Innovation and Competitiveness of the Geothermal Heating and Cooling Sector

Philippe Dumas[1], Thomas Garabetian[1], Andrea Bogi[1].

[1] EGEC, Place du Champ de Mars, 2, 1050, Bruxelles, Belgique

t.garabetian@egec.org

Keywords: competitiveness, industry, innovation, RD&I, heating and cooling, district heating, shallow, value chain.

ABSTRACT

Geothermal heating and cooling (H&C) is a growing sector in the European Union, with sustained growth rates in installed capacity on all over Europe. This growth is carried by a European geothermal H&C industry, were historical actors and new entrant alike are at the forefront of innovation. Europe is among the leading industrial actors globally in geothermal H&C, rich of a strong know how, many large companies and a widespread bedrock of SMEs.

Despite the relative prominence of the European geothermal industry, it is faced with harsh competition from other geographical areas. It is particularly the case on export markets where the European geothermal sector must prove its competitiveness to obtain projects. Beyond competition within the geothermal sector, there is the question of the capacity of the European geothermal sector for heating and cooling with alternative heating and cooling technologies. This issue questions the structure of the market, the robustness of the geothermal sector, and the capacity of the regulatory framework to lay out a levelled playing field.

Moreover, the technological challenges for an accelerated deployment of geothermal heating & cooling across Europe is to develop innovative solutions. A next generation of geothermal technologies is needed to remain number one in the world.

The Geothermal implementation plan 2013-2020 produced by the Geothermal panel (RHC platform) presents a detailed strategy for developing these research, development and innovation projects. The first RD&I geothermal projects to implement the European Geothermal technology Roadmap started in 2014.

This paper will present the status of the implementation with a monitoring of the first project results and an assessment of the European industrial competitiveness in this sector.

The results of the European Commission service contract number PP-2041/2014 on “the support to key activities of the European Technology Platform on Renewable Heating and Cooling” will be presented in this paper.

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, and the increased growth of deep geothermal systems for heating and cooling.

But several technological challenges need to be addressed for an accelerated deployment of geothermal heating & cooling across Europe by developing innovative solutions.

The geothermal panel was established in 2009, following an initiative of EGEC, and it became integrated to the RHC-Platform from 2010. In April 2013 the RHC-Platform launched the Strategic Research and Innovation Agenda for Renewable Heating and Cooling (RHC-SRIA). The research agenda 2013 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 2010. 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. 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).

The geothermal panel then worked on the implementation roadmap to plan research priorities and investigate ways of funding. It also further defined key performance indicators (KPIs). The Geothermal technology roadmap was published in March 2014.

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

2. THE GEOTHERMAL HEATING AND COOLING INDUSTRY

2.1. Description of the industrial sector

2.1.1. Different types and use of geothermal for heating and cooling

Geothermal energy is the thermal energy stored below the earth's surface. This energy can be found at different temperatures in the ground and the ground water, depending on local geology and depth. Three types of geothermal energy for heating and cooling are distinguished:

- The first one (very low temperature in the range of the annual mean air temperature on site, up to about 30 °C) is based on the relatively stable ground and groundwater temperatures at shallow depth (the limit is typically set at 400 m). Typically, heat pumps are used to extract energy from the ground and raise the temperature to the level required by the heating systems. The ground is sometimes also used for thermal energy storage.
- The second one (low and medium temperature, ranging from 30 °C to over 100 °C) extracts the heat from ground and groundwater at higher temperature, and typically at greater depth (than 400 m).
- A third category (high temperature (high enthalpy) resources of well over 100 °C up to above 300 °C) is primarily used for electric power generation. However, geothermal power plants still provide energy for heating through cogeneration, and some high-temperature industrial processes are supplied directly with heat from this type of resource

Based on these considerations, the geothermal industry sector is typically split into two main segments: shallow and deep geothermal.

Shallow Geothermal industry

This segment is manly engaged in delivering systems devoted to space heating and cooling buildings, with a special focus on residential buildings. A small portion of this industry is also involved in the construction of underground seasonal thermal storage in aquifers and borehole heat exchangers (BHE).

The shallow geothermal market is the largest segment of the geothermal sector by far and is slowly but steadily increasing across Europe. Sweden, Germany, France, and Switzerland have the highest number of geothermal heat pumps, accounting for 69% of the total installed capacity. It should also be noted that the shallow geothermal does not correspond to small systems for individual households but can meet the needs of very large buildings for heating and cooling, or for a district heating at scales of several MWth.

Deep Geothermal industry and Direct Uses

If the geothermal heat is at a level of temperature compatible with the temperature required by a space heating and DHW system, the energy from the ground or the ground water can be used directly. Direct applications are found in district heating, agriculture (horticulture, aquaculture, drying), industrial processes and balneology.

District heating and cooling has been a success story for the geothermal industry, which continues to expand into new markets. The largest geothermal district heating systems within Europe can be found in the Paris and Munich area, with Austria, Hungary, Italy, Poland, Slovakia and others showing a substantial number of interesting geothermal district heating systems.

Geothermal energy is also increasingly being used in the agro-food industry and for leisure purposes, as it meets many of the sectors' requirements. Low or medium temperature geothermal heat is available everywhere in the world and the technologies enabling its use are simple and easy to maintain.

When medium to high temperatures are available, geothermal energy is mainly used in power-to-heat applications, where warm water or steam are used in combination with ORC devices or turbines to provide both electricity to the grid and thermal energy to a district heating network.

2.1.2. Description of the supply chain

Most of the companies involved in the geothermal sector are SMEs. The markets of the geothermal companies are rather national. Since geothermal technologies are site specific (the geology is different all over Europe and knowledge of the local conditions is essential) and capital-intensive, the needs regarding exploration, resource development, construction and O&M are covered by the local industry and workforce.

It is especially the case in the shallow geothermal sector. Designers and drillers for shallow geothermal are typically regional and just some of them are active in another country and usually for cross-border projects.

In the deep geothermal industry, SMEs are active during the design phase, but mid-caps or large companies are encountered when referring to developers, drillers, manufacturers and operators (See figure 1 below).

Given the many different disciplines that are required in the industry, job opportunities are provided for people with different types and levels of skills.

Scientists and engineers are needed to explore new geothermal fields. Skilled technicians are required for construction and operation of the new geothermal power plants. Development of EGS (enhanced geothermal systems) or other conventional technologies can contribute to further creation of jobs (see also figure 2).

Given the nature of the work, we can also assume that construction and O&M cannot be relocated, meaning that they are "European" jobs. Regarding equipment (rigs, turbines), the number of large manufacturers is not expected to boom internationally.

In general, it can be anticipated that the sector will move from a geological approach to an engineering approach where systems can be replicated but can hardly be industrialised. Therefore, it is estimated that 85% of the geothermal value chain is going to remain in Europe, as it is now.

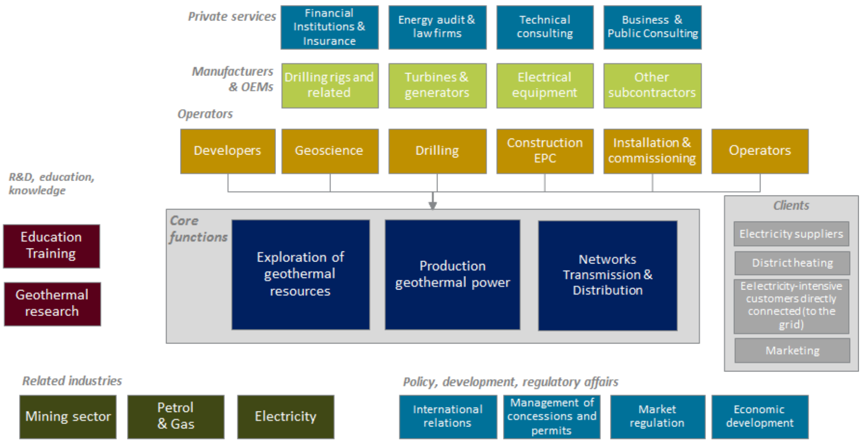


Figure 1. Geothermal industry overview. Source: GEOELEC, from Capgemini Consulting and Canmetenergy

Start-up	Exploration	Feasibility drilling	Drilling and Construction	Operation and Maintenance
•Geologists •Biologists •Hydrologists •Archeologists •Lawyers •Paralegals •Environmental engineers	•Geologists •Geophysicists •Geochemists •Engineers •GIS specialists •Exploration drillers •Sample analysts •Consultants	•Drilling engineers •Rig hands •Mud loggers •Drilling fluids personnel •Cementing personnel •Casing crews •Directional drillers •Rig transportation •Fuel transportation •Welders •Safety managers •Geologists •Construction personnel	•Engineers •Power plant designers •Document controllers •Project managers •Construction managers •Project engineers •Field engineers •Safety managers •Welders •Steel erectors •Concrete placers •Assembly mechanics •Inspection personnel	•Plant managers •Engineers •Plant technicians •Site operators •Service repairmen

Figure 2. Job types through the project development and operation. Source GEA and ILo

2.1.3. Supply chain components

In the deep geothermal sector, most of the supply chain is European. Leading countries in terms of sales are Italy, France and Germany. Key components of the geothermal supply chain include:

- Steam turbines (CHP) and ORC units
- Steel pipes
- pumps extracting and re-injecting water from/to the ground
- heat exchangers

Since a lot of geothermal companies have developed customised products (example: drilling rigs manufactures), it is expected that the factories and the jobs created will remain local and cannot be exported to countries where the personnel costs are lower than in Europe.

The supply chain specific to the shallow geothermal sector notably includes the components of the borehole heat exchanger (e.g. plastic pipes, cement…).

Plastic pipes. Due to the very decentralised nature of the market it is difficult to have clear data on plastic pipes for geothermal energy. There are however some data in the case of large systems (which publicise the length of the borehole heat exchangers, hence the length of plastic tubes). It is also possible to obtain a rough estimate of the total length for geothermal heat pumps by considering an average 4 boreholes per installation, two tubes per borehole, considering an average 100 m depth. With 1.5 million systems in the EU (EurObserv'ER, 2015), this would lead to around 600,000 km of plastic tubes installed for geothermal systems. Considering the annual addition of 100,000 units (EurObserv'ER, 2015), this corresponds to 60,000 km of plastic tubes installed each year. There are two different typologies of installation for the heat collector pipework: horizontal or vertical. The first solution needs 300 kg of HDPE pipes, while the vertical between 182 and 195 kg. The estimated quantity of plastic materials used for the yearly geothermal heat pumps installations in Europe is 25,000 tons.

In terms of the nature of the pipes used, there are some specific characteristics that are sought in the plastic pipes used in BHE (thermal conductivity), which calls for specific pipes.

Cement. Alongside pipes, cement is a key material for the borehole heat exchangers, which altogether require significant volumes. The properties of the cements used can also be specific in order to improve the thermal conductivity of the BHE. The volume of cement needed for a typical domestic installation can be estimated around at least 15,000 tons of cement used every year in the shallow geothermal the sector. The cement suppliers for the shallow geothermal heat pump market can be conventional large actors or smaller companies which may offer more specific products with characteristics specific to geothermal (e.g. thermal conductivity for shallow, corrosion and heat resistance in some deep systems).

Steel. Deep geothermal plants are made up of an intricate array of pipes, from the well to the district heating for distribution of the heat. In most cases, geothermal plants use carbon steel pipes (the same that could be used in other industrial activities, notably oil and gas). But in highly corrosive environment, stainless steel (high nickel alloys) may be required, which costs 2 to 5 times more than conventional pipes. For steam plants (which are usually CHP then), the cost of piping ranges from 80-300 EUR/KWe.

In this segment of the supply chain, there are few actors for which geothermal is the main market. Most companies are also involved in supplying pipes for other sectors.

Drilling rigs (extrapolated by the total market of oil & gas industry). For deep geothermal heating and cooling projects, drilling represents 30% to 50% of the total project costs. It is also the phase of the project development that has the most risk, with success rates as low as 50% in green field and 75% in operated fields. In general, drilling for deep geothermal energy is very similar to drilling for oil or gas, with some specific characteristics. This means that the rigs used for deep geothermal drilling tend to be the same ones that operate in oil and gas fields.

In 2018, Baker Hughes identifies that over 2160 rigs are used globally, 84 of which in Europe (a number that has been steadily declining since 2014). 70% of those rigs being exploited for oil and gas drilling. Between one and three rigs had been used in France, Germany, Hungary, Iceland, Italy and Netherlands, and more than thirty rigs have been used for geothermal in Turkey.

The fact that the rigs used for deep geothermal projects are the same as for oil and gas is a key aspect of the market for geothermal drilling. Although there are a sufficient number of rigs in Europe for the needs of the geothermal market, there may be issue in terms of the availability of rigs at certain times.

The rig daily rate in drilling contracts ranges between € 13,000 and € 25,000 per day in Europe (and is very dependent on the price of oil – i.e. the demand for drilling in the oil and gas sector). If we assume that 40 rigs were in operation for deep geothermal drilling in 2017, each rig drilling 3 wells in a year, around 120 deep wells were drilled in Europe this year. The yearly turnover of this sector is about 400 million €.

Average is around 20 crew members working daily on a drilling rig, they are working on 8 to 12 hours shift. It includes other 3rd party participants, notably services companies, rolling in and out of location as well. The geothermal drilling rig sector employs today around 1000 FTE in Europe.

Pumps: Deep geothermal energy production rests on the extraction of hot water or steam from the ground. While in many cases the geothermal fluid can flow naturally thanks to the reservoir pressure (which is called an artesian flow), in others, so-called production or downhole pumps may be required. In general, circulation pumps are also installed in the surface for the functioning of the plant.

Downhole pumps tend to have lifespan of 4 to 6 years, meaning they must be replaced several times throughout the lifespan of the geothermal well (several decades). The typical cost of such an equipment ranges from 180-300 thousand euros. International competitors from US, Canada and Europe cover the pumps market for deep geothermal installations. Many of these companies are also global manufacturers of the valves, monitoring and control systems associated with the lifting mechanisms.

The estimation is that one pump is installed in each new deep geothermal heat or CHP plants (around 15 units) and every 5 years the 300 operating plants renew their pumps. In total, about 50 pump units are sold per year for deep geothermal in Europe. The turnover is estimated to be 12,5 million euros. The geothermal pump sector today directly employs several hundreds of FTE in Europe.

Heat exchangers: Heat exchangers are an essential component of every geothermal installation. However, there are steep differences between borehole heat exchangers where a plastic pipe filled with water runs through a borehole to extract low temperature heat from the ground, and the heat exchanger in a high temperature plant where the brine (geothermal fluid) runs through an intricate system to transfer the heat to another fluid (usually water, but not always, especially for ORC units), which will carry the geothermal energy to the point where it is used.

The main heat exchanger technologies used in the geothermal sector are: shell and tube, gasket plate heat exchanger, welded plate heat exchanger and shell and plate. Europe has traditionally been a strong market, and it features some of the global leaders in heat exchanger manufacturing. Large heat exchangers manufacturers based in Europe (Sweden, Germany, Denmark and Belgium) are the other most active players in the heat exchanger market and compete with US importers.

Newcomers to the European geothermal market are large manufacturers coming from India and Japan, or highly specialised SMEs in Europe able to answer project specific challenges regarding corrosion and scaling. Considering the case of the Rittershoffen plant in Alsace, the operator notes that the cost of heat exchanger was about 127 thousand euros.

Minimum expected life of the heat exchangers based on these corrosion rates is reported to be 7 to 12 years. The estimation is that the heat exchangers are installed in each new deep geothermal heat or CHP plants (around 15 units) and every 10 years the 300 operating plants renew their pumps. A plant has between 2 to more than 10 heat exchanger units. In total, more than 150 heat exchangers units are sold per year for deep geothermal in Europe. The turnover is estimated to be 20 million euros. The sector employs today directly few hundreds of FTE in Europe.

2.2. Value chain assessment

2.2.1. Manufacturing readiness level

The geothermal energy sector is not as dependent on the presence of a well-established manufacturing as are other sectors. A large part of the value of a geothermal system resides in drilling. More than manufacturing, it is therefore the availability of drilling rigs for shallow and for deep drilling that is a key factor in the cost of geothermal systems and the capacity for deployment.

The readiness of the geothermal value chain in terms of manufacturing is fairly high, as the companies that manufacture the components are usually also involved in other sectors: typically, the steel pipe manufacturers for wells, cement producers, heat exchanger manufacturers.

When it comes to companies specialised in geothermal energy exploitation, a lower manufacturing capacity is encountered (at the level of an individual company which tend to be SMEs), together with a high level of readiness in dealing with the specific requirement of a geothermal energy system design and installations. Altogether the combination of these different manufacturing ecosystems contributes to a robust manufacturing supply chain for the geothermal sector in Europe.

2.2.2. R&D capacities

It is difficult to estimate precise expenditures in R&D for this sector, as it is strongly dominated by SMEs, and large companies are normally involved in more sectors that just the geothermal. Moreover, especially regarding drilling, the sector benefits from R&D in other sectors such as the oil and gas. A typical example is the technique of horizontal shale gas drilling that has been demonstrated for the first time in a geothermal system in the Paris Basin in 2018.

2.2.3. Business models

Geothermal energy projects are defined by their capital intensiveness. Indeed, geothermal projects' cost structure is primarily made up of capital expenditures, of which the drilling is a significant component. However, while this general characteristic is true for all geothermal projects, the different types of geothermal projects have different business models.

Geothermal heat may be competitive for district heating where a resource with sufficiently high temperatures is available and an adaptable district heating system is in place. Geothermal heat may also be competitive for industrial and agriculture applications (greenhouses), industrial or tertiary sectors.

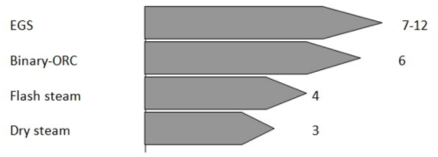
Regarding shallow geothermal technologies, it can be considered mature and competitive, but only a level playing field with the fossil fuel heating systems will allow phasing out any subsidies for shallow geothermal in the heating sector.

All in all, geothermal electricity and heat can be competitive under certain conditions, though RD&I and enabling polices are still necessary to reduce the levelised cost of energy of less conventional geothermal technology.

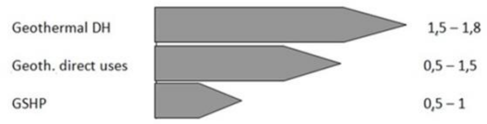
Investment costs: Geothermal electricity development costs vary considerably as they depend on a wide range of conditions, including resource temperature and pressure, reservoir depth, location, drilling market etc. See below the capital costs per geothermal technology.

Operation and Maintenance costs: O&M costs in geothermal electricity plants are limited, as geothermal plants require few or no fuel.

Commercial costs: Commercial costs associated with developments also need to be included in costing a geothermal project. These include financing charges (including establishment costs and interest), interest during construction, corporate overhead, legal costs, insurances. For geothermal, risk insurance is the main issue. It depends on the origin of the resources invested and the way they are secured, as well the amount of initial capital investment.



Capital costs, € million /MWe installed



Capital costs, € million /MWth installed

3. OVERVIEW OF MARKET TRENDS

The geothermal energy sector is diverse and driven by the development of new projects, as it rests on a robust industrial base, although to an extent that varies greatly through the different European markets.

The use of geothermal energy for heating and cooling is increasing rapidly across Europe, with different technologies according to local resources and needs. In Nordic countries, shallow geothermal systems have proven an effective solution for the decarbonisation of the heating and cooling sector. Deep geothermal systems have proven their reliability in France, Germany and Hungary and are rapidly adopted in emerging markets such as the Netherlands.

The diversity of markets, technologies, enabling technologies (district heating, heat pumps…) and types of heating and cooling supplied by geothermal systems explains the great diversity of actors involved in the sector and business models for financing projects.

Ground Source Heat Pump (GSHP) systems connected to shallow geothermal installations, mainly with sizes ranging from 2kW to 100kWh supplying heating, cooling and domestic hot water with a SPF > 3.5, cover 83% of the total geothermal installed thermal capacity. The remaining 17% is covered by deep geothermal systems. Individual geothermal heating systems represent a thermal capacity of over 23 GW in Europe, with nearly 1.9 million systems installed.

Dozens of new district heating networks are set up every year, using shallow geothermal systems with heat pumps to:

- Either enhance the temperature of the geothermal energy to the level of third or fourth generation district heating networks (80 and 50 °C respectively)
- Or to deliver low temperature thermal energy to the users -through the network pipelines- and to enhance the temperature level at user's side to the needed level (35 to 70 °C).

Deep geothermal district heating accounts for a thermal capacity of over 5.1 GW in Euurope with 304 plants currently in operation.

The geothermal industry has had an increasing turnover in the European Union to around 2.7 billion euros, the heating and cooling sector only representing 1.6 billion euros overall. The geothermal sector represents 25,000 – 30,000 jobs across the deep and shallow markets. The European geothermal industry has a know-how well recognised at global level and is a global leading actor in terms of innovative technologies thanks to consistent and robust investments in R&D.

4. INNOVATION IN THE COMPETITIVENESS OF THE EUROPEAN GEOTHERMAL HEATING AND COOLING INDUSTRY

4.1. The Key Performance Indicators

The Geothermal Panel of the RHC platform established Key Performance Indicators for developments in research, and innovation in geothermal energy for heating and cooling. They include:

Shallow geothermal:

- Decrease the energy input for operating the geothermal heat pump system by 10% in 2020 and 25% in 2030;
- Reduce costs for operating the geothermal heat pump system, leading up to 20% costs reduction of the O&M in 2020, and 30 % in 2030
- Increase value of Seasonal Performance Factor in the order of 4.5 for 2020 and 5 for 2030
- Increase value of Seasonal COP (SCOPcooling) in the order of 5 for 2020 and 5.5 for 2025
- Free cooling: Increase value of Seasonal COP (SCOPcooling) in the order of 22 for 2020 and 25 for 2025
- Increase the overall impact of a reduced borehole thermal resistance, the Hellström-efficiency, from below 60% to about 75% in state-of-the-art installations, to more than 80% in 2020 and 85% in 2030.
- GIS database to select the best combination between the dimensions of the borehole heat exchanger and of the drilling machine, reducing the uncertainty, minimizing the costs, maximize the environmental protection and the safety for the workers.
- Improve the overall efficiency of shallow geothermal installations by at least 10% in 2020 and 25% in 2030
- Increase number of installations in the EU per year to 150,000 units/y in 2020, to more than 200,000 in 2025, compared to 100,000 units in 2014.
- Reduce investment costs for a geothermal heat pump system, leading up to 20% costs reduction in 2020, and 30 % in 2030

Deep geothermal:

- Decrease geological risk to 2020 by 25% from 2014 and Reduce the exploration costs by 25% in 2025, and by 50% in 2050 compared to 2015
- Reduce the unit cost of drilling (€/MWh) by 15% in 2020, 30% in 2030 and by 50% in 2050 compared to 2015;

- New technologies to reduce operation costs, increase efficiency, reservoir performance..
- Reduction of capital cost by at least 25% in 2020 from 2014, and 50% in the longer term. Reduction of production costs below 120 €ct/kWh by 2020.

3.2. Status of Implementation of the Geothermal Technology Roadmap

A large part of the RD&I from Industry is dedicated to innovation at a high level of technology readiness. The total number of private projects for geothermal RD&I is hard to estimate. However, it can be assumed that the private sector represents one third of the total investment for RD&I in geothermal in Europe. The geothermal sector benefits from RD&I investments in other sectors such as geosciences (oil&gas), deep drilling, turbines and heat pumps.

A new powerful financing tool recently created is GEOTHERMICA – ERA NET Cofund, whichcurrently supports eight transnational projects on geothermal energy bringing innovative geothermal (essentially deep geothermal but some projects also deal with shallow geothermal) energy solutions closer to commercial deployment. The total investment in the projects is close to € 50 million. About half is funded by GEOTHERMICA and the other half comes from project partners. The projects cover a broad range of topics such as heat storage, managing induced seismicity, EGS drilling and completion, production operations, composite casing and integrated applications of geothermal heat. Participants in the the first series of GEOTHERMICA-funded projects come from the Netherlands, Switzerland, Iceland, Ireland, France, Flanders, Denmark, Slovenia, Germany, Spain and Azores Portugal.

For shallow geothermal, funding from the SME-instrument, INTERREG and ERASMUS+ offers new sources for RD&I.

5. GEOTHERMAL INDUSTRY'S STRENGTHS AND WEAKNESESSES

Geothermal energy is a renewable resource that can provide heating and cooling, and domestic hot water, and be used for cogeneration of heat and electricity. It is a resource that can be enabled through different technologies such as district heating, heat pump, heat exchangers etc., but that represents significant challenges that must be acknowledged in a sound framework.

Strengths

The geothermal industry is characterised by the possibility to produce energy in the form of electricity, heating and cooling, or directly as hot water. Geothermal energy is both base load and dispatchable, ensuring a secure and steady supply of energy.

In heating and cooling, geothermal energy is a proven local solution for buildings, industry and the agri-food sector. Geothermal projects have typically low operational costs, which are a guarantee of stable prices for consumers.

Geothermal industry exists in Europe for over a century. It is now scaling new technologies that greatly increase the exploitable resources and provide solutions for meeting Europe's heating and cooling needs (smart thermal grids, Enhanced Geothermal Systems, large borehole heat exchangers, underground thermal energy storages, etc.).

The European geothermal industry is robust and very innovative, in particular in the heating and cooling sector where Europe is clearly leading.

The European geothermal industry has a high degree of expertise which is largely sough after in other markets.

Weaknesses

Geothermal projects are very capital intensive, and the upfront costs are high even compared to other renewable technologies. This means that the development of new large projects is dependent on the availability of sufficient funding and the right financial instruments.

There is a high risk when developing a geothermal project, notably in undeveloped areas, that the project will not perform as planned. This "geological risk" is one of the main weakness of the geothermal sector, but it can largely be mitigated with the right framework and key technical measures.

The size of the geothermal sector is an inherent weakness that prevents it from scaling up to the potential of the resource.

Moreover, it is a complex sector: geothermal energy exploitation is difficult to explain because projects are very technical. It is also difficult to represent and hence to apprehend because of the absence of visual impact in systems set up (which is particularly the case for heating and cooling only projects).

Opportunities

The drive to decarbonise the European economy and the global effort to mitigate climate change are an opportunity for the European geothermal industry which can make expertise available to supply clean and carbon free energy solutions for heating and cooling needs and for electricity.

The drive to decarbonise the heating and cooling sector is a particularly important opportunity for the geothermal sector, notably enabled by the emergence of low temperature distribution systems in buildings and low-temperature district heating networks that allow to tap into diverse geothermal resources.

In addition, the geothermal industry can profit from the minerals (lithium, minerals for cosmetic products, other rare earths…) present in geothermal brine to increase their profitability (the most striking such example being the Blue Lagoon in Iceland).

Rapid development beyond Europe are an opportunity for the European geothermal industry also, due to the drive for development and supply of renewable energy to populations previously experiencing fuel poverty. It is for instance the case of Kenya, Indonesia, Philippines, Mexico where geothermal energy is a major component of the electricity supply and where geothermal heat is used in businesses.

Threats:

The main threat for the geothermal industry is the persistence of the unfair market conditions that favour fossil energy sources compared to renewable alternatives. These conditions are for instance maintained through subsidies for the sake of marginal efficiency gains in fossil heating systems (e.g. switch from old to newly installed condensing gas boilers).

The awareness of the geothermal resource and related technologies is low, which hampers the potential development of competitive solutions.

Unfit regulatory and financial frameworks may discriminate against geothermal compared to fossil technologies or even other renewable solutions due to the more capital-intensive cost-structure of the geothermal projects (for instance debt accounting rules for public authorities may prevent undertaking a large investment in a geothermal project, compared with continuing to spend large amounts of money on fossil energy for heating).

6. CONCLUSIONS

The Geothermal Technology Roadmap launched in 2014 is still in phase of implementation. First research, development and innovation projects have started but more results in terms of costs reduction, efficiency etc. are expected by 2020. The Key Performance Indicators, mentioned in the Geothermal Technology Roadmap (with respect to the figures related to 2013) have bene updated in 2018 and will now serve as a basis for the period 2020-2027. The geothermal panel is looking forward implementing the roadmap by enhancing cooperation between stakeholders through networking activities, and by stimulating research projects at both European and national level.

The next steps will then be to update the Strategic Research Priorities for Geothermal heating and cooling Technologies.

REFERENCES

The Geothermal Panel of the European Technology Platform on Renewable Heating and Cooling: Geothermal Technology Roadmap, European Technology Platform on Renewable Heating and Cooling, Brussels, (2014).

The Geothermal Panel of the European Technology Platform on Renewable Heating and Cooling: Strategic Research Priorities for Geothermal Technology, European Technology Platform on Renewable Heating and Cooling, Brussels, (2012).

Acknowledgements (optional)

We wish to thanks all Geothermal Panel members and experts having contributed. The data have been collected by EGEC during interviews, desk survey and events’ presentations. The draft version was reviewed by the geothermal panel steering committee and the ETIP on deep geothermal. They also have been in charge of validating the value reached for each KPI.

List of members - geothermal panel steering committee:

- Kujbus Attila, Geothermal Express Ltd., Hungary
- Urchueguia Javier, Universidad Politécnica de Valencia / GEOPLAT, Spain
- Pasquali Ric, Geoserv, Ireland
- Luc Pockelé, RED, Italy
- Stefano Bondua, DICAM - University of Bologna, Italy