its potential and although the basic concepts were already developed in the 1980s EGS has not yet matured into a ready-to-implement technology. Experience in the few existing research facilities and operational power plants revealed a significant discrepancy between initial layout figures and final result, both with respect to the stimulated underground heat exchanger and the realised thermal and electrical output. Therefore, apart from necessary flanking measures with regard to training, education and public acceptance, major efforts are required for developing tools and layout procedures for a design of EGS with reliable performance parameters, such as flow rate, temperature and thermal and electrical power. Ultimately, this will establish EGS as a technology applicable almost everywhere for both heat and power production.

4. CURRENT R&D ACTIVITIES

The implementation of the geothermal technology roadmap can be monitored by reviewing ongoing and recently achieved research projects and by assessing the impact of the first results on the key performance indicators. The objective of this chapter is to present the research activities, in correlation with the research priorities mentioned in the Geothermal Technology Roadmap. Future trends are also identified, by highlighting areas in which relevant projects are being developed, which could have an expected major impact on a given KPI. This analysis is performed by research area, as identified in the Geothermal Technology Roadmap.

4.1 Shallow geothermal technologies

For geothermal systems with borehole heat exchangers or groundwater wells, the drilling of the necessary boreholes is a major cost factor. Hence systems can be made much more economic by improved and innovative drilling methods, allowing for cost reduction. A lot can also be expected from further reducing manual work in drilling and installation, with automation and robotics. R&D in specific shallow geothermal drilling technology is also required to further reduce the impact on the surroundings (e.g. sensitive clays, groundwater), to provide techniques to control borehole deviation, etc. In particular in the residential sector, other types of geothermal heat exchangers like horizontal loops are in use in addition to drilling of boreholes. The use of geothermal activated structures (geothermal piles, diaphragm walls provided with embedded heat exchanges, etc.) may also lead to substantial cost reductions. However, the detailed thermo-hydro-mechanical interaction between these structures and the soil and its long term stability and performance is an area that needs substantial experimental backup, standardised approaches and new algorithms and software developments. Also here the reduction of cost, through optimised and mechanised installation methods, is an issue and needs further R&D-work. The efficiency of heat exchange with the geological strata can be increased by R&D for optimisation of components such as borehole heat exchangers (design, pipe material, grouting material), well completion materials, compressors, and pumps. Finally, improving the understanding of the shallow geothermal reservoir as an entity and as a process involves the characterisation of the important parameters (thermal, hydrogeological, environmental) as well as engineering.

In top of a series of national research projects, two main geothermal research projects have recently started supported by the European H2020 programme:

- Cheap-GSHPs - Cheap and efficient application of reliable ground source heat exchangers and pumps
- GEOTeCH: Geothermal Technology for €conomic Cooling and Heating

Moreover, a research project on hybrid RHC with geothermal was also started:

- TESSe2b: Thermal Energy Storage Systems for Energy Efficient Buildings. An integrated solution for residential building energy storage by solar and geothermal resources

In 2014, the ThermoMap project was achieved. It aimed at providing a Web GIS application, using existing data for shallow geothermal potential (GSHP).

4.2 Deep geothermal technologies

4.2.1 Resources

Firstly, to decrease the cost of exploration, a framework for pre-drilling basic research on geothermal resources and geochemistry, in addition to geophysical campaigns, have to be proposed. The aim of a drilling campaign would be to further reduce risk, and thereby promote commercial initiatives, by supporting secondary exploration through drilling of characterisation wells in prospective regions based on commercial initiatives. Data will be collected in high-quality public databases.

A Pilot Project for a European Geothermal Information Platform (EGIP) has been launched by the Geothermal-ERANET. Several research projects on exploration technologies (geochemical and geophysical exploration campaigns) are ongoing, mainly leaded by private research activities. Several national activities on potential mapping have bene finished or are ongoing: in Italy (VIGOR), in The Netherlands (Heat atlas), in Germany (AuGE), in France (GHEMOD) etc.

Finally, a major European project (FP7) will be achieved next year: IMAGE – Integrated Methods for Advanced Geothermal Exploration.

4.2.2 Drilling

Concerning geothermal drilling activities, the main areas involved are:

• Development of innovative drilling technology for exploration and preliminary reservoir assessment

• Optimisation and development of measurement-while-drilling (MWD) technologies, development of data interpretation methodologies

• Improved drilling for reservoir development and exploitation

• Drilling and installation for deep borehole heat exchangers (BHE) in low-/medium enthalpy, low permeability reservoirs to improve techniques and reduce costs

• New drilling concept: horizontal, multi-well.

Two H2020 project started in 2015 on geothermal drilling:

- ThermoDrill - Fast track innovative drilling system for deep geothermal challenges in Europe

- DESCRAMBLE - Drilling in supercritical geothermal condition

Novel drilling technologies are also developed, but mainly on a private basis.

4.2.3 Production

Sustainable and reliable production of geothermal heat from deep geothermal resources is associated with various challenges, mainly related to the high temperature, high pressure environment, and geothermal fluid composition.

Many research activities are done in this area which is rather large. Three H2020 project just started: SURE - Novel Productivity Enhancement Concept for a Sustainable Utilization of a Geothermal Resource; DESTRESS - Demonstration of soft stimulation treatments of geothermal reservoirs; and GeoWell - Innovative materials and designs for long-life high-temperature geothermal wells.

And many more projects are developed, also here mainly on a private basis, on: Reservoir Engineering, New Materials, High Temperature and High Pressure tools and Pumps, Surface systems equipment: low temperature systems, heat pumps, turbines, cooling generation (via heat absorption).

4.2.4 EGS flagship programme

This programme covers the development and demonstration of energy efficient, environmentally sound and economically viable electricity and heat and cold production from Enhanced Geothermal Systems (EGS) and its integration in a flexible electricity system. Moreover, it covers flanking measures such as training and education of professionals on EGS and ensuring public acceptance.

A H2020 project is currently developed: DEEPEGS: testing stimulating technologies for deep EGS development.

Several other research activities are developed on EGS but a flagship programme is not yet available as research activities are not fully coordinated.

5. CONCLUSIONS

The Geothermal Technology Roadmap launched in 2014 is still at an early phase. First research, development and innovation projects have started but first results in terms of costs reduction, efficiency etc. are not expected before next year. The analysis of the Key Performance Indicators, mentioned in the Geothermal Technology Roadmap (with respect to the figures related to 2013) is then rather partial.

On Shallow geothermal, the main KPI are still expected to be reached:

- A Seasonal Performance Factor in the order of 5 for 2020.
- A Hellström-efficiency (a measure of the impact of borehole thermal resistance) of about 80% in 2020.
- A further decrease in energy input and reduced costs for operating the geothermal heat pump system.

In deep geothermal technologies:

- Improved exploration of geothermal resources and creation of a European geothermal resource database. In the future, not a single project should need to be abandoned after the decision to go ahead with drilling.
- Reduce cost for drilling and underground installations by at least 25% compared to the situation 2013.
- Novel, improved production technologies to improve efficiency and reduce operation and maintenance cost by at least 25%, improve system reliability and energy efficiency of operation, in particular by decreasing energy consumption of production pumps by at least 50%.
- Enhanced Geothermal System (EGS) design with reliable performance parameters, such as flow rate, temperature and thermal and electrical power, will, ultimately, establish EGS as a technology applicable almost everywhere for both heat and power production.

The next steps for the geothermal panel in implementing the roadmap are to enhance cooperation between stakeholders through networking activities, and to stimulate research projects at both European and national level.

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