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The sole responsibility for the content of this document, however, lies with the editors.
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Introduction
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.

At the first EGEC Business Seminar in Ferrara, Italy, in 1999 we agreed upon and published the EGEC Ferrara Declaration. Within that declaration some numbers for possible geothermal development were stated, jointly discussed by experts from science and industry; some of the experts of 1999 voiced their concern the targets were too ambitious and would never be achieved.

Looking at the development since then (Figure 1), we can be somewhat satisfied: the targets were not overstated by far, but proved to be rather realistic at least up to now. In geothermal heat we exceeded the expectations, but in geothermal power we are lagging behind a bit. On the other hand, there was also a much higher electricity target of 8 MW for 2020 in the Ferrara declaration, stating what might be achieved with full policy support. We are missing that target by far, and the simple extrapolation of the development of the past years would mean we will probably miss the “normal” 2020 power target slightly, and the 2020 heat target considerably. 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 24 hours 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, as can be seen in figure 2. 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.

Finally, what is the special focus of this edition?

- An analysis of the drilling market for deep geothermal energy
- An in-depth report on the changing landscape of support schemes
- An extended coverage of shallow geothermal energy (the list of large installations with >10 km BHE length now exceeds 100 entries!)

As president of EGEC I feel proud to lay this 5th edition of the market report into the hands of members and other users. I thank the EGEC staff in Brussels for their hard and diligent work to get all data compiled and evaluated in time, and to have again produced a reference document, keeping the records of geothermal energy development in Europe, and to assist the geothermal sector in 2016 and beyond.

Burkhard Sanner
EGEC President
Electricity
Electricity Market Data Analysis: Market Development

In Europe there are 32 power plants under development and 176 under investigation.

In the EU there are 14 power plants under development and 126 under investigation.

In Europe there are 88 operational power plants with a total installed capacity of 2285 MWe.

In the EU there are 52 operational power plants with a total installed capacity of 991 MWe.
16 new power plants were commissioned in 2014 and 2015, with a total new capacity of 363 MWe.

### Italy
- **Tuscany, Mount Amiata (Bagnore 4)**
  - Installed capacity: 40 MWe

### Turkey
- **Aydın Germencik (Efe 1)**
  - Installed capacity: 47.4 MWe
- **Aydın Germencik (Efe 2)**
  - Installed capacity: 26 MWe
- **Aydın Germencik (Efe 3)**
  - Installed capacity: 26 MWe
- **Aydın Germencik (Efe 4)**
  - Installed capacity: 26 MWe
- **Aydın-Germencik (Efe 1)**
  - Installed capacity: 47.4 MWe
- **Aydın-Germencik (Efe 2)**
  - Installed capacity: 26 MWe
- **Aydın-Germencik (Efe 3)**
  - Installed capacity: 26 MWe
- **Aydın-Germencik (Efe 4)**
  - Installed capacity: 26 MWe
- **Aydın-Hıdırbeyli**
  - Installed capacity: 24 MWe
- **Aydın-Salavatlı (Dora3b)**
  - Installed capacity: 20 MWe
- **Aydın-Umurlu**
  - Installed capacity: 12 MWe
- **Denizli Tosunlar**
  - Installed capacity: 3.5 MWe

### Germany
- **Bavaria- Oberhaching-Laufzorn-Grünwald**
  - Installed capacity: 45 MWe

### Other
- **Çanakkale- Babadere**
  - Installed capacity: 45 MWe

---

**Figure 5. Geothermal electricity cumulative installed capacity in Europe (2011-2015, MWe)**

- **New installed capacity**
  - 2011: 0 MWe
  - 2012: 500 MWe
  - 2013: 1000 MWe
  - 2014: 1500 MWe
  - 2015: 2000 MWe

- **Total cumulative capacity**
  - 2011: 2073 MWe
  - 2012: 2526 MWe
  - 2013: 3037 MWe
  - 2014: 3548 MWe
  - 2015: 4059 MWe

---

*only available in full report*
Gross electricity production in selected countries in 2014 (GWh)

<table>
<thead>
<tr>
<th>Country</th>
<th>Installed capacity in 2010</th>
<th>Projection for 2015</th>
<th>Actual installed capacity in 2015</th>
<th>Difference between projection and actual installed capacity (%)</th>
<th>Projection for 2020</th>
</tr>
</thead>
<tbody>
<tr>
<td>Italy</td>
<td>754</td>
<td>837</td>
<td>915.5</td>
<td>9.37</td>
<td>920</td>
</tr>
<tr>
<td>Germany</td>
<td>10</td>
<td>79</td>
<td>36.6</td>
<td>-53.67</td>
<td>298</td>
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<tr>
<td>Greece</td>
<td>0</td>
<td>20</td>
<td>0</td>
<td>120</td>
<td></td>
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<tr>
<td>France</td>
<td>26</td>
<td>53</td>
<td>17.1</td>
<td>-67.7</td>
<td>80</td>
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<tr>
<td>Portugal</td>
<td>25</td>
<td>40</td>
<td>23</td>
<td>-42.5</td>
<td>75</td>
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<tr>
<td>Hungary</td>
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<td>4</td>
<td>0</td>
<td>57</td>
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<td>Spain</td>
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<td>4.4</td>
<td>0</td>
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<tr>
<td>Republic</td>
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<td>5</td>
<td>N/A</td>
<td>10</td>
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<tr>
<td>Croatia</td>
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<td>4</td>
<td>0</td>
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<td>0.05</td>
<td></td>
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<td>EU</td>
<td>816</td>
<td>1047.4</td>
<td>993.25</td>
<td>-5.16</td>
<td>1627.9</td>
</tr>
</tbody>
</table>

In 2014 the production in Europe was approximately 12TWh. The Production in the EU was 6.2 TWh.

Gross vs net electricity generation in Italy - GWh, 2009-2015

Italy reached its highest ever level of production 2015: 6188 GWh gross.
Spotlight on Croatia:

Production licenses were previously granted for the Lunjkovec-Kutnjak and Velika Ciglena geothermal fields.

In 2015, 10 new exploration licenses were approved at: Draskovec, Prelog, Kotoriba, Legrad-1, Mali Bukovec, Ferdinandovac-1, Slatina and Babina Greda for electricity generation, and Bošnjaci sjever and Sveta Nedelja in Zagreb area for direct use. These new licences cover an area more than twice the size of that covered by existing production licenses.

Europe has:

- 3 EGS power plants in operation
- 1 EGS heat plant in operation
- 10 EGS plants under development
- 10+ projects under investigation

Figure 9. Map of EGS projects

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Focus on Turbines

**Figure 10. Turbines - Installed capacity (MWe) per technology**

- Dry Steam: 809.5
- Single Flash: 727.2
- Double Flash: 188.5
- Triple Flash: 60
- Binary ORC: 493.34
- Binary Kalina: 7.44

**Figure 11. Turbines - Installed capacity (%) per technology**

- Flash and Dry steam turbines dominate the market

- Dry Steam: 37%
- Flash: 43%
- Binary: 20%
83% of turbines installed in 2014/2015 are Binary

67% of all installed turbines were provided by Ansaldo Tosi, Mitsubishi/Turboden*, and Ormat

Figure 12. Turbines - Number of turbines per technology

- B-ORC: 39
- Dry Steam: 32
- Single Flash: 11
- Double Flash: 4
- B-Kal: 3
- Triple Flash: 1

Figure 13. Turbines - Number of turbines per manufacturer

Figure 14. Turbines - Installed capacity (MWe) per manufacturer

* Turboden became part of the MHI Group (Mitsubishi Heavy Industries) in 2013

only available in full report
National governments use a wide range of public policy mechanisms to support the development of geothermal electricity in Europe. These can be divided into two categories: investment support (e.g. capital grants and soft loans, including those to reduce the resource risk and for research and innovation) and operating support (e.g. price subsidies, quota systems, tender schemes, etc.). The level and type of instruments vary depending on the market maturity as well on the geological settings and the accessibility to the resource.

Figure 15 provides an overview of the operating aid available in selected European countries with potential for geothermal power. It is followed by a review of the evolving framework in place.

The most stable form of operating support is a feed-in tariff for a mid to long-term duration, i.e. a fixed and guaranteed price paid to the eligible producers of electricity from renewable energy sources. At the end of 2015, this type of instrument could be found in France, Croatia, Portugal, Turkey and Switzerland. The highest feed-in tariff is available in Switzerland (a minimum of 18.9 ct€/kW for plants above 20 MW and a minimum of 33,3ct€/kW for plants below 5MW for 20 years), while in Turkey a local-content bonus applies for the first 5 years (approx. €ct 0.5-2.1 per kWh) on top of a general tariff of 8.1 €ct/kWh for the first 10 years of operation. This instrument has played a significant role in attracting new investments in Turkey, France and Croatia, as well as Germany in the past.

In the European Union, however, operating aid is subject to major changes. The new state aid rules for projects in the field of environmental protection and energy (EEAG) for the period 2014-20 will phase out feed-in tariffs from 2016 onwards, in favour of more market-based incentives such as feed-in premium, i.e. a bonus on top of wholesale price. According to the standard rule, operators will have to sell the electricity directly on the market and no bonus is provided in case of negative prices. Additionally, as of 2017 this aid should be allocated via a technology-neutral bidding process open to all technologies regardless of their maturity.

However, the following derogations are still possible if requested by Member States:

- Feed-in tariff is possible for demonstration projects;
- Member States can set up technology-specific bidding to ensure diversification, and take different levels of maturity into account;
- Support can be granted without bidding if the Member States demonstrates that this would result in underbidding or in low project realisation rates.

A safer system has been put in place in Germany and France and will last until the end of 2016; in this case applications are collected and project developers are given some years to realise their projects. Italy is currently introducing a similar system. In these countries, therefore, a dash to secure incentives is expected to intensify in 2016.

Germany was the first country to implement the new EU rules in its EEG2014. That scheme puts in place a system whereby the project developers are free to choose whether:

- To sell the electricity on the market (direct marketing) and receive a bonus calculated from the value (25.2 ct/kWh reduced by 5% annually as of 2018) and the average spot market price of the previous month. In order to be eligible for the bonus, a remote control of the plant must allow the dispatching the power by the trader or buyer; or
- To sell the electricity to the grid operators. In this case the value is paid with a deduction of 20%.

The important point is that the premium for geothermal can be calculated on the gross electricity produced, including that used on-site. From 2017 on, the premium should be allocated via a bidding process but an exemption is being considered for geothermal projects. The new German scheme has contributed to the relaunching of investments in the country after months of doubt and precariousness.

1 At the time of writing (January 2016) Italy had notified the European Commission of its new scheme for State aid clearance.
In France, the year 2015 saw intense activity which will pave the way for promising development of geothermal electricity. Following the adoption of the 2015 Energy Transition Law, which sets a 32% target for renewables in 2030, the French authorities have established a methodology to define the feed-in premium level for geothermal operators. As in Germany, the operator can opt for reduced compensation in case he chooses not to sell the electricity in the market.

Complementary to operating aid, France is also defining the last details of GEODEEP, a new 50-million Euro risk insurance facility dedicated to deep geothermal energy. The fund aims to protect project operators against the geological risk faced during the exploration and development phases. The strategy developed in France clearly takes into account the emerging nature of the geothermal power sector in mainland France and the need for tailor-made policy instruments. At the same time, it also aims to further strengthen and export national know-how.

In light of the above, Turkey, Germany, and France can be considered good examples to follow. The investment climate in emerging markets is, however, more uncertain; in those markets, a desirable option may be to allow a feed-in tariff to be allocated to demonstration projects, in combination with some form of risk insurance.

Authors of the Electricity chapter:

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all national coordinators
District Heating
Figure 16. Geothermal DH capacity installed in Europe, per country in 2015 (MW_{th})

**257 district heating plants in Europe** with a total installed capacity of **4701.7 MW_{th}**

**177 district heating plants in the EU** with a total installed capacity of **1551.8 MW_{th}**

Figure 17. Geothermal DH systems in Europe, per country in 2015 and 2019
Two of the new plants in Germany are CHP and will soon begin to produce electricity only available in full report.
In 2014 the production in the EU was 4.3 TWh
The 5 countries with the highest **Capacity** in 2015 (MW\(_{th}\))

- Iceland (2169)
- Turkey (834.79)
- France (389.5)
- Hungary (271)
- Germany (262)

Countries with the highest number of systems in 2015 and 2019

<table>
<thead>
<tr>
<th>2015</th>
<th>2019</th>
</tr>
</thead>
<tbody>
<tr>
<td>France (52)</td>
<td>France (99)</td>
</tr>
<tr>
<td>Iceland (32)</td>
<td>Germany (66)</td>
</tr>
<tr>
<td>Hungary (24)</td>
<td>Hungary (40)</td>
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<tr>
<td>Germany (23)</td>
<td>Italy (35)</td>
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<tr>
<td>Italy (20)</td>
<td>Iceland (33)</td>
</tr>
<tr>
<td>Turkey (20)</td>
<td>Serbia (25)</td>
</tr>
</tbody>
</table>

**Figure 20.** Geothermal DH - Average plant size by country (MW\(_{th}\))
Towards smart thermal grids

Our current energy system is now moving towards a Smart Cities and Smart Rural Communities model, where different technologies and renewable energy sources are integrated and combined, reducing environmental impact and offering citizens a better quality of life.

Smart thermal grids, which are characterised as being flexible, adapting, intelligent, integrated, efficient, competitive, sizable, and securing energy supply, will use renewable energy like geothermal to ensure a reliable and affordable heating and cooling supply to various customers. Indeed, geothermal has a particularly important role in smart electricity and thermal grids, since it can deliver both heating and cooling, as well as flexible electricity. Both deep and shallow geothermal energy can be integrated with smart thermal grids, and several examples already exist.

Concerning deep geothermal, heat can be used for district heating (in particular the base-load part) and, through absorption chillers, for district cooling. Combined heat and power from geothermal power plants, with variable, controllable shares of heat or electric power, can serve as the energetic base of smart thermal grids (and smart grids in general).

Shallow geothermal can also be used in smart energy systems for example with underground thermal storage (UTES) or with individual heat storage in heat pump installations for residential and tertiary buildings. These technologies ensure a reliable and affordable heating and cooling supply to both urban and rural areas. As they can be installed in both grid and off-grid heating and cooling systems, they perfectly fit this new smart cities and rural communities approach.

In addition, there is also an important role for shallow geothermal energy in connecting with and managing smart electricity grids. Geothermal heat pumps can provide demand response services, thereby contributing to grid stabilisation, whilst UTES is an excellent storage solution.

Traditionally, major GeoDH sites have been developed in areas which enjoy favourable geothermal settings. Such systems are increasingly being developed economically in low and medium enthalpy fields. This is the case in Milan, where we can also see the installation of lower temperature, heat pump sustained systems. In several instances (Denmark, Germany, Iceland) absorption heat pumps, associated with CHP plants, have been successfully implemented. These new GeoDH systems work with lower temperatures, with the heat pumps boosting the low temperature, generally groundwater source to meet the temperature requirements of the heating grid. Small as well as large systems can now be developed.

Shallow geothermal systems are very versatile and can be adapted to almost every subsurface condition. The trend in mature markets is to develop large systems in particular for the tertiary sector (office buildings), but also for the service sector (supermarkets, telecommunications and IT-centres, etc.).

Examples of first-generation efficient, renewable and flexible smart thermal grids already exist and can be found for example:

- **In Turkey (Istanbul).** The Ümraniye Meydan Shopping Center of Istanbul has 208 BHE, at a depth of 40-150m (average 88m) with an installed capacity of 1MWth for heating and cooling. It is a hybrid system combined with other energy sources. The system includes a water-loop system in the buildings and individual heat pumps for heating and cooling.

- **In Germany (Troisdorf).** A ‘Cold’ District Heating began in 2014 in Troisdorf (Germany). Groundwater is circulated around two new residential development areas (c.5km plastic pipe), with individual heat pumps in the houses (c.100 units) which use the circuit as heat source and sink.

- **In France (Paris).** The geothermal project in Paris (Rue de Rivoli, Louvre district) is innovative in that it concerns the need to supply heat and cold to buildings where heated/cooled areas exceed land availability. The project is for a 7000m² tertiary building (offices + shops) with a capacity of 470kWth heating and 850kWth cooling. Geothermal energy is delivered through Groundwater wells, with a balanced consumption (efficiency of the heat pumps).

- **In Switzerland (Zurich).** Two large systems with thermal grids for supply or rejection of heat, using BHE fields as storage, are operational in initial stages: one for the technical university (ETH), and one for an existing housing area (FGZ). These types of networks, named “anergy nets” by the Swiss, will be further enlarged in the coming years.

- **In the Netherlands (Heerlen).** Second generation smart thermal grids now include Intelligent management with integrated ICT. One example can be found in Heerlen (Netherlands) with a thermal grid based on water from abandoned mines. Here we have cluster grids, and all wells are bidirectional: hot to hot, cold to cold. The project is presented in detail below in the chapter on EGIA innovation award.
SMART THERMAL GRIDS

Smart Thermal grids will use renewable energy like geothermal to ensure a reliable and affordable heating and cooling supply to various customers. This is possible because they are:

**Flexible, adapting**
- In the short-term to the energy supply and demand situation.
- In the medium-term by adapting the temperature level in existing networks and the installation of new distributed micro-networks.
- In the long-term by aligning the network development with urban planning.

**Intelligent**
They are intelligently planned and operated, and enable the end-user to interact with the heating and cooling system. They can, for instance, supply heating or cooling back to the network and to off-grid applications.

**Efficient**
They are designed to achieve the highest overall efficiency of the energy system, by choosing the optimal combination of technologies and enable a maximum exploitation of available local energy resources by cascade usage.

**Competitive**
They are cost effective in a way that makes operation affordable, both for consumers and businesses. They increase the cost efficiency of heating and cooling supply, and create opportunities for customers to participate.

**Integrated**
They are integrated in the whole urban energy system from a spatial point of view (related to urban planning parameters and processes), and from an energy system point of view (e.g. optimising the interfaces to other urban networks – electricity, sewage, waste, ICT, etc).

**Securing energy supply**
They increase security of energy supply at a local level by using local sources of energy for heating & cooling.

**Sizable**
These systems can be both applied for neighbourhood level or city-wide, according to the demand of heat and cold.
Authors of the district heating chapter:

P. Dumas
L. Angelino
B. Sanner

all coordinators
Technology
Focus on Drilling

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.

Although geothermal drilling often uses the same technology as the oil and gas industry, particularly in low enthalpy sedimentary settings, geothermal drilling displays several distinctive attributes. The established deep drilling technique is rotary drilling; the tri-cone rotary bit, used since 1909, was supplemented in the 1970’s by the polycrystalline diamond bit. A wide variety of rotary techniques exist, amongst which hydraulic, electrically driven drilling is best suited to deep seated targets.

Geothermal drilling benefits from on-going industry improvements both in terms of drilling tools and concepts. Despite these improvements, drilling costs continue to be high and therefore considerable emphasis needs to be placed on the development of new drilling technologies.

Research and Development (R&D) can improve geothermal drilling technologies in order to reduce costs, but the main challenge today is to improve market conditions for geothermal deep drilling, a market which has still not been thoroughly assessed. Problems include limited access to available geothermal drilling cost data and limited interaction between project developers and drilling contractors.

Technology

Five generations of deep drilling techniques for geothermal have been seen since the first development of geothermal power in 1913 and of district heating mainly after the 1960s (Fig.21). The trend has always been to allow cost reduction and to improve efficiency and reliability.

The first generation saw two vertical wells drilled from a two distant drill pads, while the second introduced deviated wells and single drill pads. The next generations were focused mainly on improving the design of deviated wells until deviated symmetric wells were developed. The fifth generation proposed for the first time (sub) horizontal wells for deep geothermal. This is, for example, the technology currently used in the Paris basin for new geothermal DH systems.

On top of improving the drilling concepts, the trend has always been to reduce drilling costs by decreasing drilling duration (fig 22). Better drilling equipment and better knowledge of the underground environment can save both time and money.

Technological development should focus both on novel drilling concepts and on improvements to current drilling technology, as well as other ways to optimise the economics of drilling operations (horizontal, multi-wells etc.). The target is to reduce costs for drilling and underground installations in 2020/2025 by at least 25% compared to the situation today. Nowadays, drilling for deep geothermal energy uses equipment originally intended for the hydrocarbon industry.

New drilling technologies developed in the oil and gas sector could be replicated for geothermal: multi-well pad, new vertical drilling systems etc.

Some potential breakthrough technologies have been demonstrated in the laboratory and now need to be tested under field conditions at significant depths. These include: jetting (high performance/mud jet bits), thermal drilling (spallation, plasma bit), direct stream, millimetre wave, and high voltage electro impulses.

![Figure 21. Drilling - Innovative wells](image)
Currently, two research projects focusing on deep drilling, both of which began in 2015, are operating within the European Union R&D programme Horizon 2020. The DESCRAMBLE project focuses on drilling into super-critical conditions and studying drilling components, in addition to well completion materials, design, and control. The Thermodrill project objectives are to focus on conventional rotary drilling with water jetting, with the aim of achieving 50% faster drilling in hard rock in addition to reducing costs by 30%, whilst also reducing induced seismicity risks.

On top of technological developments, drilling costs are dependent on the rig demand (mainly for oil & gas, therefore dependant on crude oil prices), the drilling price (€/m), and the raw material cost. It is therefore key to improve market conditions concerning drilling rigs, to save time (for example with the use of multi-well pads, etc.), and for tools such as drill bits to be reliable and not require frequent changes.

The challenge of deep drilling for geothermal is to move from an exponential well cost curve to a linear curve when drilling deeper.

On top of the R&D activities described above, it is notable that drilling costs reduce when more projects are developed in a given region, and when multi-well projects are developed.

Such a cost reduction has been demonstrated by the project in Unterföring (Germany) developed by Erdwerk gmbh. In 2009, the first two wells in Unterföring had drilling costs of 1400€/m then, two years after, a project in nearby Ismaning had a drilling costs of 1150 €/m; by 2014 when two new wells were drilled for the expansion of the Unterföring system, the drilling cost was 1100€/m. In five years, drilling costs were been reduced by more than 25%, principally through ‘learning by doing’.

**Drilling Market**

During 2015, the Baker Hughes 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 as depicted in figure 23 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

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**Figure 22.** Drilling - Reducing drilling cost

Adapted from EnBW, 2011 (T. Kölbel)
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.

Focus on Turkey

As presented in the market analysis above, Turkey is today the hot market for geothermal project development and for geothermal drilling. This analysis of the drilling market and drilling conditions in Turkey further details the statements above.

In Turkey 82 geothermal wells were drilled in 2013, and around 104 in 2014. More than 30 rigs (see table 24 below) are active in the Turkish geothermal drilling market, 90% of which are active in Menderes and the Alasehir Graben.

Drilling equipment in Turkey is rather old fashioned but developers benefit from Government funding for early exploration (MTA). Moreover, the Government is undertaking discovery and confirmation drilling. The regulatory framework in Turkey for geothermal drilling operations is improving with the development of the sector but developers still find that time is wasted due to administrative procedures stemming from the oil and gas framework.

Drilling in Turkey benefits from the same conditions as other medium enthalpy areas in the world, meaning costs for
<table>
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<tr>
<th>Rig.</th>
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<td>TPIC</td>
</tr>
<tr>
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<td>F200</td>
<td>11 Aydin</td>
<td>TPIC</td>
</tr>
<tr>
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<td>F200</td>
<td>10 Manisa</td>
<td>TPIC</td>
</tr>
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<td>MTA</td>
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</tr>
<tr>
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<td>Enerji A+6</td>
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**Figure 24.** Drilling - Table of rigs in Turkey

Adapted from Schlumberger, 2014 (T. Kaya)

*only available in full report*
casing, well heads, and costs of cementing services are lower than in High enthalpy areas. There are low management costs and low service costs for mud and cementing.

Rig rates are rather low at $15-19 K/day, in comparison with the global rig rate of $25-27 K/day.

- A 1500/2000 m well, drilled in 30/40 days, would cost ca. 1,858,000 USD
- A 2000/2500 m well, drilled in 40/50 days, would cost around 2,900,000 USD
- A 2800/3500 well, drilled in 60/70 days, would have a cost of approximately 3,650,000 USD.

The penetration rate of geothermal drilling in Turkey is rather high, similar to Kenya and Iceland for example, average drilling has a penetration of around 500 Managed Pressure Drilling (mpd). This means that the total development period of a project in a proven field in Turkey can be reduced to a duration of 36 months.

The future for drilling costs

In the near future, the main driver for the reduction of costs of power and heat production leading towards grid parity will be the drilling cost. The drilling costs are expected to decrease firstly with learning-by-doing. The cost reduction will essentially be through better use of the current drilling rigs, a decrease in the number of hours to drill a well, and an increase in the number of wells per site (from two - four towards four-eight wells per site). This highlights the importance of engineering for the cost of drilling operations. Current experiences in geothermal confirms that new technology and concepts in drilling help to save money.

Because of the low market price of oil in 2016, drilling and service costs are lower than two years ago. Geothermal developers are starting to focus on saving time to further decrease costs. For example, performance and deviated wells drilling in geothermal are increasing in Turkey; and (sub) horizontal wells for deep geothermal are developed in France. In Turkey, the expectation is to reduce the number of drilling hours for a well from ca. 300h to less than 130h, a reduction by a factor of more than two.

Further research and development to improve current technologies is expected to decrease costs by more than 20% in the next ten years. Long-term cost reduction will be brought about by novel drilling technologies becoming mature.

The market conditions for geothermal drilling are, however, not expected to change dramatically until the development of a substantial number of deep geothermal projects and the creation of a proper geothermal drilling industry. In the

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2 Definition of MPD adopted by the IADC: “Managed Pressure Drilling (MPD) is an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly.”

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Authors of the drilling chapter:

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With contributions from

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T. Kaya (SCHLUMBERGER)
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T. Koelbel (EnBW)
Shallow Geothermal
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 (graph 25). 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.

Market development

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 (graph 26). 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. Graph 27 shows the annual sales for 2014 in most EU member states, with two large GSHP countries, Norway and Switzerland, added from national information sources.

An interesting development can be noted in Central and Eastern Europe. While the absolute numbers in these countries still are low (and thus hard to discern in graph 26), there is a quite positive development, as can be seen in graph 27. 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; graph 27 shows the values for the individual countries for 2013 and 2014. 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, as can be seen from graph 28.

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 as in graph 29, and the resulting graph 30 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.

GSHP as part of the heat pump market

The European Heat Pump Association (EHPA) is tracking the market for heat pumps in Europe. Based on EHPA data, the development of the share of geothermal heat pumps in the total heat pump market can be shown (graph 31). The heat pump market had a good growth until 2008, and has been mainly stagnant ever since. From 2006 on we can see a steady decrease of the share of GSHP in the total heat pump sales. However, it should be noted that the variety of different usages in the European heat pump market is growing. In particular in the South, smaller air-to-air units for heating and cooling, often produced in the Far East, account for an increasing part of the units sold. Also exhaust-air heat pumps and heat pumps for warming of domestic hot water (DHW) are included in the EHPA numbers. Thus compared to the numbers of heat pumps mainly for space heating, and considering the average size of heat pumps, GSHP might do much better than the descending curve in graph 31 looks like.

The statistical office of the Netherlands publishes some of the best-categorised statistical data for heat pumps and geothermal energy. At first view the development in the Netherlands (graph 32, top) seems to be quite similar to the EHPA numbers for Europe (graph 31), indeed, even worse with the decreasing share of GSHP. Hence the country can serve as an example for interpreting the heat pump statistics: looking at the capacity of newly installed heat pumps per year (graph 32, bottom), the share of GSHP is much higher than by sheer number, due to the higher average capacity of GSHP. Also the decrease in share of GSHP is much less when looking at capacity than when just counting the unit numbers.
Figure 27. Sales numbers for geothermal heat pumps (units, no size distinction) in Europe; for EU-countries and EU countries from Central and Eastern Europe, based on data from EurObservER Heat Pumps Barometer 2015 and previous editions, for CH based on FWS (national information) and for NO based on WGC 2015.
There is a pronounced difference in the development of the GSHP share in different countries. As graph 33 shows, the decrease of GSHP sales is much less in Switzerland and the share stays fairly constant, while in Germany the GSHP share clearly drops. An attempt to explain this development is made in the following chapter.

Spotlight on the situation in Germany, the Netherlands and Switzerland

Geothermal heat pump systems for the heating of residential houses are widespread in Germany and Switzerland. While in Germany all types of systems – horizontal heat collectors, or borehole heat exchangers and groundwater systems with extraction and injection well(s) – are common, the prevailing type in Switzerland is the borehole heat exchanger. The cooling option (usually direct cooling) is also increasingly used also in the residential sector. For non-residential buildings, heating and cooling using geothermal heat pumps is already a standard option in all three countries.

In large systems the transition from simple ground source heat pumps to UTES applications, where heat or cold is stored intentionally in the underground, is gradual. Adapted to the prevailing geology, these large systems use mainly groundwater wells in the Netherlands (ATES) and BHE fields in Switzerland (BTES), with both options found in Germany.

For the Netherlands, a distinction for residential and non-residential buildings is made in the statistics, and as graph 34 shows, the non-residential share is much larger when installed capacity is considered, due to the substantially higher capacity per unit in non-residential use.

System concepts that were demonstrated years ago find new applications, like low-temperature distribution systems with individual heat pumps in the buildings connected (‘cold district heating’ or ‘anergy systems’). As examples, a system based on groundwater wells and providing heat for a new housing development was installed in Troisdorf (DE) in 2014, and two large systems with BHE fields, one for the technical university (ETH) and one for an existing housing area (FGZ), are operational with initial stages in Zurich (CH) and will be enlarged in the coming years (see table at the end of this chapter).

Another unique feature of the Swiss GSHP market is the relatively high share of retrofit installations with geothermal systems. The FWS statistics on BHE drilled per year (graph 35) show not only that BHE drilling has remained at a high level since about 2010, but also that drilling in the retrofit sector has increased from <20% of the total BHE drilling in 2001 to continuously >30 % since 2006, with a peak of ca 44% in 2008. The retrofit market thus is successfully managed in Switzerland, and might also be a solution to keep GSHP installation up in other countries. The areal density of GSHP in Switzerland, with about 3 standard 12 kW units per km², is the highest in the world.

For Germany, figures are already available for 2015. In graph 36 the development over the last 20 years can be seen, with a steep increase in 2006 (first Ukraine gas crisis) and a subsequent decrease. Numbers for 2015 are still higher than 10 years ago, however, the share of GSHP in the total heat pumps sales (cf. previous chapter) continued to fall, as low as to 29.8% in 2015. As virtually all GHSP are operated by electricity, the relation of the price for electricity to fossil fuels can be seen as a main driver. During times of stagnancy or decrease, electricity price was higher than that for natural gas (pre-2000 and in recent years), while the time of highest increase in GSHP sales corresponds with the time when natural gas and fuel oil was substantially more expensive.

Figure 28. Comparison of the values for renewable heat from shallow geothermal energy set forth in the Common Vision of the RHC-Platform with the value achieved in 2014.
Figure 29. Renewable heat produced in 2013 and 2014 by geothermal heat pumps, calculated with the EU rules of March 2013, based on data from EurObservER Heat Pumps Barometer 2015 and previous editions, for CH and NO calculated with WGC 2015 data.

Figure 30. Comparison of heat from shallow geothermal energy as to values from Eurostat and from this market report.
Figure 31. Annual heat pump sales in Europe and share of GSHP in annual sales, based on data from EHPA

Figure 32. Annual heat pump sales in the Netherlands by number (top) and by capacity (bottom), and respective share of GSHP, based on data from CBS NL
Figure 33. Annual heat pump sales in Germany (top) and in Switzerland (bottom), and respective share of GSHP, based on data from BWP and FWS.
Figure 34. Annual GSHP sales in the Netherlands by number (top) and by capacity (bottom), distinguished for residential and non-residential buildings, based data from CBS NL.
Figure 35. Drilling for Borehole Heat Exchangers (BHE) per year in Switzerland, based on data from FWS

Figure 36. Annual GSHP sales in Germany by number, based on data from BWP
than electric power (approximately 2006-2010). The current situation and probable future development is thus not very promising for GSHP economics in Germany (and elsewhere).

The decrease in annual GSHP installations is quite different in some German states (Länder). Numbers on licenses granted annually for BHE drilling and installation are available in two adjacent states, Hessen and Rheinland-Pfalz (graph 37). This data does not reflect the number of BHE installed, as one installation might comprise more than just a single BHE, and not all projects granted a licence may have been completed. Geology, climate, and energy cost in the two states is comparable, while from 2007-2014 (to exclude the extraordinary year 2006) the average decrease of licenses in Hessen is more than twice as fast as in Rheinland-Pfalz. The decrease in the number of GSHP sales for the whole of Germany is again much slower, with an average of just 5% for the same period, 2007-2014. While this value is not directly comparable to the number of BHE licenses, as other ground coupling methods than BHE are included, and some plants might have more than one heat pump installed, the trend, however, can be seen clearly, with the market for BHE in Hessen shrinking much faster than in the rest of Germany. A similar development can be expected for Baden-Württemberg, were extremely rigid regulations have been put in place, but exact numbers are not public yet.

In total, the amount of heat produced annually by GSHP in Germany is steadily increasing (graph 38), and the geothermal energy that can be reported for 2015 relating to the RES-Directive will amount to almost 490 Ktoe when calculated with the BWP numbers. The final numbers from Eurostat might differ, as the counting of GSHP and the assumptions for calculation as to annex VII of the RES-Directive and subsequent decisions are still to be used in a consistent way. For the Netherlands, the amount of heat produced is shown in graph 38. The Netherlands is one of the few countries were Underground Thermal Energy Storage (UTES) is used widely, mainly for cooling, but also for heating purposes. The statistics thus include UTES and distinguish it from GSHP at least partly, and they count the energy for cooling, which is still uncommon in energy statistics in Europe. In graph 39, heat and cold production from all shallow geothermal uses is shown for the Netherlands.
**Figure 38.** Heat produced annually by GSHP in Germany and in the Netherlands, and heat extracted from the underground (renewable heat as to the RES-Directive), calculated after data from BWP and CBS NL.

**Figure 39.** Annual heat and cold supplied from the ground by GSHP and UTES in the Netherlands (renewable energy as to the RES-Directive), calculated with data from CBS NL.
ReGeoCities Project Results

The ReGeoCities project (2012-2015) worked on regulatory issues for shallow geothermal, involving many stakeholders in the development, installation, and use of shallow geothermal energy. The main ReGeoCities results include:

1. **Increased awareness amongst policy and decision makers from local and regional authorities** about the potential of this technology. One objective of the ReGeoCities project was to present best practices in order to replicate them all over Europe.

2. **The simplification of the administrative and regulatory procedures and, in some cases, the filling of regulatory gaps.** Decision makers from municipal and local authorities as well as energy authorities need to put better regulatory frameworks in place, and procedures at a local level should be simplified. In collaboration with local authorities and private bodies involved in local energy planning, the ReGeoCities project has produced some key recommendations for the regulation of shallow geothermal in Europe.

3. **Innovative financial models.** Financial incentives schemes for supporting ground source heat pumps are not available in all European countries, although the competition in the heating sector can be considered as unfair with fossil fuels still receiving subsidies. Financial incentives have been phased out in several countries, as shallow geothermal energy is deemed competitive on the market. In other countries support is still required, and in some support needs to be introduced to start a development at all. Thus financial support is still required in emerging markets where they should be tailored for both individual and collective installations. Possible schemes are grants, tax reduction, and interest free loans, which should have a link to quality, and certification etc.

4. **The training of technicians, civil servants and decision-makers of regional and local authorities** in order to provide the technical background necessary to approve and support projects. These training activities are supported by promoting shallow geothermal best practices on small and large systems, cooling applications etc.

More information on regulation is available at [www.regeocities.eu](http://www.regeocities.eu)

The ReGeoCities project results indicate a widespread lack of awareness among public authorities and the general public regarding ground source heat pumps. For this reason it was deemed important - as part of the dissemination and communication activities - to launch a communication campaign under the name **The Heat Under Your Feet** which targets mainly public authorities, architects and builders, but also the general public.

The campaign uses a narrative that aims at making the technology more accessible and easy to understand for the target groups at which the campaign is aimed. This is done partly through the use of graphics, which have the advantage of making highly technical content more accessible.

The key messages focus on illustrating the advantages of geothermal heat pumps in the heating and cooling sector: The heating and cooling sector for buildings is today, for the large majority, dominated by the use of fossil fuels such as natural gas and heating oil. This means it is contributing heavily to costly fossil fuels imports, exposure to price volatility and security of supply, and production of harmful greenhouse gas (GHG) emissions.

Geothermal heat pumps are the perfect solution to replace fossil fuels and reverse the current unsustainable situation. Their wide range of application, their efficiency and, their reliability, all strongly contribute to providing affordable heat, to reducing emissions, and to saving primary energy.

The campaign resources can be found online at [www.heatunderyourfeet.eu](http://www.heatunderyourfeet.eu). The campaign can be contacted through twitter [@heatunderurfeet](https://twitter.com/heatunderurfeet)
Conclusions on shallow geothermal market development

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 practices 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 over-regulation, 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 (see chapter on ReGeoCities above).

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](http://www.geotrainet.eu).

References:


EurObservER (2013): Heat Pumps Barometer, 18 p., Observ’ER,

EurObservER (2015): Heat Pumps Barometer, 12 p., Observ’ER,


Data from: Eurostat, CBS (Centraal Bureau voor de Statistiek, NL), StatBA (Statistisches Bundesamt, DE), EHPA (European Heat Pump Association), BWP (Bundesverband Wärmepumpe, DE), FWS (Fachvereinigung Wärmepumpen Schweiz, CH), EGC 2013 country update reports, WGC 2015 country update reports, various National Renewable Energy Action Plans (NREAP) progress reports, and personal information.

Authors of the chapter on shallow geothermal:

B. Sanner, UBeG GbR

P. Dumas, EGEC

All coordinators
## List of large GSHP systems in Europe (>10 km BHE length)

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<td>10000</td>
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</table>
Mijnwater: European Geothermal Innovation Award 2015 winner

The mijnwater project in the Netherlands uses groundwater in the town’s abandoned coal mines to supply local homes and businesses, giving this former mining town a new life as an innovative, green, geothermal community, leading the way in smart thermal grids.

After their closure the coal mines in Heelen and surrounding areas filled with groundwater, where there heated geothermal resource remained untouched for many years. In 2005, the town began to investigate using this resource for heating and cooling local buildings.

The project began life in earnest as a project supported by the European Interreg IIIB programme and the 6th Framework Programme. Now, Mijnwater B.V. is a rapidly expanding private company owned by the municipality. It is continuing to diversify and develop an innovative concept, the success of which has been proved over more than ten years.

The reputation of the project is growing as it develops into a responsive system, altering supply biased on a number of demand-side factors, including the weather and customer demand, and working in synergy with other renewable energy sources.

More information about the project can be found at www.mijnwater.com
## The three phases of the Mijnwater project

<table>
<thead>
<tr>
<th>Phase</th>
<th>Description</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008-2013</td>
<td>Mijnwater 1.0: Proof of concept: using mine water as an energy source</td>
<td>The groundwater in flooded, abandoned coal mines at depths of about 800m is first used as a source of heating and cooling. Energy at low temperature is delivered to clusters of buildings via a grid, with heat pumps used to adjust the temperature. CO2 emission reductions: 35%.</td>
</tr>
<tr>
<td>2013-2015</td>
<td>Mijnwater 2.0: Using the Mine water as an energy balanced buffer</td>
<td>The mine water is no longer used as just a source of energy, but as a reservoir in a balanced system, meaning the resource is not depleted. Mijnwater works on a smart thermal grid system where users are grouped into clusters. Heat and cold from different sources (e.g. renewables and waste heat) is exchanged both within each cluster, and between clusters, with surplus energy transported in the Mijnwater reservoir for storage. In this way energy can be used several times in succession and customers become prosumers, supplying their waste thermal energy back to the grid. Three points of control are established; pressure is controlled at the Mijnwater wells, flow is controlled at cluster level, and temperature is controlled at building level. Unlike traditional thermal grids, which have a top down hierarchy with a heat plant at the top, the Mijnwater grid is based on equal connections in a decentralised system. The power for transportation and heat pumps is increasingly supplied by renewable sources. 2014 125,000 M² connected, 200,000 M² contracted. CO2 emission reductions: 65%.</td>
</tr>
<tr>
<td>2015-ongoing</td>
<td>Mijnwater 3.0: A demand and supply controlled system</td>
<td>The next stage of development will see the move to a demand and supply controlled system, which is optimises supply based on factors such as weather forecasts and user behaviour patterns. 2016: 500,000 m² connected; 800,000 m² contracted. CO2 emission reductions: 80-100%.</td>
</tr>
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</table>

This award is a real incentive for us to further develop our intelligent thermal smart grid as key element for the future energy infrastructure. Geothermal energy - in several common forms- is an essential part of this infrastructure. This means not only through abandoned mines, but also applying deep and shallow geothermal.

-Louis Hiddes, director
Appendix 1. Data collection & methodology

The instructions given to national data coordinators in order to develop the district heating and electricity chapters is given below

Geothermal electricity

Existing plants

For each power plant already in operation contributors submit available information regarding:

- Locality (region, province, of municipality),
- Power plant name and type (hydrothermal or EGS),
- Year of commissioning (in case of refurbishment or upgrading coordinators should report the most recent date)
- Turbine type (dry steam, single double or triple flash, ORC, Kalina)
- Turbine manufacturer (in case of two or more manufacturers please provide all of them)
- Capacity installed (in MWe and MW$_{th}$ (in case of CHP)
- Gross electricity production\(^1\) in 2014 (in GWh)
- Operator

Power plants under development

Power plants under development refer to projects for which financing has been announced and/or contracts for drilling services not been signed. For each project contributors submit available information regarding:

- Locality (region, province, of municipality),
- Power plant name and type (hydrothermal or EGS),
- Expected year of commissioning
- Expected capacity installed (in MWe and MW$_{th}$ (in case of CHP)
- Expected Gross electricity production (in GWh)
- Consortium

Power plants under investigation

Power plants under investigation refer to projects for which a research permit has been issued but financing has not been announced and/or contracts for drilling services not been signed. For each project contributors submit available information regarding:

- Locality (region, province, of municipality),
- Power plant name and type (hydrothermal or EGS),
- Expected year of commissioning
- Expected capacity installed (in MWe and MW$_{th}$ (in case of CHP)
- Expected Gross electricity production (in GWh)
- Consortium

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\(^1\) “Gross electricity production is the sum of the electrical energy production by all the generating sets concerned (including pumped storage) measured at the output terminals of the main generators.” (Eurostat, IEA, UNECE & OECD, 2012).
Geothermal district heating

‘Geothermal district heating or district cooling’ is defined as the use of one or more production fields as sources of heat to supply thermal energy through a network to multiple buildings or sites, for the use of space or process heating or cooling. It includes greenhouses and geothermal heat projects above 500 kWth supported by heat pumps as long as the heat is distributed via a heat network. In this case the capacity of heat pumps should also be released.

Existing plants

For each plant already in operation contributors submit available information regarding:

- Locality (region, province, of municipality),
- Year of commissioning (in case of refurbishment or upgrading coordinators should report the most recent date)
- Capacity installed (in MWth)
- Gross heat production\(^2\) in 2014 (in GWh)
- Operator

Planned plants

For each plant under planning contributors submit available information (if available) regarding:

- Locality (region, province, of municipality),
- Status (under construction, planned, negotiations)
- Expected year of commissioning (please indicate if it is an extension/upgrading)
- Expected capacity installed (in MWth)
- Consortium

Methodology for the Shallow Geothermal Chapter

EGEC undertook a data collection exercise for the shallow geothermal sector for the first time in 2012, as a complement to the deep geothermal market report. The lack of official statistical data on geothermal heat pumps has not yet been resolved sufficiently: Eurostat has started to provide data, but not for all countries, and a number of occasions a distinction between heat sources is not made, just ‘heat pumps’ are reported. So often the figures are based on:

- Estimations provided for conferences (EGC 2013, and WGC 2015)
- Sales data for heat pumps as recorded by some national heat pump associations and the European Heat Pump Association, EHPA
- the bi-annual (geothermal) heat pump barometer prepared by EurObserv’ER

In combination with data from other publications, information provided by companies, and original research, a consistent picture (with some irregularities) could be achieved. Most data is for 2014; 2015 data could already be included for Germany. Work within the ReGeoCities project helped to consolidate the findings. Further information on the methodology and the calculation methods for renewable heat from heat pumps, as imposed by the EC, are given in the 2013/14 issue of the EGEC Market Report.

\(^2\) Gross heat production: “Gross heat production is the total heat produced by the installation and includes the heat used by the installation’s auxiliaries that use a hot fluid and losses in the installation/network heat exchanges. As only heat sold to third parties is reported, gross heat production for autoproducers will be equal to net heat production.” (Eurostat, IEA, UNECE & OECD, 2012).
EGEC Market Report 2015

EGEC is the voice of Geothermal in Europe

More than 120 members from 28 countries, including private companies, national associations, consultants, research centres, geological surveys, and public authorities, make EGEC the strongest and most powerful geothermal network in Europe, uniting and representing the entire sector.

An international non-profit organisation founded in 1998 and based in the heart of the European quarter in Brussels, the role of EGEC is to promote members’ interests, making sure they develop and thrive. It enables the development of the European geothermal industry—whether shaping policy, improving business conditions, or driving more research and development.

The work of the secretariat can be divided into three categories:

<table>
<thead>
<tr>
<th>Intelligence gathering</th>
<th>Promotion</th>
<th>Impact</th>
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<tbody>
<tr>
<td>monitoring, analysing and researching the political environment, briefing members on legislative and financial developments and the effects their businesses</td>
<td>speaking for the geothermal industry and make sure it has a positive position in public discourse. Members have exclusive marketing opportunities are represented at the main industry events</td>
<td>giving members access to decision makers and helping them shape European policy. The secretariat also arranges and facilitates networking and makes contacts on members' behalf.</td>
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</table>

Members receive tailored and individual support, regular updates on news and opportunities from Brussels and the rest of Europe, access to privileged information in the members’ only section of the website, and a number of financial benefits.

About the EGEC market Report

The European Geothermal Energy Council originally developed the Market Report in order to fill an information gap in the geothermal sector. It is designed to give market intelligence to companies and investors already working in the sector, and to inform new entrants about the current state of the market and its future development.

The report, which includes chapters on the Shallow, Power, and District Heating sectors, is compiled each year using data from various statistical analyses, local experts, utilities, energy Agencies, and national associations. It includes details of all major projects operational, under development and under investigation, as well as an analysis of market development, the regulatory and public policy environment, financial tools and incentives, market forecasts, and key players.
Details of all electricity and district heating plants in operation and under development