The Geothermal market report for Europe

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ABSTRACT

EGEC publishes each year a market report to evaluate the development of the shallow and deep geothermal sector in Europe. The 2015 issue of this market report shows that interesting new projects have emerged. Some of the key findings are:

•Electricity: Sixteen new power plants became operational in 2014-2015, increasing the installed capacity in Europe by 363 MWe. The total installed capacity in Europe is now 2285 MWe, producing some 12 TWh of electric power in 2014.

•District Heating: Twenty three new systems have been installed in six European countries in 2014-2015, increasing the installed capacity by 281.8 MWth. The total installed capacity in Europe is now ca. 4700 MWth, with 13000 GWh th/year used for heating.

•Shallow Geothermal: For shallow geothermal energy (ground source heat pumps and Underground Thermal Energy Storage), the installation growth rate is spectacular; a capacity of at least 19, 000 MWth was achieved at end of 2015, distributed in over more than 1.4Mio installations.

In the whole debate, the potential of geothermal energy does not yet receive enough attention. We need a stronger focus on geothermal as a reliable contribution helping to reach Europe's climate and energy targets. With this market report, EGEC calls again for a level playing field, and the recognition of geothermal advantages: being a renewable, local, base load, and flexible source of energy.

1. INTRODUCTION

In 2011, EGEC published for the first time a market report to evaluate the development of the geothermal sector in Europe. We have witnessed within the last five years a resurgence of interest in geothermal power, after nearly a decade of only small development in capacity in the deep geothermal sector both for electricity and for direct uses (mainly district heating). A substantial number of projects have been developed throughout Europe, and geothermal energy is on its way to become a key player in the European energy market.

The 2015 issue of this market report shows that interesting new projects have emerged equally, unfortunately some other projects have been stopped for the time being. The reasons for not proceeding can be found primarily in changes in the relevant national policy framework. Some new plants, both for power and for heat, came on line this year. In this respect it should not be forgotten that the duration for project development, from the time the project is officially announced to the first heat or power delivered, is usually in the order of 4-7 years. It is for this reason that this report presents not only the plants in operation, but also those under development and others under investigation.

Some of the key findings are that:

•In geothermal electricity, the financial crisis has slowed down some development, and it is apparently a difficult time to attract the necessary investment. However, we can state the investigation into possible projects is happening in more countries than ever.

•For geothermal district heating, the need for thermal grid infrastructure is a key issue, both with new or renovated networks. Development must also pursue scalable solutions: capacities small or big, with low or high temperature, just to meet the demand.

2. ANALYSIS OF GEOTHERMAL ELECTRICITY MARKET IN EUROPE

The geothermal community celebrated in 2013 a century's worth of experience in operating geothermal power plants. It was therefore a special year to present the steps the sector has already taken, and to develop ideas on future technological trends, especially in the turbine and drilling sectors and on the economic potential up to 2050. For the fifth edition of the Market Report, an update of the market trends was presented.

In 1913, the first geothermal electricity plant started its operation in Larderello (Italy) and was composed of an alternator Ganz 250 kW, three-phase 50 Hz, with a voltage of 4500 volts coupled with a Tosi Parsons turbine of 350 hp.

Until the 1970s, only a few other plants were installed in Europe, i.e. in Italy and Iceland, followed by France (Guadalupe), and Turkey. And all of these were high

temperature with flash/dry steam turbine technology. With the development of new turbine technologies i.e binary cycle (Kalina and Organic Rankine Cycle-ORC) for low and medium temperature, more countries (Austria, Germany, Portugal) have installed geothermal power plants in the last 40 years.

Against this background it is interesting to analyse the current and prospective development of turbine technology, which is why the market report 2013 and 2014 put a particular focus on this sector. Drilling represents from 30% to 50% of the cost of hydrothermal geothermal electricity and heat projects and more than half of the total cost of Enhanced/Engineered Geothermal Systems (EGS). Moreover, success rate in drilling for geothermal projects is about 50% in green fields and 75% in operated fields. The significant costs and low success rate are the main reasons for the European Geothermal Energy Council to present this in-depth analysis of the drilling market in Europe today, having focused its analysis on turbines over the last two years.

There were, at the time of writing, 88 power plants in Europe representing a total installed capacity of more than 2285 MWe and a production of ca. 12000 GWh.

Geothermal plants are characterised by a high availability (amount of time that a plant is able to produce electricity over a certain period, typically a year, divided by the amount of the time in the period i.e. 8765-8766 hours) and net capacity factor (the ratio of the actual output of the geothermal plant over a period of time, to its potential output if it were possible for it to operate at full nameplate capacity indefinitely), typically in excess of 80%. Some geothermal plants operate at 100%.

52 geothermal electricity plants are located in the European Union. The total installed capacity in the EU-28 now amounts to around 991MWe, producing some 6,2 TWh of electric power yearly.

According to the 32 projects under development, capacity on the continent will grow to around 3,500 MWe in 2020, with this major increase linked to the rapid growth of the Turkish market.

On average, during the year 2015 the capacity factor was about 80%, because some power plants were commissioned in the later part of the year or were under repair (Bouillante in France, Italy) and therefore were only productive for a limited number of days. Additionally, the capacity factor of a number of (cogeneration) plants, e.g. in Austria, was lower because production in these cases is mainly driven by heat demand.

The geothermal power market is not developing as quickly as expected. There are 3 main reasons for this:

• Firstly, the vast geothermal potential is still underestimated and thereby there is an urgent need to increase awareness of its advantages especially for decision makers and investors

• Secondly, much more financial support should be brought to the geothermal sector. Support schemes are crucial tools of public policy for geothermal to compensate for market failures and to allow the technology to progress along its learning curve. Funding allocated to geothermal energy is negligible compared to that which is allocated to other technologies. Adequate financial support for low temperature plants and EGS is available only in France, Germany and Switzerland.

• Finally, beyond exploration, the bankability of a geothermal project is threatened by the geological risk. Risk insurance funds for the geological risk already exist in some European countries (France, Germany, Iceland, The Netherlands and Switzerland). The geological risk is a common issue all over Europe. Collaboration between Member States is desirable; it can allow them to save money and trigger the uptake of a valuable technology alike. For this reason the establishment of a Geothermal Risk Insurance Fund all over the EU is of the utmost importance for the deep geothermal sector in Europe.

2.1 Focus on EGS

Europe has three EGC power plants in operation: Insheim and Landau in Germany and Soultz-sous-forêts in France. Moreover, One EGS heat plant will be operation from June 2016 in Rittershoffen (France).

We can also count for 10 EGS plants under development and for more than 10 projects under investigation in Europe.



FIGURE

Figure 1: Map of EGS projects in Europe.

2.2 Focus on Turbines market

Dry steam power plants utilise straight forwardly steam, which is piped from production wells to the plant and then directed towards turbine blades. The first ever exploited geothermal field, still in operation in Larderello in Italy, is among the very few dry steam fields recorded worldwide. Flash steam plants, by far the most common, address water dominated reservoirs and temperatures above 180°C. The hot pressurised water flows up the well until its pressure decreases and it vaporises, leading to a two phase watersteam mixture and a vapour lift process. The steam, separated from the water, is piped to the plant to drive a turboalternator. The separated left over brine,

together with the condensed steam, is piped back into the source reservoir, an injection process meeting waste disposal, heat recovery, pressure maintenance and, last but not least, resource sustainability requirements.

Binary, known also as Kalina and Organic Rankine Cycle (ORC), plants operate usually with waters in the 100 to 180°C temperature range. In these plants, the heat is recovered from the geothermal fluid, via a heat exchanger, to vaporise a low boiling point organic fluid and drive an organic vapour turbine. The heat depleted geothermal brine is pumped back into the source reservoir, thus securing sustainable resource exploitation. Since the geothermal and working fluids are kept separated during the process there are little (if any), atmospheric emissions. Developments in working fluid selection may allow the extension of the former design temperature range from 180°C to 75°C. These are the most appropriate for EGS projects at low and medium temperature.

There are 4 types of turbines falling into 2 categories for operating geothermal power plants in Europe: Conventional (flash and dry steam), Binary (ORC and Kalina). Currently, there are more conventional plants in operation, but with on-going development of the other technologies, as well as the geographical flexibility of EGS plants, there will be an increase in binary types in the future. Binary processes are emerging as a cost effective conversion technology for recovering power from water dominated geothermal fields at temperatures below 180°C.

Conventional geothermal plants (flash and dry steam turbines) operating with Hydrothermal resources at high temperature have 100 years of history are fully commercial today with full costs (integrating systems costs and externalities) of about 7€ct/kWh.

Medium & Low temperature/enthalpy (< 180°c) geothermal power plants have been developing for some years and are becoming more and more commercially viable, thanks to the improved efficiency of the binary (ORC and Kalina) turbines with full costs of around 12-18 €ct/kWh for hydrothermal medium/ low enthalpy, and of ca. 25-30 €ct/kWh for EGS.

Globally, the market is dominated by the first three major manufacturers (Mitsubishi, Ormat and Fuji), who were responsible in 2015 for approximately 75% of the installed capacity and 60% of the units. The global market for geothermal turbines is indeed partially controlled by Japanese manufacturers including Toshiba Corp., Mitsubishi Heavy Industries Ltd. and Fuji Electric Co. Those companies have market shares of about 24%, 22%, and 21% respectively, according to data compiled by Bloomberg New Energy Finance last year. The very strong involvement of Japanese manufacturers is notable, considering the stalled development in Japan due to a lack of supporting measures. However, following Fukushima a new policy supporting geothermal is being developed. Two other manufacturers are prominent in Europe, Ansaldo-Tosi (the market leader) and GE- Nuovo Pignone. Alstom (now also part of GE) has also provided two conventional turbines in Europe and British Thompson Houston one turbine.

For Binary systems, 9 manufacturers have already provided turbines to geothermal power plants in Europe. For ORC: Ormat, Exergy, Altas Copco, Electra Therm, TAS, and Turboden (not within MHI group). For Kalina cycle: Siemens, Cryostar and Rotoflow. Siemens stopped its production of turbines for geothermal after the project in Unterhaching (Germany – Kalina cycle provided by Cryostar) but decided in 2013 to return to the geothermal industry, this time with steam turbines. Notable new actors for geothermal power projects Green Energy Group, which are providing turbines for project under development in Europe. It is interesting to highlight the first triple flash plants in Europe at Denizli and Pamukören in Turkey Many new actors coming from the fossil fuel industry and the waste heat recovery sector, and specialising in Combined Heat & Power, have recently shown an interest in the geothermal sector. Indeed, several emerging players are entering the small- and medium-sized turbine industry.

The stimulation of the market for binary systems should bring costs down rapidly with energy efficiency improvement and competition between manufacturers.

2.3 Focus on Drilling market

During 2015, the Baker Hugues international rig count showed that of the 2337 rigs used worldwide (on average), 117 were used in Europe. Three quarters of the rigs in Europe were operating on land, and more than 70% drilled for oil and gas operations. It should be underlined that around 4000 rigs are available for drilling worldwide.

Between one and three rigs have been used in France, Germany, Hungary, Iceland, Italy and Netherlands, and more than thirty rigs have been used for geothermal in Turkey. Still today, the geothermal industry uses the same rigs as the oil and gas industry. This is a key factor which influences the drilling market for geothermal. Geothermal drilling costs tend to follow the general oil and gas industry trend which exemplifies a total dependence on crude oil prices. This situation is likely to persist as long as the geothermal drilling sector does not build up a strong market share of its own.

Drilling market conditions are different all over Europe. Firstly, drilling regulations have a national component which creates a barrier to the creation of a European market. In some countries, the number of drilling companies is not high enough to allow full competition and therefore competitive prices.

For example, the typical components of drilling contracts in the geothermal drilling market in Europe are:

• France: rig daily rate, lump sum

• Germany: metre rate, rig daily rate and lump sum

• Italy: rig daily rate

• The Netherlands: lump sum, rig daily rate

Another important parameter influencing the market is rig availability. Although the total number of rigs in Europe is enough for the geothermal operations currently developed, it can be the case that the rig required for a drilling is not available when needed by the project developers. The contractual relationship between geothermal developers and drilling companies is a key factor of the project and cost management. An innovative market approach has been recently developed in France. A specific drilling management contract has been developed by the French operator Fonroche Geothermie through a joint venture with Herrenknecht Vertical and Anger's & Soene, in order to build and operate an innovative a heavy land rig adapted to urban environmental constraints and deep targets (down to 6000m True Vertical Depth: TVD). This long term commitment brings price stability and availability for the ongoing development of deep geothermal in France.

3. ANALYSIS OF GEOTHERMAL DISTRICT HEATING MARKET IN EUROPE

District Heating (DH) is the geothermal sector currently with the most dynamic development and the most interesting perspective in the coming years. The renewed momentum since 2009 continues, with 5 countries installing new Geothermal DH systems in the past year. The technology is developing: in 2014, smaller systems, targeting shallower resources and assisted by large heat pump systems have been installed. In France, more triplet systems have been installed over the last years.

The total installed capacity in Europe is now ca. 4700 MWth, with 13 terawatts-hours thermal per year (GWh th/y) used for heating. In total, installed capacity increased by 281MWth in 2014-2015. Moreover, new triplet systems are installed in the Paris Basin in order to prolong the lifetime of the plants.

There are 257 Geothermal District heating plants (including cogeneration systems) in Europe. 177 geothermal DH plants are located in the European Union. The total installed capacity in the EU-28 now amounts to around 1.5 GWth, producing some 4300 GWh or of thermal power.

According to the more than 200 planned projects, the capacity is estimated to at least 6500 MWth in 2018.

In 2014-2015, the main GeoDH markets are still in France (52 systems), Iceland (32), Germany (23) and Hungary (24). The hot markets for the next years are also mainly in Germany (43 new systems being developed or upgraded), France (47), Hungary (16), and Italy (15).

There is also a large production of other direct uses for heating and cooling from deep geothermal, but the lack of a strong statistical methodology to collect and treat data do not allow us to present data on installed capacity and production of other direct uses than geothermal District heating.

Based on Europe's geothermal potential, geothermal energy could contribute much more significantly to the decarbonisation of the DH sector. A considerable expansion of the district heating sector is expected in the EU-28 until 2050; indeed, geothermal heat through future district heating systems could be available for more of 25% of the EU population.

The GeoDH project supported by the EU through the Intelligent Energy Europe programme and coordinated by EGEC, has provided an interactive web-map viewer that shows areas with good geothermal potential for district heating and heat demand.

The web-map indicates the existing DH systems, including GeoDH systems, in Europe. Moreover, regions with temperature distribution higher than 50°C at 1000 m deep, and higher than 90°C at 2000 m deep can be visualised. Besides, the online tool provides information on the areas with potential for GeoDH and the heat-flow density.

Bearing in mind that the enthalpy (temperature) is not the only selection criteria (other key factors are heat flow on the supply side, and the heat users (urban density) on the demand side) from the map below, limited to the 14 GeoDH project countries, we can note that:

GeoDH can be developed nearly in every country;

• The potential for GeoDH development by 2020 is much higher than the forecasts of Member States in their NREAPs;

• Geothermal can be installed, especially in Central and Eastern Europe, with existing DH systems during extension or renovation, replacing fossil fuels;

• The Pannonian basin is of particular interest when looking at potential development in is Central and Eastern Europe countries;

• In Southern Europe, the option of District Cooling should be considered.

4. ANALYSIS OF SHALLOW GEOTHERMAL MARKET IN EUROPE

Shallow geothermal energy is available everywhere, and it is harnessed typically by ground source heat pump (GSHP) installations, using the heat pump to

adjust the temperature of the heat extracted from the ground to the (higher) level needed in the building, or to adjust the temperature of heat coming from building cooling to the (lower) level required to inject it into the ground. The main technologies used to connect the underground heat to the building system comprise of:

• Open-loop systems, with direct use of groundwater through wells

• Closed-loop systems, with heat exchangers of several types in the underground; horizontal loops, borehole heat exchangers (BHE), compact forms of ground heat exchangers, thermo-active structures (pipes in any kind of building elements in contact with the ground), etc.

Shallow geothermal installations intended to change the underground temperature periodically (e.g. seasonally) fall under the term Underground Thermal Energy Storage (UTES). The delineation between GSHP and UTES is not sharp, and among the larger installations, only a minority are 'pure UTES'. Large GSHP plants in most cases have a high share of the annual energy turnover inside the BHE field or the aquifer, and not with the surrounding or underlying round, and thus qualify for the term 'storage'. In all these large installations it is crucial to pursue a long-term balance of heat extracted from the ground and injected into the ground.

In terms of number of installations, installed capacity and energy produced, shallow geothermal energy is by far the largest sector of geothermal energy use in Europe. It enjoys the widest deployment among European countries, with very few countries not having shallow geothermal installations at all. More basic information on shallow geothermal energy can be found in the 2013/14 issue of the EGEC Market Report.

For shallow geothermal energy (ground source heat pumps – GSHP and Underground Thermal Energy Storage – UTES), the overall installation growth is continuing at a steady pace. This brought installed capacity up to at least 19,000 MWth by 2014, distributed over about 1.4 Million GSHP installations. A good comparison is provided by the data reported at the WGC/EGC events; graph 25 shows the total installed capacity in Europe according to data from the three latest conferences. Some important countries such as Finland did not submit reports for WGC 2015; these cases, the EGC 2013 figures have been repeated. The WGC 2015 totals thus show a lower boundary, with growth in a few countries not included.

The countries with the highest amount of geothermal heat pumps are Sweden, Germany, France, Switzerland and Norway. These five countries alone account for ca 69% of all installed capacity for shallow geothermal energy in Europe.

The slightly reduced market in units of equipment can be seen clearly in the sales numbers. The fact that the unit numbers do not reflect the size of the units should be taken into account. While size is decreasing in the residential sector due to better insulation and the development towards near zero energy buildings (NZEB), with a lower limit given by DHW demand more often now than by space heating demand, an increase in unit size seems to be happening in the non-residential sector. As all available statistics do not yet provide a size distinction, it is not clear if the reduction in numbers also means a reduction of annually installed capacity, or if installed capacity actually is stable or even growing. An interesting development can be noted in Central and Eastern Europe. While the absolute numbers in these countries still are low, there is a quite positive development. The potential for market increase is definitely demonstrated here. The amount of renewable heat produced by shallow geothermal energy can be calculated according to the rules set out in Directive 2009/28/EC (the Renewable Energy Directive) and in the subsequent Decision 2013/114/EU. As base data is still not available from official sources in most countries, the calculation requires some assessment, and values might have to be corrected in future. The total for 2014 amounted to 2610 ktoe. This value is quite in line with the expectations the European Technology Platform for Renewable Heat and Cooling (RHC-Platform) set in its common vision of 2011. Eurostat has published values for renewable heat from geothermal heat pumps for some EU-countries and Norway. A comparison can be made with the values shows that in most cases a decent match is given. Eurostat reports substantially higher values for France and Italy, and lower values for Germany and Poland.

The market for GSHP is today in difficulty nearly anywhere. While in some mature markets the situation still is rather stable, in others a decrease can be seen. In parts of Germany this can be attributed to continuously stricter regulation, causing delays and higher costs (see above). What are the main reasons for the current low in the market?

1. Not enough awareness about this technology and its advantages. In particular architects, the building sector, local authorities need to be informed better.

2. Cost intensity is an issue, in particular for the initial investment. Because of the drilling, geothermal heat pumps can be considered as a capital-intensive technology in comparison with other small scale applications.

3. Quite unfavourable competition with gas: geothermal heat technologies are heading for competitiveness, but support is still needed in certain cases, notably in emerging markets and where a level playing field does not exist. In addition, there is a need for an in-depth analysis of the heat sector, including about the best practises to promote geothermal heat, the synergies between energy efficiency and renewable heating and cooling, and barriers to competitiveness. As Geothermal Heat Pumps can be considered a mature and competitive technology, a

level playing field with the fossil fuel heating systems would eventually allow phasing out subsidies for shallow geothermal in the heating sector.

4. Regulations can be a barrier, either through overregulation, or with unclear procedures. Even a lack of regulation can turn into a barrier over time, with drilling undertaken in unsuitable places or with insufficient care. We need simplifications in some countries, more stable regulations in other, and a better knowledge within the authorities almost everywhere.

5. Bad publicity with a few projects causing problems in Germany and France, receiving a lot of press coverage.

Training for installers of shallow geothermal systems is provided by professional or industrial associations, often in cooperation with existing educational institutions in countries with a mature GSHP market; this includes for example Germany, the Netherlands, Sweden, and Switzerland. In order to help other countries to set up training schemes and for all countries to have training based upon certain minimum standards, the program Geotrainet was developed. Geotrainet started as a project running from 2008-2011 with support by the EU within the IEE programme, then after lengthy preparations, was founded as an association in November 2013 in Lund, Sweden. It has been officially registered in Brussels, Belgium since spring 2014. This association is destined to continue the coordination of training activities, to set curricula, to provide common training material, etc.; the members are national training coordinators in the different states (mostly national associations). More information is available at www.geotrainet.eu .

3. CONCLUSIONS

We are surrounded by inexhaustible energy resources which allow us to meet both our energy needs and those of future generations without taking uncontrollable risks with the life and well-being of our planet. Technological developments enable us to make use of these energy sources on a scale that meets the requirements and demands of modern civilisation.

A single technology, a single renewable energy, can never meet these demands alone. Each has its specific advantages and disadvantages, and has to be applied in an intelligent, targeted way, in synergy with other technologies in order to deliver at optimum strength. Used in combination, renewable energy sources can meet the demand! This is true in particular for heating and cooling, which represents about half of the final energy demand in Europe. Only a tiny portion of the potential of geothermal energy yet is explored and in use in Europe. Increasing the use of geothermal energy and strengthening the geothermal industry will allow a substantial reduction of CO2-emissions, savings in primary energy, and the creation and sustenance of a strong work force of various disciplines and on many skill levels.

Thus we cannot relax and let things develop, instead we need to further strengthen efforts to provide the right economic and political environment, to advance research and innovation, and, most importantly, to explore, design, finance, build, and operate geothermal energy installations!

Often forgotten today, one of the main arguments to promote renewable energy sources in Europe is the local aspect. The local production of energy leads towards a decentralised approach and eventually to a reduction of the system costs. It also ensures security of supply- and with carbon free sources of energy above all. Local production of energy also empowers the consumers which can become prosumers; the choice of the energy mix can be more democratic.

Geothermal is indeed a local source of energy, producing power and heat for cities and rural communities. It allows for local economic development with many indirect positive effects such as job creation. Moreover, one cannot look anymore at an energy technology without considering its integration into the energy system and its role in the economy; here we can highlight the enriching role geothermal can play in both.

Geothermal power plants could be developed in all European regions and will contribute to grid stabilisation thereby providing much needed security of supply. The current reform of the EU climate and energy framework, which is expected at the end of 2016 and includes the Renewable Energy directive, should take into account the advantages and specificities of geothermal (being base load and flexible; producing locally 24hours per day) through dedicated provisions. Indeed, the ability to provide flexibility at a regional level, a step between centralised and decentralised systems, is one of the key but less well known advantages of geothermal.

Geothermal will be one of the renewable sources providing solutions for clean, competitive, and secure heating, cooling, and domestic hot water. Indeed, geothermal has a key role to play in the decarbonisation of the heating and cooling sector, which has a much more complex structure than electricity sector. Many options are available and the market will decide on the mix of energy sources in each region, but both geothermal direct use (district heating etc.) and shallow geothermal are bound to become major technologies here.

It is never too late to jump onto the band wagon. A remarkable example for me comes from the Netherlands. With deep geothermal exploration dating back to the 1980, very little was done in times of cheap and abundant natural gas supply. Now in the new millennium, the agricultural sector (the famous Dutch greenhouses) has led the exploitation of deep

geothermal heat- and the market is growing. The right policy measures such as risk coverage were required to make this (late) success happen!

If the energy transition is to be successful, we have to think about optimum scenarios in terms of cost and affordability for the customers and citizens. For geothermal, a local and stable source of renewable energy, the systems costs and the external costs are very much reduced, and furthermore geothermal contributes to the development of the local economy.

That said, it is now time to go beyond the levelised cost of energy technologies when considering their value. Geothermal benefits should be rewarded not only for power and heat generation, but also for its contribution to the energy transition. Geothermal therefore has a crucial role in the future energy system.

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