DEVELOPING GEOTHERMAL DISTRICT HEATING IN EUROPE

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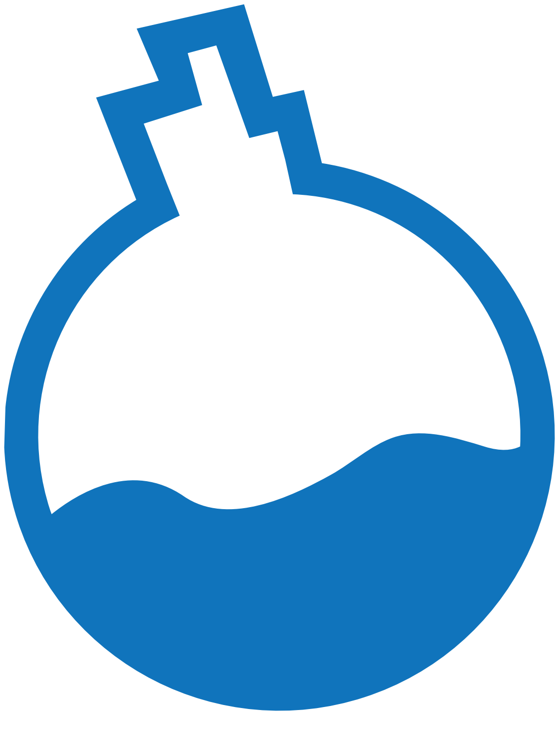


CONTENTS

Glossary

CHP: Combined Heat and Power

DH: District heating

EGS: Enhanced (or Engineered) Geothermal Systems

EIA: Environmental Impact Assessment

geoDH: Geothermal district heating

GeoDH: An IEE project 2011-2014. See www.geodh.eu

GHG: Green House Gasses

GIS: Graphical Information System

GWh: Gigawatt hour

GWh/y: Gigawatt hours per year

GWth: Gigawatt thermal

Ktoe: Thousand tonnes oil equivalent

LCOE: Levelized Cost of Energy

MWh: Megawatt Hours

MWth: Megawatt Thermal

NREAP: National Renewable Energy Action Plan

ORC: Organic Rankine Cycle

RES: Renewable Energy Sources

RES Directive: Directive 2009/28/EC on the promotion of the use of energy from renewable sources

Executive summary

'Geothermal district heating' is defined as the use of one or more production fields as sources of heat to supply thermal energy to a group of buildings and/or industries.

The district Heating sector is largely dominated by fossil fuels (e.g. 76% of the overall supply in Poland is from coal). Geothermal, with 250 heat plants in operation and 200 under development, is one of the sources contributing to its decarbonisation, and can alleviate the EU's energy dependency.

The first regions to install geothermal district heating systems (geoDH) were those with the best hydrothermal potential, however with new technologies and systems, an increasing number of regions are developing geoDH. Systems can be small (from 0.5 to 2 MWth), and larger, with capacities up to 50 MWth. Some new district heating schemes that utilise shallow geothermal resources are assisted by large heat pumps.

Installing geoDH systems in areas of high urban density improves project economics, as both resources and demand need to be geographically matched. One considerable challenge in the current economic crisis concerns the financing and the development of new heat grid infrastructures. Retrofitting existing district heating systems is a good alternative for developing the geoDH market.

The main benefits of geothermal heating and cooling are provision of local, baseload and flexible renewable energy, diversification of the energy mix, reduction of fossil fuel imports, and protection against volatile and rising fossil fuels prices. Using geothermal resources can provide economic development opportunities for countries in the form of incomes, technology export, and jobs.

The potential of deep geothermal is significant. However, geothermal DH is at present poorly developed. Four key areas have been identified as important to improve this situation:

- Consistent energy strategies aiming to decarbonise the heat sector;
- The removal of regulatory and market barriers, and simplified procedures for operators and policy makers;
- The development of innovative financial models for geoDH projects, which are capital intensive;
- The training of technicians, civil servants, and decision-makers from regional and local authorities in order to provide the technical background necessary to approve and support projects.

In addition, it is important that a level playing field is established by, for instance, liberalising the gas price and taxing GHG emissions in the heat sector appropriately.

Enabling growth

The GeoDH project (2011-2014) works on these issues, involving several stakeholders. The main GeoDH results include:

- **Increased awareness amongst policy and decision makers from national authorities about the potential of this technology.** One objective of the GeoDH project is to demonstrate the potential of geoDH to decision-makers by presenting an assessment of the potential for geothermal DH in the 14 countries covered by the project GeoDH, i.e. Italy, France, Germany, Hungary, Ireland, the

United Kingdom, the Netherlands, Denmark, Poland, Slovakia, the Czech Republic, Slovenia, Romania, and Bulgaria. The GeoDH project has produced a web-map viewer on geoDH; this interactive map presents a European overview of the deep geothermal potential of the partner countries, combined with the existing heat demand in an interactive way, thus showing best potential areas for future geoDH developments.

It appears that over 25% of the EU population lives in areas directly suitable for geothermal district heating. Geothermal district heating is a valuable and immediate option for the alleviation of Europe's energy dependency.

- **The simplification of the administrative and regulatory procedures and, in some cases, the filling of regulatory gaps.** Decision makers from municipal and local authorities and energy authorities need to put in place a better regulatory framework, and procedures at local level should be simplified.

  In collaboration with local authorities and private bodies involved in district heating, the GeoDH project produced some key recommendations for the regulation of geothermal district heating in Europe.

- **Innovative financial models.** The GeoDH project involved banks, potential investors and other market players in assessing how investment in the sector could be stimulated. Innovative financial and management models for geoDH have been investigated, taking into account the local and national circumstances, in order to overcome the financial barriers hampering the development of geothermal projects. The project gives recommendations on support schemes, reports on experiences for risk insurance, and presents the different geoDH business models in Europe.
- **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 the promotion of best practices in geothermal DH, including shallow, deep, small, large and cooling applications.

Introduction

There are over 5,000 district heating systems (DH) in Europe, representing about 12-15% of the European heat market. The majority of these systems are located in Scandinavia, Central and Eastern Europe. This segment of the heat sector is largely dominated by fossil fuels and, to a lesser extent, waste. For instance, 80% of DH in Germany is supplied by conventional combined heat and power (CHP), 76% by coal in Poland, 76% and 43% by natural gas in Italy and France respectively.

Nevertheless, district heating is considered as a key technology to decarbonise the heat sector and reduce Europe's dependency from fossil fuels, notably thanks to its potential to use thermal renewable sources, including geothermal.

The use of geothermal as a source for district heating (DH) is not new; it dates back to Roman times as seen in the ruins of city homes and baths heated via natural hot water catchments and piping. An outstanding example is found at Chaudes Aigues, in Central France, a city DH system pioneered in the year 1330, fed by the Par hot spring at 82°C, and still in operation today. As reported in the city annals, heated homes were charged a tax by the local landlord in exchange of maintenance duties.

With modern technology, geothermal resources with temperatures above 50-60°C have been more widely used for district heating, with peaks following the oil crises in the 1970s. After twenty years of slower development, the geothermal district heating market is now enjoying a renewed momentum, notably as a consequence of higher oil and gas prices, technological developments, as well as renewed concerns over energy dependency and sustainability.

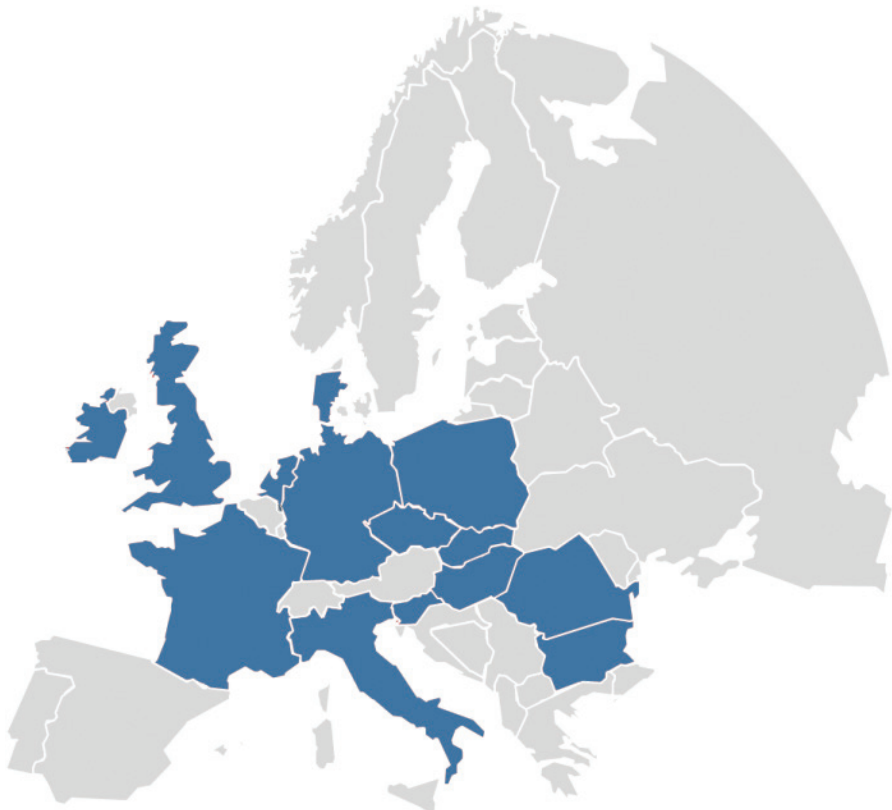
The potential of geothermal for district heating is significant; however, geothermal DH technology is at present poorly developed. There are several Eastern and Central European countries, such as Hungary, Poland, Slovakia, Slovenia, Czech Republic, and Romania, with geothermal DH systems installed. However, the potential is much larger. In other Eastern and Central Europe countries, including Bulgaria, Czech Republic, Slovenia, there is both the need to convince decision makers and to adopt the right regulatory framework, but also to establish the market conditions for a development of the geoDH market.

Several Western European countries have 2020 targets for geothermal DH, of which Germany, France and Italy are the most ambitious. In order to reach these targets, simplification of procedures is needed and more financing required.

A third group of EU countries includes those Member States currently developing their first geothermal DH systems, such as the Netherlands, the UK, Ireland and Denmark. There is no tradition of geoDH so there is a need to establish the market conditions for its development.

The GeoDH consortium has been working on these three different groups of countries, thus with juvenile, transitional and mature markets, in 14 countries in total, in order to achieve results replicable across the EU28.

Figure 1. The 14 countries covered by the project



This document is the summary of the main project results. The first chapter provides a general overview of the technology, its uses, and market development. The second chapter presents the project's work on resource assessment and the resulting geoDH GIS and the analysis of the potential in the fourteen project countries. The third chapter discusses the licensing procedures necessary to realise a geoDH project and the regulatory and market conditions in the project countries. Where sufficient information was available, the status of the implementation and the impact of Directive 2009/28/EC on renewable energy sources are presented and a number of key recommendations for policy-makers are put forward. Chapter four deals with financing, costs, business models, and discusses proposals to overcome the geological risks, notably in emerging markets, Chapter five presents concrete cases studies with the objective to explore from start to finish two concrete projects. Lastly, chapter 6 brings together a number of lessons learnt and final recommendations stemming from the 30 months of work on the local, regional, and European levels.

1 Technology:

STATE OF PLAY AND DEVELOPMENTS

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Geothermal energy is capable of producing heating and cooling for individual and commercial buildings, as well as for industry, with both shallow and deep geothermal resources.

After 20 years of slower paced development, the geothermal district heating (geoDH) market has seen a renewal of momentum in the last 5 years. Currently, there are around 250 geoDH systems in operation in Europe, with a total installed capacity of about 4,400 MWth and an estimated annual production amounting to some 13,000 GWh/y. Indeed, the heating and cooling sector represents 47% of the EU's energy demand, and geothermal is more and more attractive as a competitive renewable heating source, as there is a dual need to decarbonise this sector, while ensuring the provision of heating at an affordable price for consumers and industry.

The 'hot' geoDH markets in Europe are in France (Paris, and renewed activity in the Aquitaine basin), Germany (Bavaria) and Hungary, but it is important to always underline that geothermal DH systems can be installed in all European countries. In recent times, there have been new entrants to the market: the Netherlands, Denmark, the UK (Manchester) etc. By 2020, nearly all countries in Europe will have geoDH.

The first regions to install geoDH were those with the best hydrothermal potential, however with new technologies and systems, there is an ever increasing batch of regions that are developing geothermal technology for heating & cooling. Systems can be small (from 0.5 to 2 MWth), and larger with capacities of up to 50 MWth. There are some new district heating schemes that utilise shallow geothermal resources, assisted by large heat pumps. In addition, it must be noted that according to the size of the systems, there are different business models; some DH are developed and managed by local authorities and larger systems, requiring more capital costs, are developed by utilities.

Technologies

'Geothermal district heating' is defined as the use of one or more production fields as sources of heat to supply thermal energy to a group of buildings and/or industries.

The main services available from a district heating system are space heating, hot water distribution, and space cooling. A district heating system also include co-generating power plants, conventional boilers, municipal incinerators, solar collectors, groundwater heat pumps, and industrial waste heat sources. Depending on the temperature of geothermal water, it may be advantageous to develop a hybrid system including a heat pump and/or conventional boiler for peaking purposes. In the future, the development of hybrid renewable systems, with geothermal in combination with biomass and solar thermal, is expected.

Historically, European countries that enjoy favourable geothermal conditions have been the first to develop geoDH systems (Iceland, Italy, France, Hungary etc.).

However, such systems can be also developed economically in other low and medium enthalpy areas. Many geoDH systems (such as in the Paris Basin) are based on areas of hot sedimentary basins, and on the doublet concept of heat extraction. Modern doublet designs include two wells drilled in deviation from a single drilling pad. Hole spacing is designed to secure a minimum twenty year life span, before cooling of the production well occurs. Well depths (deviated) of 2,000m to 3,500m are not uncommon; these are often located in sensitive, densely populated urban environments, therefore require heavy duty, silent rigs (up to 350 tons hook loads, diesel electric drive).

As is the case in Milan, we are also seeing the installation for systems with lower temperature assisted by heat pumps. In several instances (Denmark, Germany, Iceland) absorption heat pumps have been successfully installed and operated.

Power generation from medium enthalpy sources, standing in the 100-150°C temperature range, becomes much more economic with a heating segment added to the utilisation grid, by using a low boiling point working fluid and an organic vapour turbine, a conversion process known as the Organic Rankine Cycle (ORC). As more binary cycles (ORC or Kalina) are installed in geothermal power plants (low temperature and/or EGS plants), the development of both CHP and geoDH becomes standard.

The installation of geoDH systems becomes more economic close to areas with higher urban density, as both resources and demand need to be geographically matched. One considerable challenge in the current economic crisis concerns the financing and the development of new heat grid infrastructures.

Retrofitting is an alternative for developing the geoDH market. Oradea, in Western Romania, is an example of the insertion of a geothermal heating system into the existing city network: a coal fired/back pressure system, CHP network, typical of previous Central/Eastern Europe district heating practice.

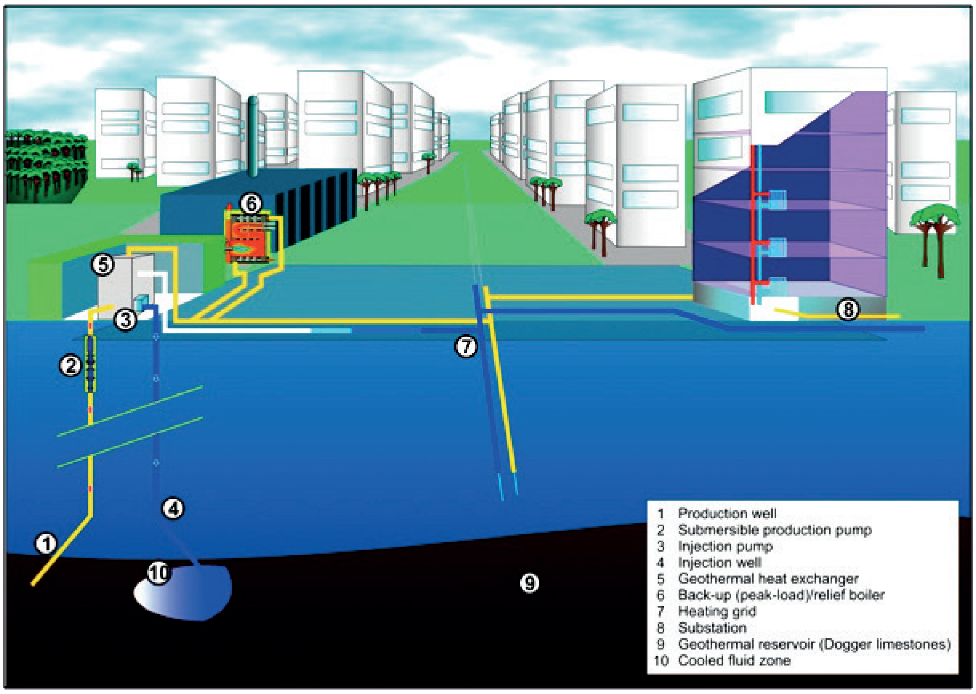
Geothermal district cooling is actually poorly developed in Europe[1], with merely 30 MWth installed capacity. This development issue should be challenged by geothermal operators (and users), as it could provide additional summer loads to geoDH systems. In the Paris Basin, for instance, absorption chillers can be placed in grid substations, and the primary hot fluid supplied by the geothermal heat plant. The chilled water can be piped to consumers via the same flow circuit used for heating.

The economic success of a geothermal DH project is influenced by a variety of factors. Although each project should be considered unique, there are elements common to all.

[1] District cooling is currently being in developed in other regions of the world, particularly the Middle-East.

A geothermal district heating system comprises three major components, as shown in Figure 7. The first part is heat production which includes the geothermal production, conventionally fuelled peaking station, and wellhead heat exchanger (elements marked 1-2-3-4-5 on Figure 2). The second part is the transmission/distribution system, which delivers the heated or cooled water to the consumers (element 7). The third part includes central pumping stations and in-building equipment. Geothermal fluids may be pumped to a central pumping station/heat exchanger or to heat exchangers in each building. Thermal storage tanks may be used to meet variations in demand.

Figure 2. Main components of geothermal district heating system

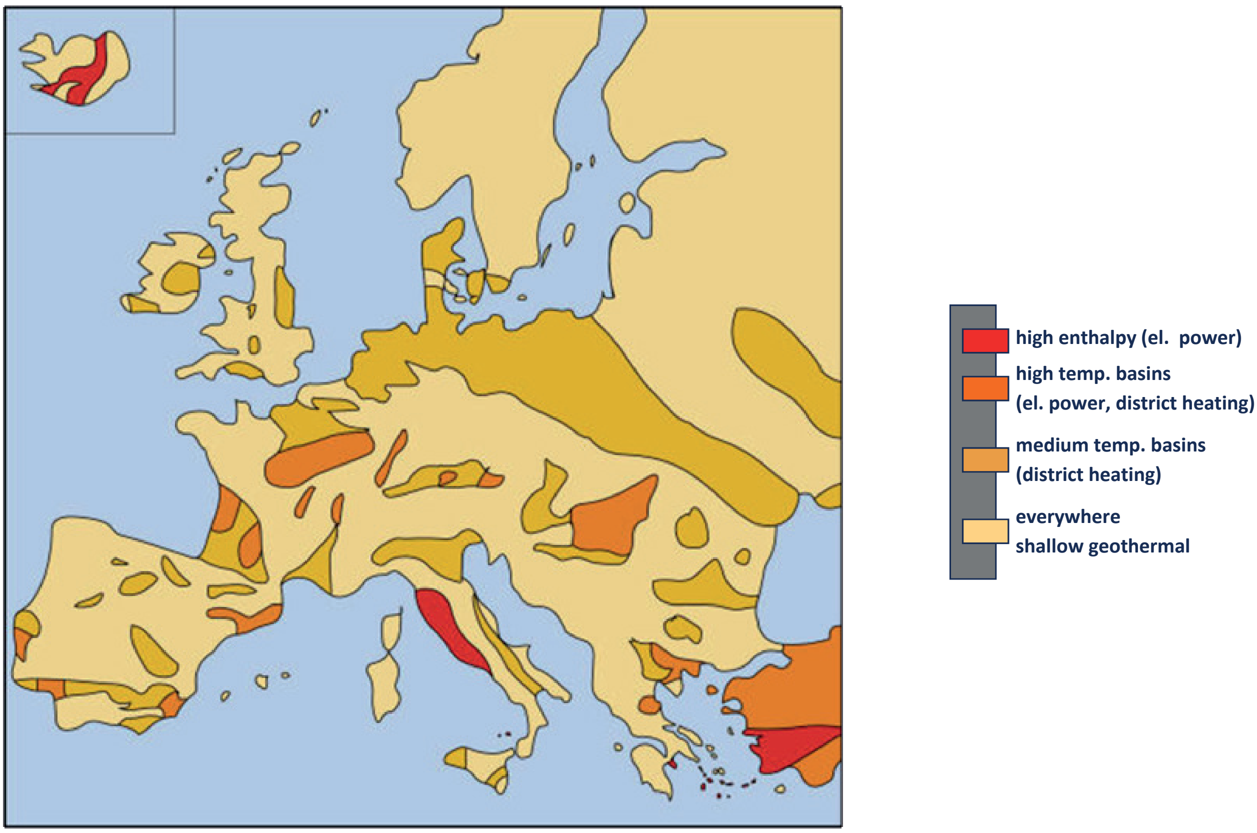


Main geothermal provinces of Europe

The main geothermal provinces of Europe reflect the geological conditions. High enthalpy resources are associated with active volcanic areas (Iceland, Italy, Turkey), while medium enthalpy sedimentary basins are found in various geological settings, e.g. the Rhine graben, the Molasse basin in the Northern forefront of the Alps, the Paris basin, the Aquitanian basin, and the Pannonian basin, as well as vast areas in Northern Europe (across Denmark, Germany, Poland) where various rocks reservoir, forming the basement of the young sedimentary basins, store high-temperature thermal ground waters (Figure 3).

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 EU28 until 2050.

Figure 3. Main geothermal provinces of Europe (source: EGEC)

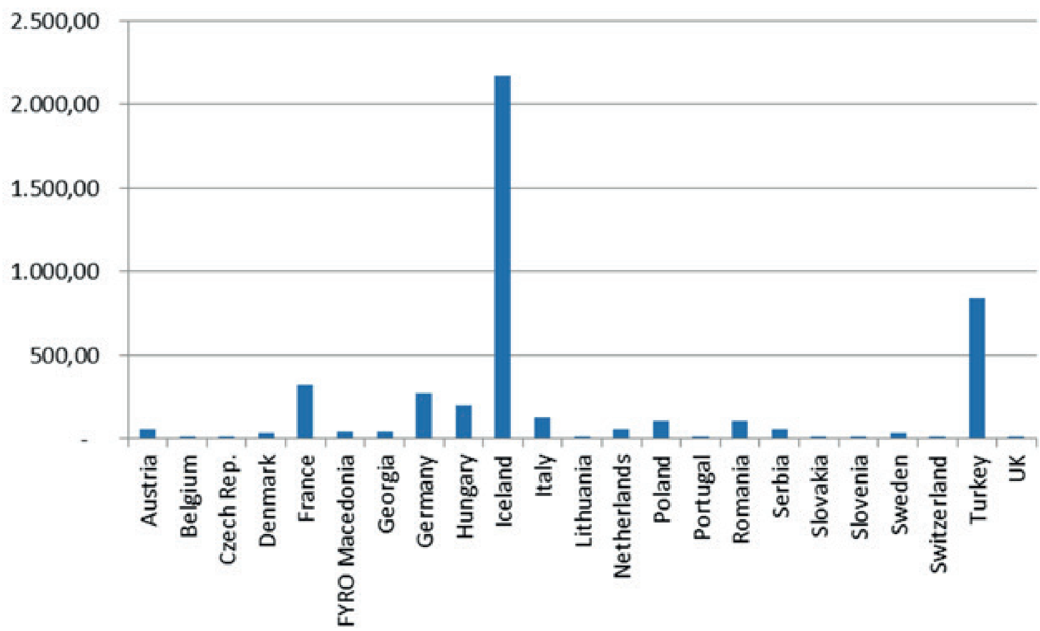


Market analysis

There are around 250 geothermal district heating plants (including cogeneration systems) in Europe. The total installed capacity amounts now to some 4.5 GWth. The plants in operation in 2012-13 produced approx. 13 terawatt-hours thermal per year (TWh th/y) for heating.

There are 162 geothermal DH plants in the European Union. The total installed capacity in the EU-28 now amounts to around 1.3GWth, producing some 4256 GWh of thermal power, i.e. 366 ktoe in 2012.

Figure 4. Installed capacity per country (MWth)-2014 (source: EGEC)

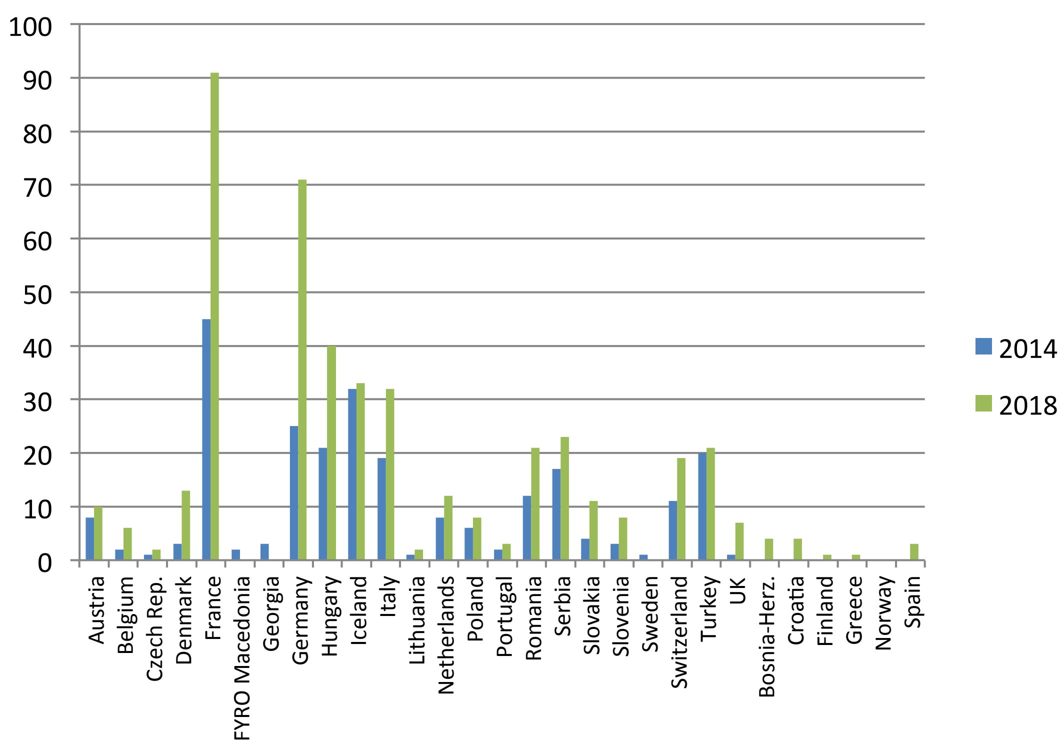


According to the 200 planned projects (including the upgrading of existing plants), EGEC estimates that the capacity will grow from 4500 MWth installed in 2014 to at least 6500 MWth in 2018.

The pioneering geographical regions using deep geothermal wells include the Paris basin (France), Tuscany and Emilia-Romagna (Italy), Bavaria (Germany), the Pannonian basin (Hungary, Serbia, Romania, Slovakia, Slovenia, Croatia) and the doublet wells of Thisted in Denmark, which have been in operation for 30 years.

There are other regions with new development, such as the Netherlands, where the potential of deep geothermal is well known thanks to the exploitation of gas, also Poland, where the potential is large, and even in the central region of Spain, around Madrid. The propensity to adopt geothermal is clear, even in regions which may be recognised as being less favourable to operation, for example in the UK (Manchester). This trend is further accentuated by the emergence of mini-heating networks which serve only a relatively small area (1,000 to 1,500 housing units). Resources utilised in this situation can be of a low temperature (15°C to 40°C), and the system is made possible by the use of cold-loops where the temperature is then augmented in each sub-station by heat-pumps. Many installations of this nature are being put in place; in particular in the Ile-de-France region where ground water at different depths is used, with capacities that are lower than the deep doublets used around Munich for example. In this case the installed capacity ranges from 2 to 5 MWth.

Figure 5. Number of geoDH systems in Europe (source: EGEC)



2 Geothermal DH Potential

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Geothermal DH Potential in Europe

The GeoDH interactive web-map viewer (developed as part of the GeoDH project) presents the geothermal resource assessment carried out in the countries covered by the GeoDH project and highlights the areas where potential for geothermal district heating exists.

Based on currently available information in terms of geological data, already operational district heating systems, and heat demand, it shows the respective potential in the 14 project countries: Bulgaria, the Czech Republic, Denmark, France, Germany, Hungary, Ireland, Italy, the Netherlands, Poland, Romania, Slovakia, Slovenia, and the United Kingdom. The geothermal potential is presented down to the depths of 2 km below ground level. In some countries prospective resources are located also at greater depths (e.g. Poland); in such cases relevant specific information is available by contacting GeoDH partners in the respective countries.

The viewer is available at www.loczy.mfgi.hu/flexviewer/geo_DH. For information on how the system works, please view the manual (available at www.geodh.eu). An example of GeoDH Web GIS screenshot is given on Figure 6 below.

Figure 6. An example of GeoDH Web GIS screen shot (www.geodh.eu)

In addition to showing areas which have potential for geoDH developments due to their favourable geological and geothermal conditions, the web-map indicates the existing DH systems, including geoDH systems in Europe. The interactive nature of the web-map viewer makes it possible to perform more in-depth searches, i.e. to show areas where temperature distribution is higher than 50°C at 1000 m deep, higher than 90°C at 2000 m deep, heat-flow density is above 90 mW/m^2, all these combined with prosperous geological environments.

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 EU28 until 2050.

Around 25% of the EU population is located in regions with hot sedimentary aquifers or other types of potential reservoirs, so are suitable for geothermal heating and cooling.

It is crucial to target areas with medium enthalpy (>60°C) at relatively low depth (<3 Km) and with an urban density which ensures the economic sustainability of the project.

From the map below, limited to the 14 project countries, we can note that:

- geoDH can be developed in all countries;
- The potential for geoDH development by 2020 is much higher than the forecasts of Member States in their NREAPs (see below);
- The Paris and Munich basins are the two main regions today in terms of number of geoDH systems in operation;
- The Pannonian basin is of particular interest when looking at potential development in Central and Eastern Europe countries;
- The extensive European Lowlands (covering significant areas in several countries: Denmark, Germany, Poland) offer good conditions to develop geoDH systems in many localities;
- Temperature is not the only selection criteria; other key factors are sufficient flow-rate on the supply side and the heat users (urban density) on the demand side;

Geothermal can be installed with existing DH systems during extension or renovation, replacing fossil fuels, and new geoDH systems can be built in many regions of Europe at competitive costs. Moreover, in southern Europe, the option of district cooling should be considered.

According to Eurostat, about one third of the EU's total crude oil (34.5%) and natural gas (31.5%) imports in 2010 originated from Russia. Of this, 75% of the gas is used for heating (2/3 in households and 1/3 in the industry). Geothermal DH technology has the potential to replace a significant part of that fuel.

Over 25% of the EU population lives in areas directly suitable for geothermal district heating. Geothermal district heating is a valuable and immediate option for the alleviation of Europe's energy dependency.

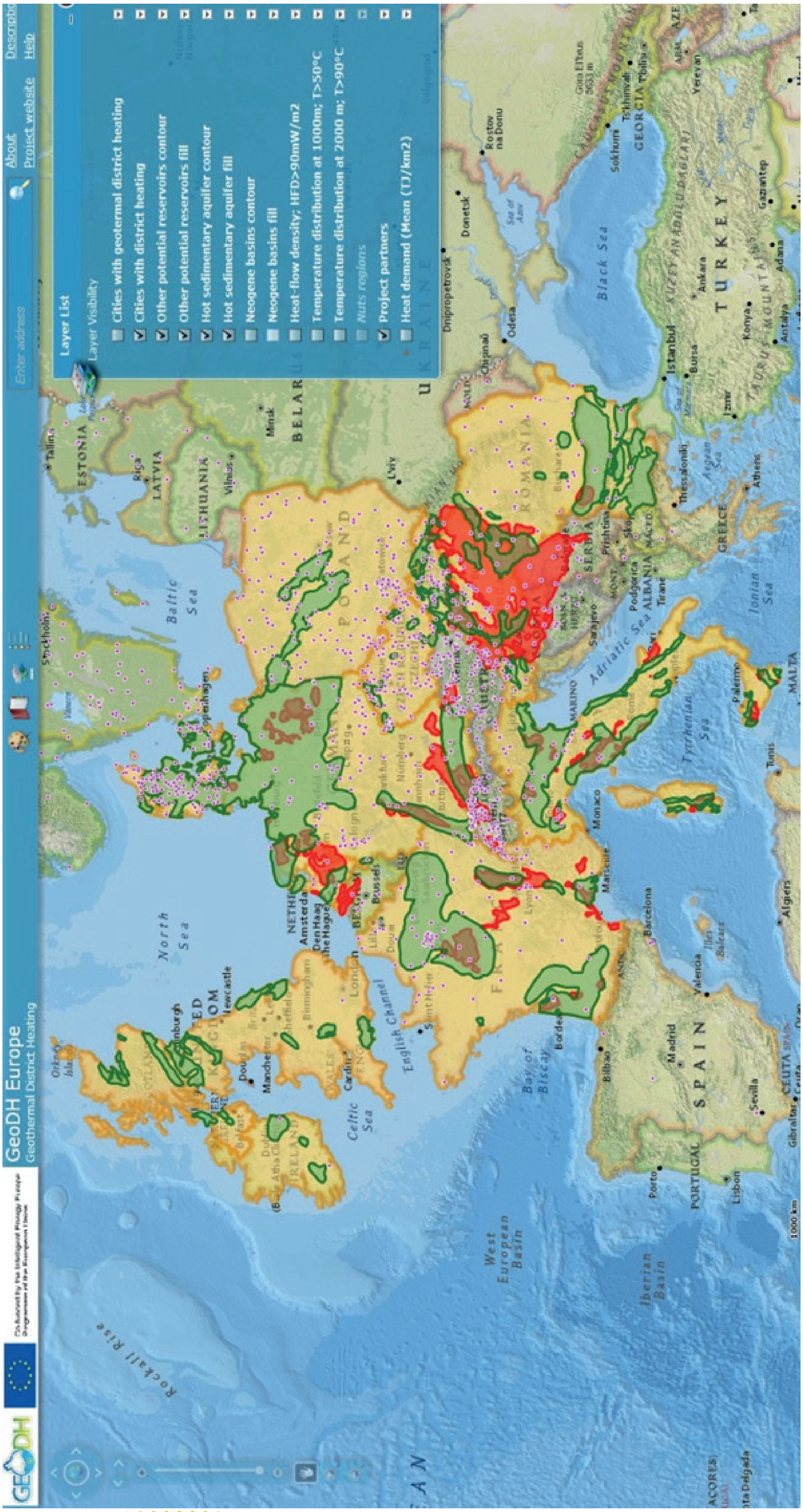


Figure 7. Map of geothermal DH potential of European Union

Geothermal DH Potential in EU countries with high resources

Starting from the resource assessment and the GeoDH web-map viewer, information on geological potential has been matched with heat demand, in order to highlight the regions with significant potential for developing geothermal DH with both a demand side and a supply side approach.

The potential is presented in terms of the percentage of the population living in areas suitable for the uses of geoDH in a given country.

The 14 GeoDH countries are divided to NUTS3[2] regions. In these regions, we have looked at the percentage of areas with geothermal DH potential; this was then multiplied by the number of inhabitants in the area. The result was the number of people living in areas suitable for geoDH in a region. This data was added together to give the number of inhabitants living in areas suitable for geoDH at national level.

It was decided to present the potential in relative terms in order to integrate a percentage error. So this number was divided by the total population of the whole country to express the potential in percentage. Below the general formula used:

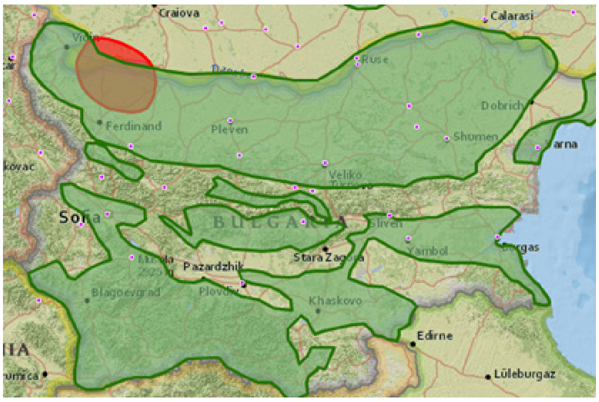
% POPULATION LIVING IN AREAS SUITABLE FOR GEODH IN A COUNTRY

$$\frac{\text{Sum at national level of the (\% of the NUTS 3 area with a geoDH potential} \times \text{Number of inhabitants in this NUTS 3 regions)}}{\text{Total population in the country}}$$

[2] The NUTS classification (Nomenclature of territorial units for statistics) is a hierarchical system for dividing up the economic territory of the EU for the purpose of: a) The collection, development and harmonisation of EU regional statistics; and b) Socio-economic analyses of the regions. Source: http://epp.eurostat.ec.europa.eu/portal/page/portal/nuts_nomenclature/introduction .

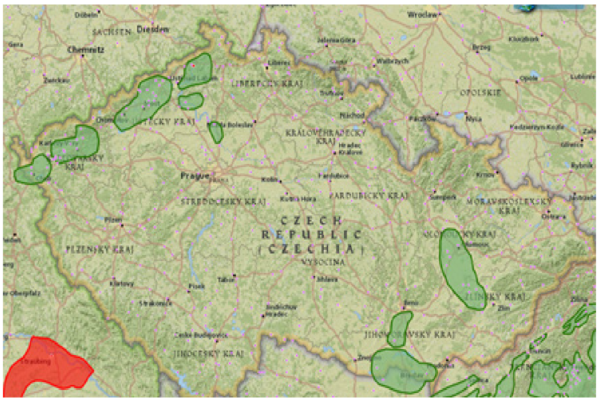
BULGARIA

There are only fifteen DH systems in Bulgaria, and none of these utilise geothermal energy. There is, however, huge potential in most of the country. With the total population of about 7.2 million inhabitants, the proportion of Bulgarian population that can be reached with geothermal district heating (with geothermal heat at 1000m 60°C to 100°C), is around 50%. The regions which can be fully supplied by geothermal DH are Pleven, Shumen, Targpvishte, Blagoevgrad and Smolyan.



CZECH REPUBLIC

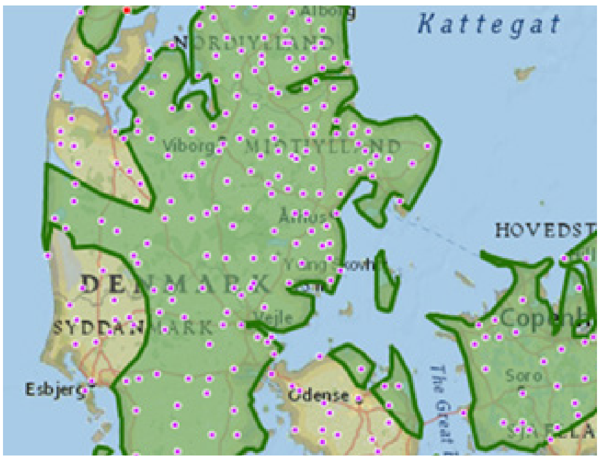
As shown in the map, the North-West and Eastern parts of the Czech Republic are particularly suitable for geothermal district heating. With a total population of about 10.5 million inhabitants, the proportion of Czech population that can be reached with a geothermal district heating (with geothermal heat at 2000m 60 °C to 100°C) is around 10%. Most favourable areas include NUTS 3 regions such as Ústecký kraj and Karlovarský kraj, Jihomoravský kraj, Moravskoslezský kraj, Stredoceský kraj, Pardubický kraj and Olomoucký kraj.



DENMARK

Most of the Danish territory is suitable for geothermal district heating. Another aspect presented is that the existing infrastructure is well developed. Huge geothermal resources are documented in the subsurface below most Danish cities.

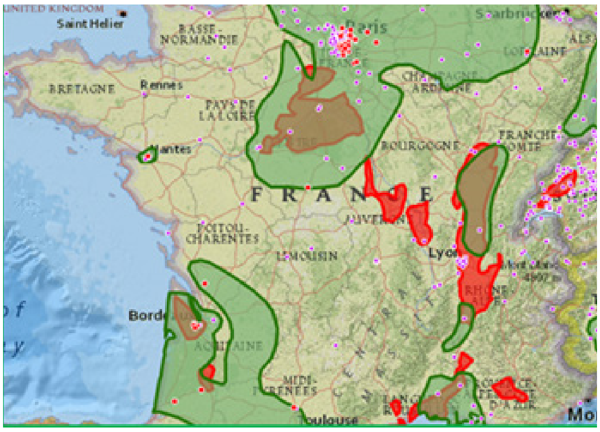
With the total population of 5.6 million inhabitants the proportion of Danish population that can be served by geothermal district heating (with temperatures between 60 °C to 100°C at 2000m deep) is around 75%. This area includes regions that can be fully supplied with geothermal installations such as Københavns omegn, Nordsjælland, Østsjælland, Østjylland and Vest- og Sydsjælland.



FRANCE

Two regions in France are more suitable for geothermal district heating. One is related to the exploitation of the deep Dogger reservoir in the Paris area, where the infrastructure is very well developed, and the second one in Aquitaine, with around 10 single production wells, which were mostly developed in the 1980s.

Geothermal heat production is expected to increase by a factor of 5 between 2006 and 2020, whereas the objective for RES heat in general is an increase by a factor of 2. With the total population of 65, 588, 117 the proportion of French population that can be reached with a geothermal district heating (where geothermal heat at 1000m 60 °C to 100°C) is around 37%.

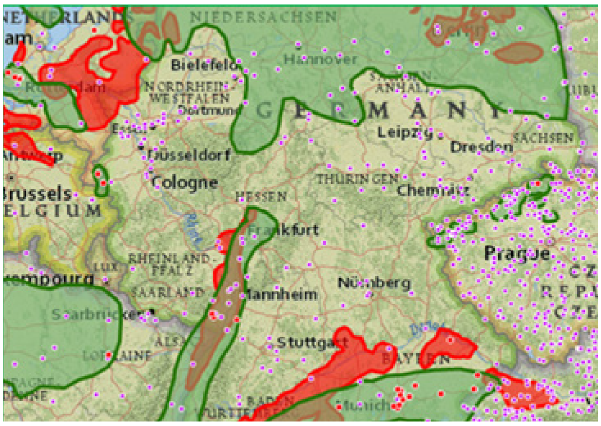


GERMANY

The most widespread utilisations of deep geothermal heat are thermal spas. However, the number of larger district heating plants is growing continuously. They presently account for about half of the deep geothermal heat production, with an upward tendency.

As shown on the map some parts of German territories are suitable for deep geothermal production. The heat network infrastructures are well developed with more than 3,300 district heating systems.

With a total population of 82 million inhabitants, nearly half of German population can be reached with a geothermal district heating (38 % with temperature between 60°C and 100°C at 1000m depth, and the rest with temperatures above 100°C at 2000 m). This number includes many areas that can be fully and partially served by geothermal installations. Almost all regions on the NUTS 3 level in Mecklenburg-Vorpommern, in Niedersachsen and Schleswig-Holstein are suitable. Some other potential locations are in the regions of Baden Württemberg, Brandenburg and Sachsen-Anhalt.



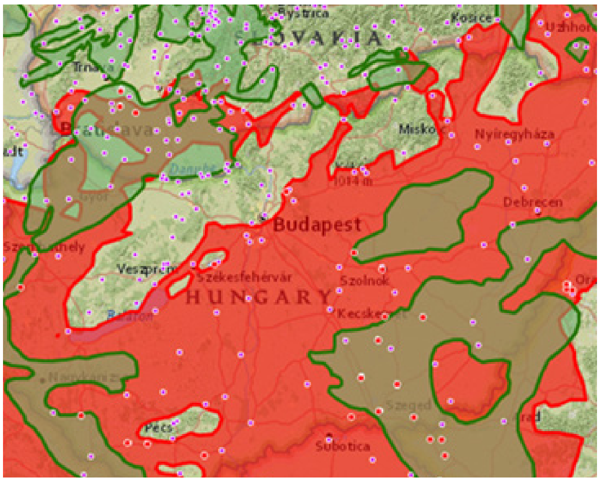
HUNGARY

Most of the Hungarian territory is suitable for geothermal district heating, corresponding to areas where around 72% of the population lives.

The existing infrastructure is well developed (there are 95 district heating systems installed in 2011). Therefore geothermal can be more easily integrated into existing networks (with refurbishment) and replace gas and fossil fuels at lower costs.

With the total population of nearly 10 million inhabitants, the proportion of Hungarian population that can be reached with geothermal district heating (where geothermal heat, at 1000m or at 2000m, has a temperature higher than 60 °C) is around 90%. The areas where heating needs can be 60-90% covered with geothermal installations includes Csongrád and Békés.

There are about 950 thermal wells operating in Hungary, out of which 274 provide thermal water warmer than 60 °C, i.e. would be theoretically suitable for geoDH.



IRELAND

Some parts of Ireland are suitable for geothermal district heating. Indeed the potential exists, however, the infrastructure is not developed (there are only 2 district heating systems installed). With the total population of 4.5 million inhabitants the proportion of Irish population that can be reached with geothermal district heating (where geothermal heat at 1000m is 60 °C to 100°C) is around 35%. These areas include cities like Dublin, where the heating requirements can be fully covered with geothermal installations and other NUTS 3 regions such as the Mid-East, which can be covered at 45%.

ITALY

Geothermal still has a large untapped potential in Italy. In addition, the DH infrastructure should be further developed (there are 133 district heating systems installed), mainly concentrated in the north of the country.

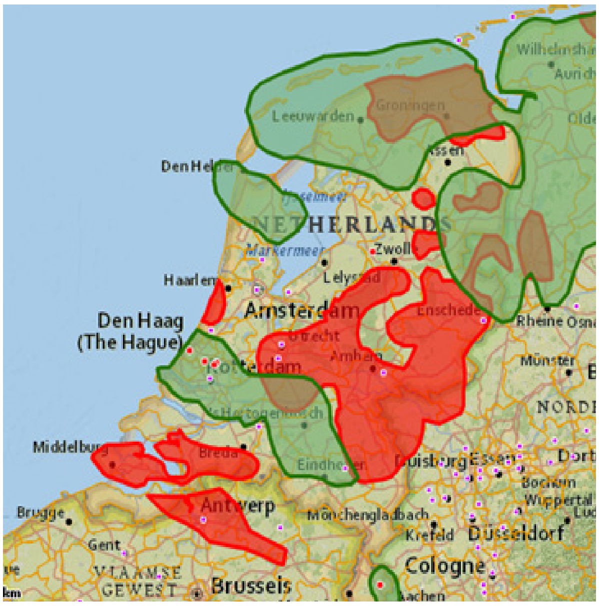
With the total population of 59, 685,227 the proportion of Italian population that can be reached with geothermal district heating (when geothermal heat at 1000m is 60 °C to 100°C) is around 50%. The area that can be fully covered with geothermal installations includes NUTS 3 regions (provinces) including: Cremona, Mantua, Monza and Brianza, Padua, Rovigo and cities such as Milan and Pisa.

In some parts of Italy, including areas in the central and southern part of the country, there is promising potential for district cooling.

NETHERLANDS

Many parts of the territory in the Netherlands are suitable for geothermal district heating and the infrastructure seems to be well developed.

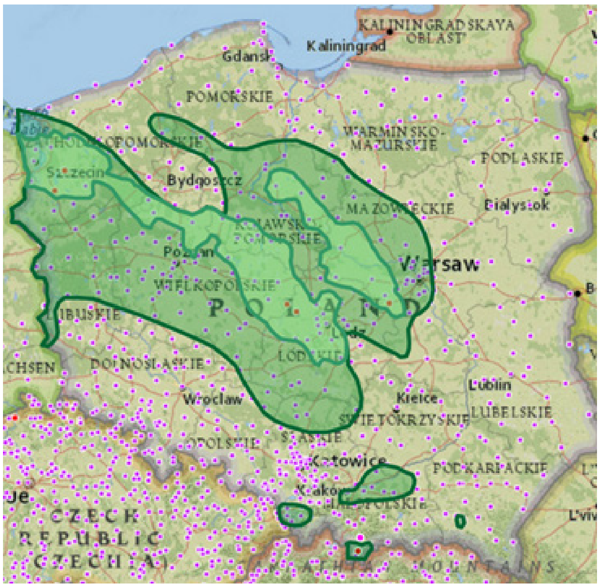
With the total population of 16, 779,575 inhabitants, the proportion of Dutch population that can be reached with geothermal district heating (where geothermal heat at 1000m is 60 °C to 100°C) is around 30%. The area that can be fully covered with geothermal installations includes NUTS 3 regions like Overig Gronigen, Nord Frisland, Zuidoost-Drenthe, Agglomeratie's, Delft and Westland, Zuidoost-Zuid Hollland



POLAND

There are many DH systems in Poland, but few use renewable energy sources. Geothermal district heating is usually implemented by retrofitting pre-existing systems.

Some parts of the country's territory, in particular Central and North Western Poland (within the Polish Lowlands) are suitable for geothermal district heating. With a total population of ca. 38.6 million, the proportion of Polish population that could be reached with geoDH where geothermal heat at 2000m is about 60°C (or higher) is around 10%. This area includes major cities such as Szczecin and Lodz, and NUTS 3 regions such as Lodzki, Koninski, Szczecinski and Warszawski Zachodni.

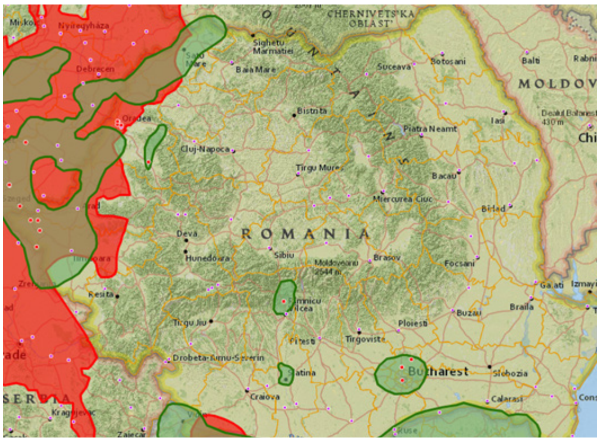


ROMANIA

The west and the south of Romania are particularly suitable for geothermal district heating.

With the total population of 20,095,996 the proportion of Romanian population that can be reached with geothermal district heating (where geothermal heat at 2000m is 60 °C to 100°C) is around 20%.

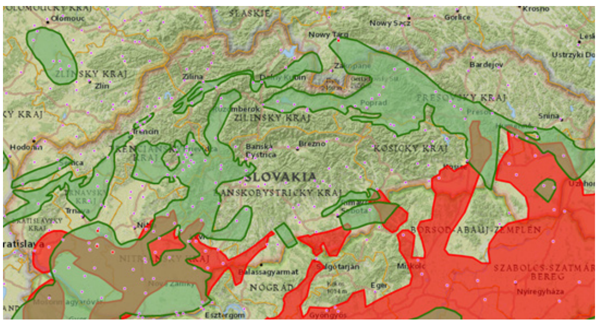
The area includes city Bucharest that can be fully supplied with geoDH system and NUTS 3 regions such as Satu Mare and Ilfov where 90% of the needs can be met. In addition, almost 50% of the Bihor region is also suitable for geothermal installations.



SLOVAKIA

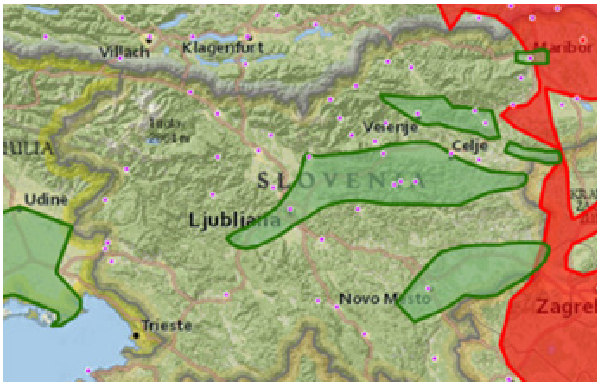
With a total population of 5,410,836, the proportion of the Slovak population that can be reached with geothermal district heating (where geothermal heat at 2000m is 60 °C to 100°C) is around 50%. This area includes NUTS 3 regions such as Nitriansky kraj, Trnavský kraj, and Presovský kraj.

Furthermore, the proportion of the country's population that can be reached with geoDHs with temperature above 100°C at 2000m is around 20%. This potential includes mostly NUTS 3 regions such as Nitriansky kraj and Kosický kraj.



SLOVENIA

In Slovenia some suitable areas for exploitation and energetic use were identified, in particular in eastern part of the country. With a total population of 2,058,821, the proportion of Slovenian population that can be reached with a geothermal district heating (where geothermal heat at 2000m is 60 °C to 100°C) is around 50%. This area includes NUTS 3 regions such as Podravska, Savinjska, Spodnjeposavska, Jugozhodna Slovenija and Osrednjeslovenska.



UNITED KINGDOM

The exploitation of geothermal resources in the UK continues to be minimal. As shown in the map overleaf, the south west, Yorkshire and the Humber, and southern and north eastern Scotland, are particularly suitable to geothermal district heating.

With the total population of 63,256,142 the proportion of British population that can be reached with geothermal district heating (with geothermal heat at 2000m 60 °C to 100°C) is around 20%. The area includes NUTS 3 regions such as Clackmannanshire and Fife, Falkirk, West Lothian that can be fully covered with geoDH systems. Other NUTS 3 regions like Cheshire East, Dorset, East Lothian and Midlothian can be covered partially at 80-90%.

3 Regulatory and market frameworks

(STATE OF PLAY AND RECOMMENDATIONS)

3 Regulatory and market frameworks

(STATE OF PLAY AND RECOMMENDATIONS)

Developing geothermal district heating requires an enabling framework beginning with clear and consistent national / regional strategies from public authorities. From the project developer's point of view, realising a geothermal project requires several authorisations and the compliance with a number of national and local regulations, and legal and financial safeguards.

The main requirements / permits that may be required for a geothermal district heating project development are the following:

- Water, mineral, and mining rights;
- Exploration permits;
- Well construction permit;
- Development rights;
- Payment of royalties;
- Environmental impact assessment (EIA);
- Environmental permit;
- Building permit for the plant/distribution network,with a possible spatial planning obligation to realise a DH-network;
- Dismantling permit.

Regulatory barriers and long-administrative procedures can result in additional costs. It is therefore crucial that a fair, transparent and not too burdensome regulatory framework for geothermal and district heating is in place.

Building on the feedback received in several national workshops organised within the project, the GeoDH consortium has gone beyond simple analysis of legislation. An accurate assessment was carried out to understand the practical implementation of regulations and the overall conditions influencing the development of the technology. The main best practises and barriers are reported, country by country, in a dedicated report[3].

This assessment shows how regulatory and market conditions widely vary across the 14 GeoDH project countries. However, it is still possible to observe that - regardless of the market maturity - some practices can be considered as being pre-requisite or very favourable to the development of geothermal district heating technology. For instance, where:

- Geological data is freely available to project developers (e.g. after a five year period in the Netherlands);
- A public risk insurance scheme is in place (e.g. in France and the Netherlands);
- There is a clear definition of procedures and licensing authorities (e.g. France, Poland and Denmark);
- Adequate national and regional strategies exist (Bulgaria) and are integrated with some form of financial support (e.g. Hungary, Italy, and, Netherlands, and the UK).

Contrariwise, a persisting number of barriers are noted as being detrimental to any further market development of geothermal district heating:

- Market sometimes closed to new entrants (e.g. in Slovenia);
- Long and burdensome administrative procedures (e.g. in Italy, Slovenia, and Hungary);
- Serious regulatory gaps such as a lack of dedicated licencing system for deep geothermal and unregulated right to use the geothermal resources (e.g. in Ireland, UK, and Czech Republic);
- Lack of support (e.g. in Ireland, Poland and Slovakia);
- Lack of a level-playing field (e.g. in Bulgaria, Czech Republic, Slovenia, Poland, Hungary and the Netherlands where gas prices are regulated and connection to the gas grid is sometimes mandatory).

In this context, it is worth highlighting that in some countries the presence of some good practices may be largely offset by the persistence of barriers. It is therefore crucial to have a consistent enabling framework from start to finish.

Other interesting aspects have emerged during the project:

- Assessing the implementation of key articles of the EU RES Directive (e.g. articles 13 and 14) is not an easy task and should be properly carried out by the European Commission. In the target countries, it is generally observed that the EU 20-20-20 framework has indeed attracted some new interest in the sector. However, dedicated legislation and simplification of administrative procedures, when observed, were not stemming from the RES Directive but rather linked to reforms for the mining and oil & gas sectors. This issue should be addressed in the review of the relevant EU legislation.
- Particularly in emerging markets there is shortage of qualified specialists and the industry, mainly composed of local SMEs, is not organised in a structured national association. The result is weak advocacy power and the inability to remove persisting market failures against conventional competitors. In this case, it is advised that policy-makers to create the initial conditions to attract investments and specialists from close fields such as the mining and gas sectors.
- It is not only a lack of information which is detrimental; in certain cases misinformation about deep geothermal between policy-makers and citizens may bring about confusion and social opposition. While it is important to deal with communication at the very beginning of project development, it is still equally critical to launch large awareness and educational campaigns to improve the general knowledge about geothermal energy.

In order to remove the regulatory barriers and promote the best practices identified in the project countries and presented in this report, the GeoDH consortium has developed a set of recommendations collected in an ideal 'Regulatory Framework'.[4]

This regulatory framework is primarily addressed to regional public authorities in charge of regulations and local development, since they are deeply involved in licensing and other procedures related to geothermal energy exploration, development, and management.

3 Full report available on the GeoDH website www.geodh.eu
4 The full regulatory framework is available at www.geodh.eu.

These proposals should lead to regional and local regulations and policies favourable to geothermal DH development in Europe. The key recommendations are provided below:

Figure 8. Key elements of a regulatory framework for geothermal district heating

4 Financing

(PHASES AND INHERENT COSTS AND RISKS OF A GEODH PROJECT)

4 Financing

(PHASES AND INHERENT COSTS AND RISKS OF A GEODH PROJECT)

Financial support schemes for geothermal heating

The geothermal energy source is free of cost, but the upfront investments to use it are significant. The higher upfront-costs of geothermal district heating (DH) can be compensated by much lower operating costs, but only if a sufficiently low 'cost of capital' can be reached,

That is to say if the risks can be properly managed. Therefore, innovative solutions for financing projects have to be found to overcome this challenge.

Over the last years Member States have been using a wide range of public policy mechanisms to support the development of geothermal technologies: European Investment Bank (EIB) loans to project developers or a cluster of banks, loans and grants provided by national or regional authorities, etc. These can be distinguished between investment aid (capital grants, loans – including from EU Structural Funds, risk insurance) and operating aid (price subsidies, e.g. feed-in tariffs or premiums, renewable energy obligations with green certificates, and tax exemptions or deductions on the purchase of goods). Against this background, combination of financing schemes and incentives can be a key point for the economic success of projects. A special focus has to be set on the geological risk insurance mechanisms that guarantee the presence and the quality of the resource. This could be a key aspect to overcome existing difficulties.

When this important parameter has been overcome, in some cases there is still a need for a comprehensive enabling framework in order to make geothermal competitive against fossil fuels (as long as the final price of the latter does not fully reflect the real costs to society).

Why should public funds be used to support the geothermal industry and interfere with the market?

The primary objective of financial incentive schemes is to compensate for market failures and unfair competition. They are also intended to favour the deployment of a given technology by creating a secure investment environment catalysing an initial round of investment and thereby allowing the technology to progress along its learning curve. Hence, support schemes should be temporary and can be phased out as this technology reaches full competitiveness in a (then) complete and open internal market where a level playing field is fully established.

Today, however, market conditions in the EU heat sector prevent geothermal from fully competing with conventional technologies developed historically under protected, monopolistic market structures where costs reduction and risks were borne by consumers rather than by plant suppliers and operators. The internal market is still far from being perfect and transparent. Firstly, in many countries electricity and gas prices are regulated, thus they do not reflect the full costs of the electricity and/or heat generation. Secondly, the conventional sectors still receive many subsidies. Thirdly, there is lack of market transparency, including lack of information provision to customers and tax-payers, and clear billing.

Support measures for geothermal technologies are therefore needed to favour the progress towards cost-competitiveness of a key source in the future European energy mix and to compensate for current market-failures.

Support schemes and EU State Aid regime

Any kind of support, when granted by Member States need to be compatible with EU State Aid rules. As far as geothermal district heating technology is concerned, the most important pieces of legislation in this field are the following:

- Guidelines on State aid for environmental protection and energy 2014-2020(2014/C 200/01)
- Regulation (EU) No 651/2014 of 17 June 2014 declaring certain categories of aid compatible with the internal market in application of Articles 107 and 108 of the Treaty on the functioning of the European Union.

The conditions under which public support is compatible with the internal marker differ for operating and investment aid.

Regarding operating aid for renewable heat, according to Paragraph 3.3.3.2 of the Guidelines, it is compatible with the internal market if the following cumulative conditions are met:

- the aid per unit of energy does not exceed the difference between the total levelised costs of producing energy ('LCOE') from the particular technology in question and the market price of the form of energy concerned;
- the LCOE may include a normal return on capital. Investment aid is deducted from the total investment amount in calculating the LCOE;
- the production costs are updated regularly, at least every year;
- aid is only granted until the plant has been fully depreciated according to normal accounting rules in order to avoid that operating aid based on LCOE exceeds the depreciation of the investment.

Regarding investment aid, the table overleaf summarises eligible costs and maximum aid intensity for geothermal heat and district heating infrastructure (% of eligible costs) compatible with the internal market.

Figure 9. Eligible costs and maximum aid intensity for geothermal heat and district heating infrastructure

	Notification threshold	Eligible costs	INTENSITY AID COMPATIBLE WITH THE INTERNAL MARKET		
			Small enterprise	Medium-sized enterprise	Large enterprise
Aid for environmental studies		The eligible costs are the costs of the studies.	70%	60%	50%
Aid for renewable energies **Aid for cogeneration installations**	EUR 15 million per undertaking per investment project	The counterfactual is a conventional power/ heat plant with the same capacity in terms of the effective production of energy.	65%, 100 % if bidding process	55%, 100 % if bidding process	45%, 100 % if bidding process
DH infrastructure	EUR 20 million for DH network		65% 100% if bidding process	55%	45%
			To the aid intensities mentioned above may be increased by a bonus of 5% point in regions covered by Article 107(3)c or by a bonus of 15% in regions covered by Article 107(3)a Treaty up to a maximum of 100% aid intensity.		

Support schemes for geoDH

- 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. By definition, they are temporary and shall be phased out as this technology reaches full competitiveness.
- Geothermal heat technologies are heading for competitiveness, but support is still needed in certain cases. Financial support schemes should be adapted to the level of maturity of markets, notably in emerging markets and where a level-playing field does not exist.
- Innovative financing mechanisms should be adapted to the specificities and the maturity of geothermal technologies.
- 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 competition.
- A Geothermal Risk Insurance Fund is seen as an appealing public support measure for overcoming the geological risk. As costs decrease and markets develop, the private sector will be able to manage project risks with, for example, private insurance schemes, and attract private funding.
- Innovative support schemes have to be developed at the regional level too. Based on a better knowledge of the local ecosystem, such support schemes respond more quickly and effectively to the regional environmental targets.
- Whatever the support scheme, it has to be set up on a long-term basis to offer enough visibility to geoDH project developers.
- Alternatives to public investment have to be found; the development of third party financing is essential. To reach this aim, it is important to increase the communication about the profitability of geoDH projects in order to encourage private investment.

Business models

In order to define the business model of a geoDH project, the heat customers are a key element.

The presence of one large heat consumer helps the economy of a project greatly. Local DH utilities with a need for renewable and flexible heat supply, and building owners with a need of heat supply are two interesting customer segments.

Generally geoDH offers the heat consumer the following:

- Stabile secure heat supply;
- Fixed, long term prices (for production and depreciation);
- Lower need for maintenance (compared to other conventional heat sources);
- Lower risks (when in operation);
- Ease and comfort for the end-user.

GeoDH technology is quite a mature one, in use for 50 years, and geoDH installations are competitive. However geothermal space and district heating systems are capital intensive, especially drilling the wells. Operating expenses, nevertheless, are rather low and much lower than in conventional systems. Generating costs and selling prices are usually around 60€/MWh thermal, within a range of 20 to 80€/MWh thermal. There are three frequently used financing models:

1. Firstly, public investment undertaken by the local or regional authority (usually at municipal level);
2. secondly, private sector investment which in turn is granted the opportunity to sell the heat directly to the grid-connected subscribers over long duration (20 to 30 years contracts);
3. finally a 'mixed' solution, which entails the creation of companies dedicated to the development of the geothermal with capital investment shared by both publicand private entities.

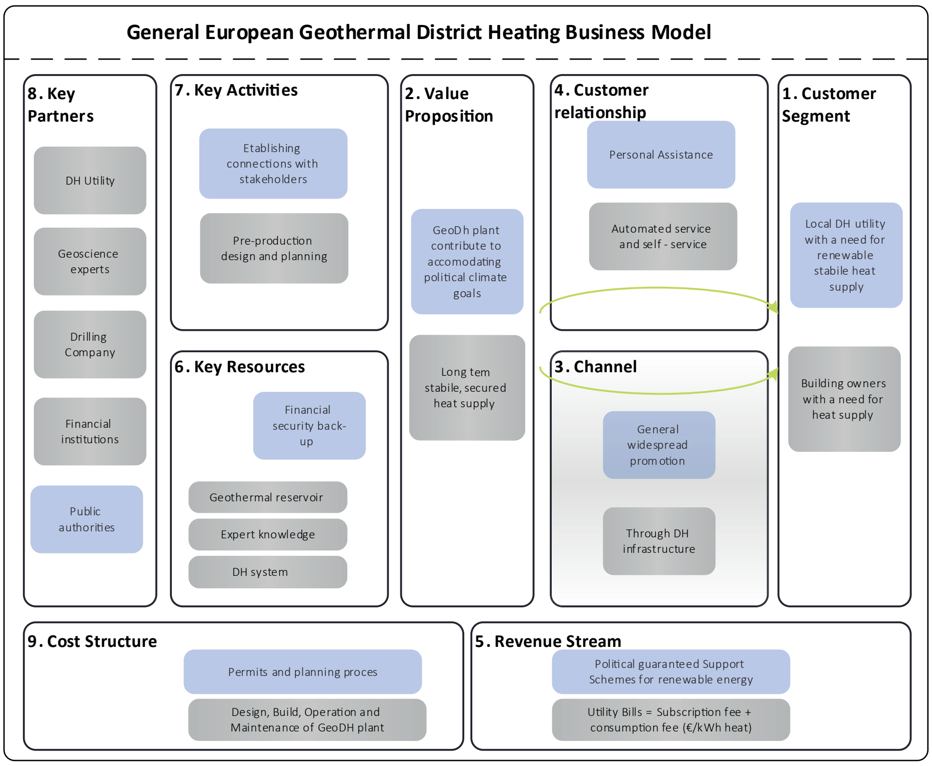
The first model (public scheme) has been developed mainly in Austria, Germany, and Denmark. The second (private DH utilities) is today used in France and the UK, among others. The third model, (a Public private Partnership) applies else where and is gaining popularity in several European countries.

Two business models can be given as an example:

1. The case of a DH company decarbonising its heat supply in close cooperation with ESCOs. Here the main marketing strategy would be to combine sustainable heat supply (possibly with use of labels or certificates) and energy saving services so as to widen the scope of activity, and reducing the impact of the inevitable reduction in energy consumption.
2. The second case would concern a geoDH project developer (public or private) aiming at proposing a newDH system supplied by geothermal. The objective would be to convince heat users of the value of renewable energy sources which are stable and competitive.

Finally, specific attention should be paid to cascade uses. It is sometimes presented as an obvious solution for improvingthe economy of (notably) CHP, but it seems less and less easy to develop them. Today few examples exist all over Europe.

Figure 10. GeoDH general business model



Before the drilling of the first well, a contract has to be negotiated to sell the heat and cold to the customers. This step is of paramount importance; many projects cannot find any financial support if this type of Heat Purchase Agreement (HPA) is not provided to the bank, before beginning the negotiation and after covering the geothermal risk. There are two different cases:

- If the district heating network already exists and some technical modifications are needed in the network or in the heating stations and substations, the client is clearly identified (public or private or a mix) and a pre-contract has to be negotiated. It aims at signing a minimum agreement to purchase a certain amount of heat per year during a sufficiently long period, usually comprised between 15 up to 30, in order to secure the reimbursement of the bank loan, depending the laws in force in the country;
- If the district heating network is to be built, the same type of agreement has to be signed and negotiated with guarantees of quantity, price and duration of the heat sales contract. Separate contracts will be required if there are several clients.

Risk insurance for geothermal district heating projects

Any industrial project is exposed to risks, even if these risks do not ultimately materialise. Nevertheless, unlike any common project, a geothermal DH project has an additional and particular risk that lies in the geological characteristic of the geothermal resource. This risk, known as the geological risk, is an inherent part of any geothermal project.

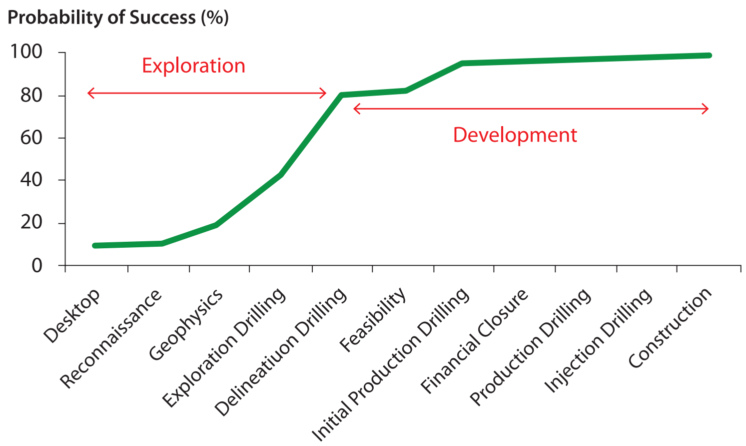
The geological risk covers:

- The short-term risk of not finding a sufficient geothermal resource (temperature and flow rate) during the drilling phase for an economically sustainable project to be established;
- The long-term risk of the geothermal resource depleting over time rendering the whole project economically unprofitable once operation of the geothermal plant has taken place.

Analyses of investment costs and risks underline that the financing of the exploration phase of a geothermal project is an important, even if not the most important barrier (Figure 4). During the exploration phase, the risk is high while the costs are already significant as e.g. seismic data has to be purchased or seismic investigations have to be conducted. One of the largest obstacles for investment in deep geothermal systems is that the presence and quality of the resource is not proven until the first exploration well is drilled. On the other hand exploration wells have a relatively high success rate (80-90%) in developed regions and low success rate (20-60%) in not yet explored areas. To establish a comparison, in oil and gas exploration a success ratio of 20% is considered as rather good, taking into account the geophysical campaign carried out before (with huge associated cost)which allows for a much better prognosis of geological conditions which is not the case in geothermal exploration. As a consequence, only if the flow rate and temperature fulfil the expectations of the investor (e.g. profitability), can it be determined that the project achieves its objectives.

The reduction of the risk coming from limited geological information can be in some cases covered by government through geological exploration (drilling, seismic profiles, etc.) funded by the state. Unsuccessful drilling is an important risk that has to be taken. Drilling costs are significant and can represent a non-negligible part of the overall project costs, however have to be financed somehow.

Figure 11. Variation of risks at different phase of a geothermal project (source: GEA 2008)



Regardless of the accuracy of the exploration phase that takes place, the short term geological risk can only be fully removed when drilling confirms the expected temperature and flow rate. In spite of the geothermal plant being operational, there is no guarantee that original conditions remain over time and that the original temperature and flow rate will not decline.

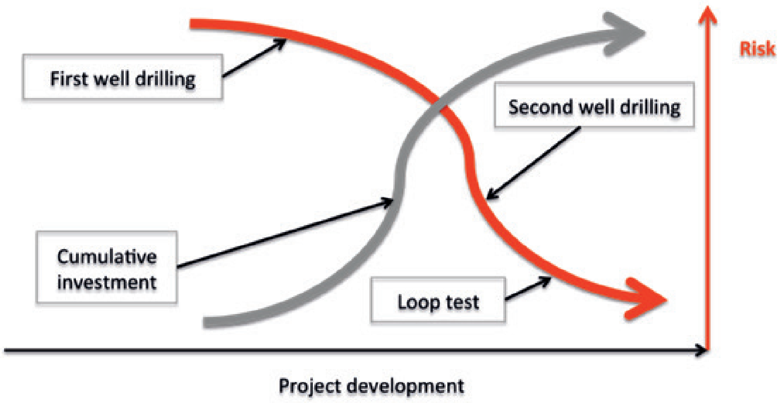
When considering the geological risk, the whole financing of the geothermal DH project is at stake. Geothermal projects require high upfront investments that will never be available unless the geological risk is adequately handled. This can only be achieved by obtaining an insurance policy for the geological risk.

There are different insurance designs in existence in Europe to cover the geological risk. Apart from Germany, where the private insurance sector engaged in providing market-based insurance policies for geothermal projects, insurance is usually made available from national insurance funds that have been set up at the initiative of governments willing to support geothermal development. Some countries also propose repayable grants for drilling the first well.

In this respect, national funds may either offer a post-damage guarantee for the geological risk (for example in France, The Netherlands, Switzerland) or a guaranteed loan, which is forgiven in case the risk materialises (e.g. Germany, Iceland). Both insurance concepts offer pros and cons. However, they undoubtedly contribute to the strengthening of confidence in the geothermal sector.

In this context, insurance is of such significant importance for geothermal development that it is in the interest of all European policy makers and investors to give some consideration to the establishment of a European insurance fund to cover the geological risk at European level.

Figure 12. Risk management for a geothermal DH project and capital investment



Last but not least, an European Geothermal Risk Insurance Fund (EGRIF) has been promoted by the GEOELEC project.

Financing costs of geothermal district heating projects

Geothermal heat may also be competitive for industrial and agriculture applications (for example, greenhouses).

Geothermal space and district heating systems are capital (CAPEX) intensive. The main costs are generated by initial investments for production and injection wells, down-hole and surface feed pumps, pipelines and distribution grids, monitoring and control equipment, peaking stations, and storage tanks. Operating expenses (OPEX), nevertheless, are much lower than in conventional systems, consisting of pumping power, system maintenance, operation and control.

The financial performance of the system depends on the thermal load density, or the heat demand per unit area. The levelised costs of geothermal energy are presented in Figure 13 below.

Figure 13. Levelised costs (LCo) of geothermal energy (acc. to Update of Strategic Research Priorities for Geothermal Technology (2012, European Technology Platform on Renewable Heating and Cooling), EGEC copyrights)

LCO OF GEOTHERMAL HEAT	COSTS 2014		COSTS 2030
	RANGE (€/KWH)	AVERAGE (€/KWH)	AVERAGE (€/KWH)
Geothermal DH	0.02 – 0.20	0.6	0.04
Geothermal direct uses*	0.04 – 0.10	0.05	0.04

* Direct uses are geothermal applications in balneology, greenhouses, agro-industrial processes etc.

Generating costs and selling prices are usually around 60 €/MWh thermal, within a range of 20 to 80€/MWh thermal. This depends on local geothermal settings (high/low heat flows, shallow/deep seated sources), socio-economic conditions and pricing policies (kWh thermal or m^3 of hot water) In addition, district heating networks achieve an important share of the total costs for a geoDH system expenditure: around 1 Mio €/ Km for the grid and the substations.

One considerable challenge in the current economic crisis concerns the financing and the development of new heat grid infrastructures. Retrofitting is an alternative for developing the geoDH market. Oradea, in Western Romania, is an example of the insertion of a geothermal heating system into the existing city network: a coal fired/back pressure system typical of historical Central/Eastern Europe district heating practice was adapted for a combined heat and power (CHP) network.

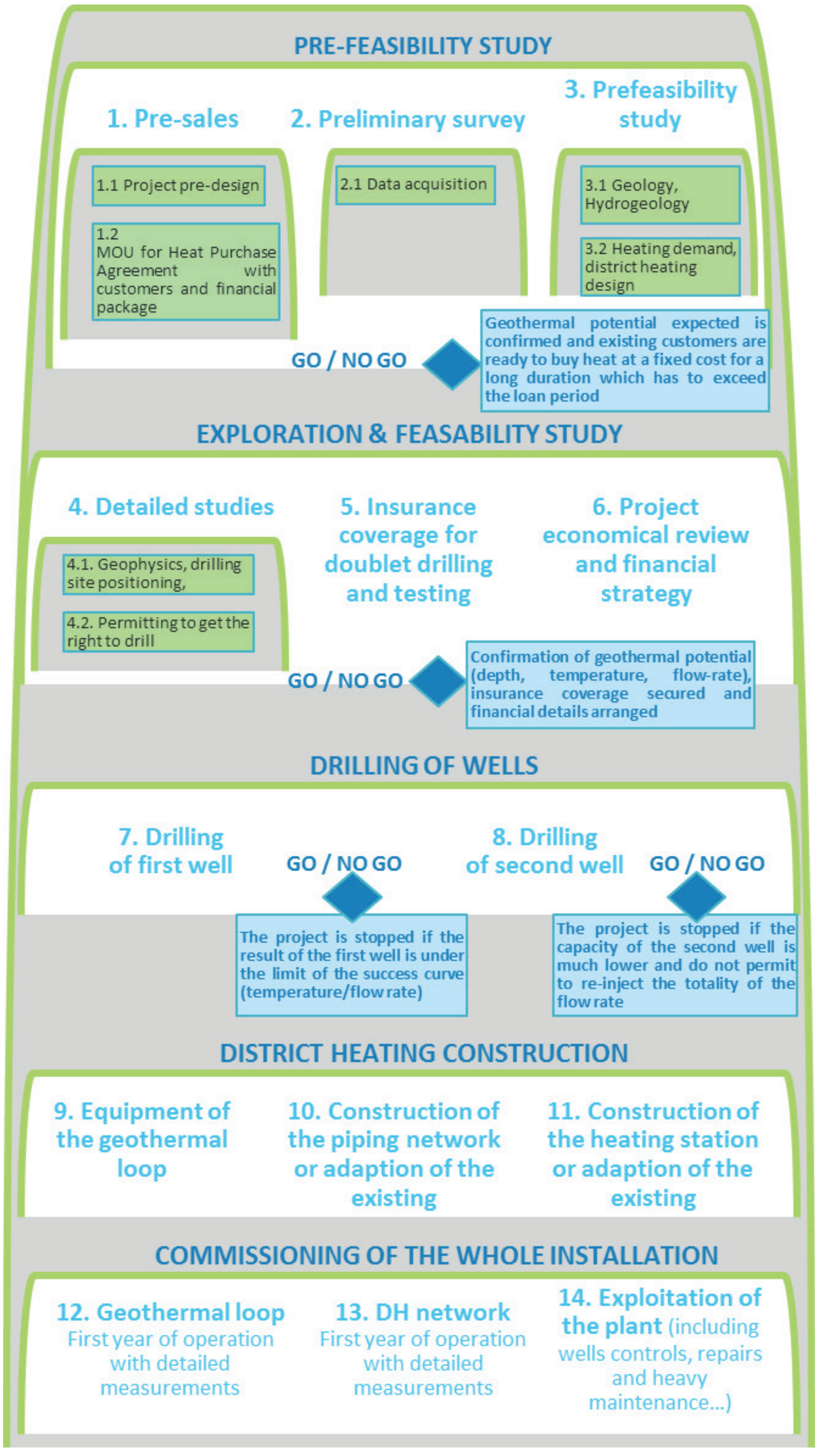
With regards to financing, the levels of investment vary from around 3 to 12 million Euro for capacities between 3 and 10MWth (ca. 1 to 1.5 Mio €/MWth installed), dependant on the location of the project, the geological conditions, the drilling prices, combined electricity generation, etc. There are 3 modes of financing frequently used. Firstly, there is public investment undertaken by the local or regional authority (usually at municipal level). Secondly, there is private sector investment, which in exchange receives the opportunity to sell the heat directly to subscribers of the network over a long period (20 to 30 years). Finally, there is a 'mixed' solution, which entails the creation of companies dedicated to the exploitation of the geothermal network with capital divided between public and private entities.

Figure 14. Investment and financial need for geothermal projects: typical project volume: €20 – 30 Mio. depending on project type (e.g. electricity, district heating or CHP).

exploration	wells	insurances
1-2 Mio. €	10-15 Mio. €	0,5 Mio. €

power plant (4-5 MWTH)	energy center	network
1-2 Mio. €	1 Mio. €	10-15 Mio. €

Feasibility of a geoDH project



5 Case studies

5 Case studies

SAUERLACH, GERMANY

GENERAL

Description: Triplett system (2007-2009). 1 production and 2 injection wells, depth of 4 757 m to 5 567 m MD
Contact: Stadtwerke Muenchen

PROJECT

INHABITANTS CONNECTED	Around 16,000 households in the city of Munich	PRODUCTION OF HEATING AND/ OR COOLING	2 step ORC process (Turboden), cogeneration
		COMPARISON WITH FOSSIL ENERGIES	CO_2 reduction: 36 000 t/a

FINANCING

INVESTMENT FOR DH NETWORK AND SUBSTATION	Existing district heating system

INSTALLED CAPACITY (MWTH)	4 MWth	TEMPERATURE OF THE GEOTHERMAL RESOURCE (PRODUCTION - INJECTION)	Thermal water: 110 l/s, 140 °C
INSTALLED GEOTHERMAL CAPACITY	5,1 Mwe and 4 MWth, production: 40 000 MWh/a electric and 4 000 MWh/a heat		

THISTED, DENMARK

GENERAL

OWNER	ThistedVarmeforsyning (the local consumer owned district heating company)	OPERATOR	ThistedVarmeforsyning
REGION	Thisted		

PROJECT

INHABITANTS CONNECTED	5016 (13000 inhabitants in town)	DESIGN OF THE DH	Water based with pre-insulated pipes
OTHERS USES (DRINKING WATER, CASCADE USES…)	No	PRODUCTION OF HEATING AND/ OR COOLING	For district heating
PLANNING OF THE OPERATION (FROM PRE-STUDIES TO FULL COMPLETION)	1980 - 2001	DATES OF BEGINNING AND END OF CONSTRUCTION	1982 - 1984
ADMINISTRATIVE PERMITS	None	DIFFICULTIES FACED	Production from cooler reservoir due to declining transmissivity in first tested deeper reservoir. Tax on power for electric heat pump causing shift to absorption heat pumps.

FINANCING

INVESTMENT FOR GEOTHERMAL WELL	6 million euros for two wells	INVESTMENT FOR GEOTHERMAL HEATING STATION	6 million euros
INVESTMENT FOR DH NETWORK AND SUBSTATION AMOUNT OF SUBSIDIES IF ANY	Not part of geothermal plant 2,3 million euros in EU grants	FINANCING (BANKS, FUNDS, PPP…)	Owner, former co-owner and EU grants
COST OF THE MWH SOLD	Not applicable. Consumers pay all costs for heat from the net. This includes network costs and costs for heat production from different heat production units.		

TECHNICAL

INSTALLED CAPACITY (MWTH)	78	SUBSURFACE AND SURFACE TECHNICAL SCHEMES	One production and one injection well. Absorption heat pumps driven by straw boiler.
OPERATING TEMPERATURE OF THE DH	Winter/summer: Supply: 76/70 °C; Return: 40/44 °C	TEMPERATURE OF THE GEOTHERMAL RESOURCE (PRODUCTION - INJECTION)	43 ° C / 11 ° C
GEOTHERMAL FLOW RATE	Up to 200 m3/h	HEAT PUMP IF ANY (POWER IN MWE AND COP)	Absorption heat pumps: 7,7 MWth / COPth 1,7
INNOVATION IF ANY	The use of absorption heat pumps driven by straw district heating boiler, which makes it free to drive the heat pumps.	DH LENGTH	219 km

AÉROPORT DE PARIS - ORLY

GENERAL

Description: Faithful to the commitments made at the Grenelle Environment Forum in 2007, Aéroports de Paris creates a geothermal power plant for heating its buildings. Two wells are dug in The Dogger, a 1.8 km depth aquifer. The water comes up at 74°C. Geothermal energy reduces carbon dioxide emission of 9000 tonnes each year.

OWNER	Aéroport de Paris (ADP)	OPERATOR	Aéroport de Paris (ADP)
REGION	Ile-de-France		

PROJECT

INHABITANTS CONNECTED	Airport Heating and sanitary water	DESIGN OF THE DH	Water based with pre-insulated pipes
OTHERS USES (DRINKING WATER, CASCADE USES…)	No	PRODUCTION OF HEATING AND/ OR COOLING	Heating + Sanitary Water
PLANNING OF THE OPERATION (FROM PRE-STUDIES TO FULL COMPLETION)	/	DATES OF BEGINNING AND END OF CONSTRUCTION	2008-2011
ADMINISTRATIVE PERMITS	French Mining Code Arrêté interpréfectoral du 26 mai 2011		
COMPARISON WITH FOSSIL ENERGIES	Spared CO_2: 8200 t/year		

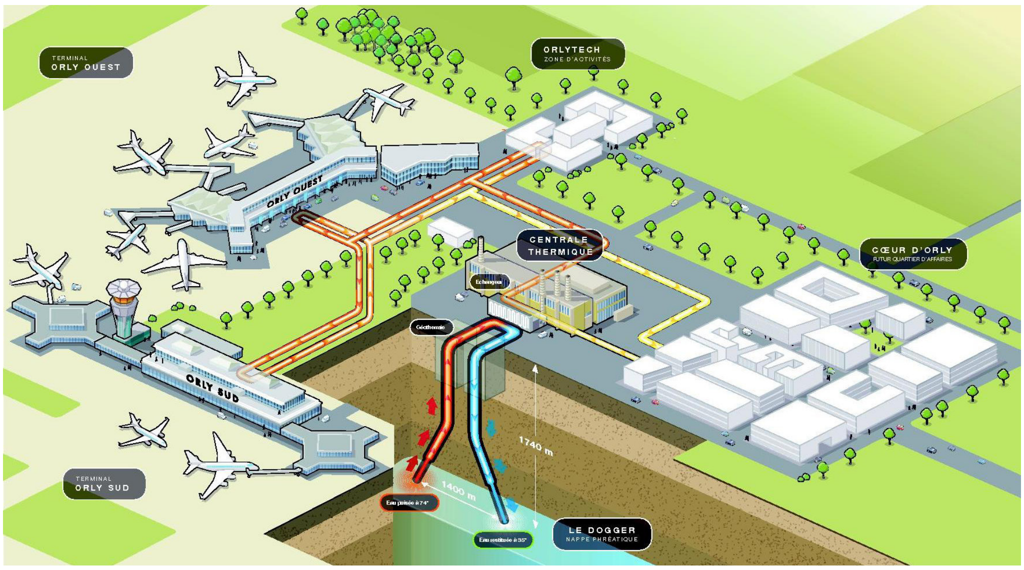
FINANCING

INVESTMENT FOR GEOTHERMAL WELL	9M€ for the doublet system		
INVESTMENT FOR DH NETWORK AND SUBSTATION	Not part of geothermal plant	FINANCING (BANKS, FUNDS, PPP…)	Banks, Funds, “Fonds Chaleur”
AMOUNT OF SUBSIDIES IF ANY	27,4%		

TECHNICAL

INSTALLED CAPACITY (MWTH)	135 MWth	INNOVATION IF ANY	The use of absorption heat pumps driven by straw district heating boiler, which makes it free to drive the heat pumps.
OPERATING TEMPERATURE OF THE DH	max temperature 105°C	TEMPERATURE OF THE GEOTHERMAL RESOURCE (PRODUCTION - INJECTION)	74°C - 40°C
GEOTHERMAL FLOW RATE	300 m3/h	DH LENGTH	35 km (108 sub-stations)

Figure 15. Aéroport de Paris- Orly



HÓDMEZŐ-VÁSÁRHELY

GENERAL

OWNER	Municipality	OPERATOR	Municipality
REGION	Southern Hungarian Plain		

PROJECT

INHABITANTS CONNECTED	2725 flats plus 130 institutional consumer	DESIGN OF THE DH	8 production, 2 injection wells were installed since 1967
OTHERS USES (DRINKING WATER, CASCADE USES...)	Household warm water, balneology (thermal bath plus swimming pool)	PRODUCTION OF HEATING AND/ OR COOLING	188500 GJ/y
PLANNING OF THE OPERATION (FROM PRE-STUDIES TO FULL COMPLETION)	3 years/new installation (for example a new injection well)	DATES OF BEGINNING AND END OF CONSTRUCTION	1967 - 2013
ADMINISTRATIVE PERMITS	Water management operating permit	DIFFICULTIES FACED	Injection
COMPARISON WITH FOSSIL ENERGIES	71.7% of gas price		

FINANCING

COST OF THE MWHPRODUCED	3.7 €/MWh (excluding investment costs)

TECHNICAL

INSTALLED CAPACITY (MWTH)	18,66 MW of geothermal energy 20 MW full power of the district heating	TEMPERATURE OF THE GEOTHERMAL RESOURCE (PRODUCTION - INJECTION)	90-105oC of the produced, 30-50 of the injected water
OPERATING TEMPERATURE OF THE DH	80-87oC in the heating system 40-42oC of the household warm water	HEAT PUMP (POWER IN MWE AND COP)	No
GEOTHERMAL FLOW RATE	1200 liter/min/well	DH LENGTH	> 10 km
INNOVATION IF ANY	15 years re-injection into sandstone reservoir, cascade system		

Hódmezővásárhely GeoDH, Photo: Ádók J.

6 Recommendations

FOR DEVELOPING GEOTHERMAL DH

6 Recommendations

FOR DEVELOPING GEOTHERMAL DH

Based on the project results, the GeoDH consortium suggests three main drivers for geothermal DH development in Europe:

FIRSTLY, THERE IS THE NEED TO CONTINUE INCREASING AWARENESS AMONGST DECISION-MAKERS AND INVESTORS WITH COMMUNICATION CAMPAIGNS CONCERNING THE IMPORTANCE OF THE HEATING SECTOR, THE BENEFITS OF DH SYSTEMS, AND THE POTENTIAL AND ADVANTAGES OF GEOTHERMAL ENERGY.

Currently, there are around 250 geoDH systems in operation in Europe, with a total installed capacity of about 4,400 MWth and an estimated annual production amounting to some 13,000 GWh/y. Many new geoDH projects were announced 2013-2014. The near future is very bright, with more than 200 geoDH projects in development all over Europe. Future hot markets will be in Central & Eastern Europe States: Croatia, the Czech Republic, Hungary, Poland, Romania, Slovakia and Slovenia. For that, we need an increased level of financing, as is typically the case with infant industries.

With such a high share of gas used for heating, security of supply is a concern in many countries, especially since the ability to switch fuels is limited in the short term. Another main concern is about the affordability of heat. Energy poverty, which is for large part heat poverty, is growing in Europe due to increasing fossil fuel prices. GeoDH is one of the solutions for this.

SECONDLY, MORE FINANCING IS NEEDED TO DEVELOP GEOTHERMAL SYSTEMS AND DH INFRASTRUCTURES ALL OVER EUROPE, AND IN PARTICULAR IN DENSE URBAN AREAS WHERE IT IS A HIGHLY COMPETITIVE OPTION. BUT A LEVEL PLAYING FIELD IS ALSO CRUCIAL AS A FLANKING MEASURE.

GeoDH technology is not new, but mature, benefitting from a 50 year history. Whilst the competition in the heating market can be regarded unfair (regulated gas/heat prices, many subsidies for conventional energy sources, lack of market transparency), geoDH technology is quite competitive. Often it is installed without any subsidies whatsoever.

Adequate incentives must be set to provide help to develop markets (geological risk insurance, financing for drilling), reduce prices, and raise investors' awareness of the technology.

Fair competition would be established with system costs and externalities integrated in the full costs of each energy technology. Externalities are notably emissions of GHG such as Carbon dioxide (CO2), Sulphur dioxide (SO2) and Nitrogen Dioxide (NO2), but also subsidies to fossil fuels and nuclear energy, and regulated electricity and gas prices. Ideally also the security of energy supply should be taken into account. The EU Emission Trading Scheme (ETS) has a twofold objective of reducing CO2 emissions while promoting new low carbon technologies. However, CO2 emission reduction is mainly due to the economic downturn, and the over allocation of allowances has pushed the CO2 price close to zero, which is undoubtedly insufficient to trigger innovation. In addition, today a carbon price is not assigned to heat installations below 20MW, which represents the largest part the sector. In order to internalise the CO2 price, a national carbon tax applying to all systems including small scale installations could be an efficient solution. That said, it is clear that because of unfair competition, the trend to decarbonise the heat sector with geothermal is slow.

FINALLY, RESPONSIVE POLICY MAKERS IN FOCAL COUNTRIES HAVE TO ESTABLISH A REGULATORY FRAMEWORK SUITABLE FOR A SUSTAINABLE DEVELOPMENT OF GEOTHERMAL DH SYSTEMS.

Regulatory barriers and long administrative procedures can result in additional costs. It is therefore crucial that a fair, transparent, and a not too burdensome regulatory framework for geothermal and district heating is in place.

What is clear is the need for a new policy for the heat sector, including the best practices to promote geothermal heat, the synergies between energy efficiency and renewable heating and cooling, and proposals to remove barriers to competition, including the existence of subsidies for fossil fuels and the long-standing regulated price for gas.Regulated prices and social tariffs applied only to fossil fuels are creating an unfair competition on the heat market.

So where lies the future of geothermal DH development? With more than 200 new geothermal DH plants likely to be installed by 2018, the forecasts are promising. However, in the heating sector, as with the electricity sector, fair competition is crucially needed because conventional technologies still receive more financial support from governments and their external costs are not integrated to their market prices.

Some technological improvement will also help to foster this development, as lowering the temperature of the networks will be the key point for development of smaller scale projects. Fostering innovation is important: in drilling, using heating and cooling, smart heat grids, in integrating geothermal heating and cooling with the built environment (e.g. use the mass of the building as storage) etc.

The future of the geothermal market remains bright in the EU and the rest of Europe. Many projects will be announced in the coming years in all European regions, representing an ever increasing market share for geothermal.

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FOR MORE INFORMATION VISIT
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