REGEOCITIES

Developing Geothermal Heat Pumps in Smart Cities and Communities

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Executive summary

We are surrounded by inexhaustible energy resources that allow us to meet our energy needs and those of future generations without taking uncontrollable risks with the life and well-being of our planet. The development of modern technology now enables 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 this demand alone. Each alternative has its specific advantages and disadvantages, and has to be applied intelligently and targeted in those places where it can deliver its optimum strength in synergy with other technologies. Used in combination renewable energy sources have a chance to meet the demand, especially for heating and cooling which represents 50 % of final energy demand in Europe.

Heat supply from geothermal energy in Europe is primarily from hot water from deep aquifers used for district heating or in a large number of small to medium shallow geothermal plants. Shallow geothermal also provides storage solutions through underground seasonal and long term storage.

Only a tiny portion of the potential geothermal energy is as yet explored and in use in Europe. Increasing the use of geothermal energy, and strengthening the geothermal industrial sector, will allow a substantial reduction of CO2 emissions, the saving of primary energy, and the creation and sustainment of a work force with many skill levels.

The potential of shallow geothermal is significant. However, shallow geothermal technology 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.**
- **The development of innovative financial models for small-scale shallow geothermal 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 ReGeoCities project (2012-2015) works on these issues, involving several stakeholders.

The main ReGeoCities results include:

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

b. **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.

c. **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.

d. **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.

Introduction

Heating and cooling represents around 50% of EU's final energy consumption. Buildings consume more than two thirds of the thermal energy in Europe and buildings hold a large untapped potential for renewables and energy efficiency in order to decarbonise the EU economy, to ensure security of supply, and to provide cost savings to EU households and businesses alike.

In this context, shallow geothermal energy, including ground source heat pumps (GSHP) and Underground Thermal Energy Storage (UTES, including ATES and BTES), represents a renewable energy source (RES) with a vast potential of energy savings for heating and cooling of buildings. Shallow geothermal could achieve up to 70% energy savings compared to traditional H&C systems. However, this sector is tackling challenges related to regulatory barriers at different levels which are affecting the implementation of those systems in cities.

The ReGeoCities project is focused on the achievement of the National Renewable Energy Action Plans (NREAP) geothermal targets for 2020 in countries with ambitious objectives regarding GSHP, by means of the removal and clarification of the non-technical administrative/regulatory barriers at local and regional levels. These barriers, not only from the point of view of the resources, but also from a point of view of administrations, are analysed in order to overcome the current situation which is restricting the introduction of shallow geothermal as renewable systems for H&C buildings.

Furthermore, this project assesses current legal barriers for shallow geothermal in mature markets (Germany, France, Denmark, the Netherlands) and juvenile markets (Spain, Romania, Italy). The project has the objective of developing a common methodology for the regulation of shallow geothermal systems in cities and communities. The project thus directly addresses the need arising from article 13 of the RES directive, calling for clear and fast administrative procedures.

One outcome of the project is a set of recommendations to be used as a powerful tool during the regulation of shallow geothermal systems. Some specific tasks of the project are:

1. Description and analysis of the different scenarios of cities;
2. Presentation legal framework for shallow geothermal;
3. Identification of the main regulative barriers;
4. Compilation of best practices and experiences from mature regions;
5. Development of the common pre-normative framework;
6. Implementation of training programs and help desks offices focused on the decision makers and the administration staff;
7. Implementation of results in selected cities and development of regulation adopting the methodology.

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 view on integrating these technologies in cities and rural communities to make them smarter. The third chapter discusses the licensing procedures necessary to realise a shallow geothermal project and the regulatory and market conditions in the project countries; a number of key recommendations for policy-makers are put forward. Chapter four deals with public acceptance of this technology. The fifth chapter is about financing, costs, and support schemes available. Chapter six and seven present the ReGeoCities training activities on shallow geothermal and concrete cases studies. Lastly, chapter 8 brings together a number of lessons learnt and final recommendations stemming from the 36 months of work on the local, regional, and European levels.

1

Technology: State of play and developments

1 Technology: State of play and developments

Introduction

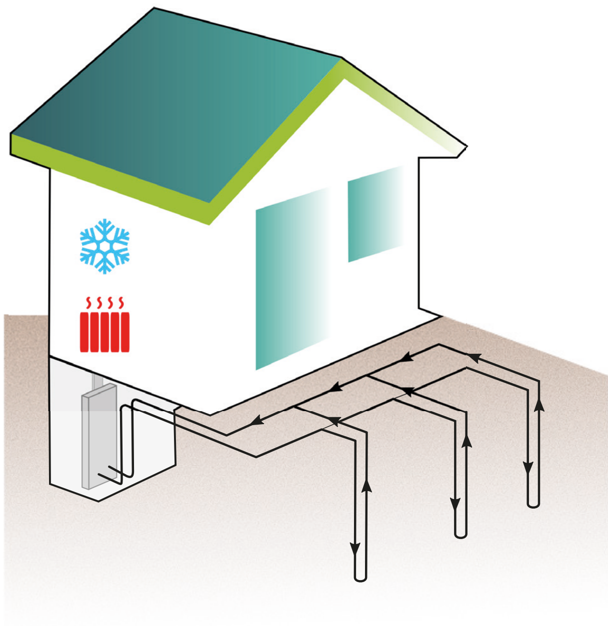
Shallow geothermal energy is available everywhere, and it is harnessed typically by ground source heat pump installations, using a heat pump to adjust the temperature of the heat extracted from the ground to the (higher) level needed in the building, or to adjust the temperature of heat coming from building 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 with BHE fields or aquifer systems also qualify for the term 'storage'; In all these large installations it is crucial to pursue a long-term balance of heat extracted from and injected into the ground.

The different natural ground temperatures throughout Europe, from 2-3°C near the polar circle to about 20°C in the very South of Europe, have a great influence on the options and design for shallow geothermal

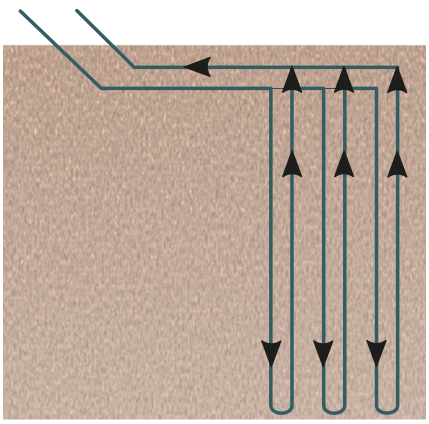
Figure 1
A closed loop system in a house



installations. Taking into consideration the building loads, the climatic zone the site is in, and the thermal and hydraulic parameters of the underground on site, the plant design has to guarantee that temperatures in the underground systems are kept within a given range in the long term. This temperature range is defined on one side by the technical (thermal) requirements of the building system, and on the other side by environmental considerations concerning the groundwater and ground at the specific site.

Often buildings have a rather unbalanced heating and cooling demand, either given by their climatic surroundings (very cold and warm climates), or by the specific use of the building (there are e.g. shopping malls even in Northern Europe that require virtually no heating, but a lot of cooling). In these cases, hybrid systems are designed to cover as much load as possible from the geothermal system, and to balance the heat in the underground by separate sources like cold air in winter or at night time, waste heat, solar heat, etc. Using all the different design options available to geothermal design allows for small and large, energy-efficient, economic, and reliable installations all over Europe. A nice example here is the case of the Swedish company IKEA. A growing number of stores from Sweden to Spain (and in the USA, too) are equipped with shallow geothermal technology of different types, and adapted to the respective geological and climatic situations.

In terms of number of installations, installed capacity and energy produced, shallow geothermal energy is by far the largest sector of geothermal energy use in Europe. It enjoys the widest deployment among European countries, with very few countries having no shallow geothermal installations at all.



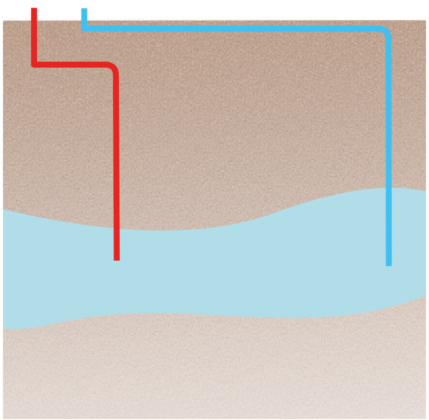


Figure 2 (left)
A closed loop system

Figure 3 (right)
An open loop system

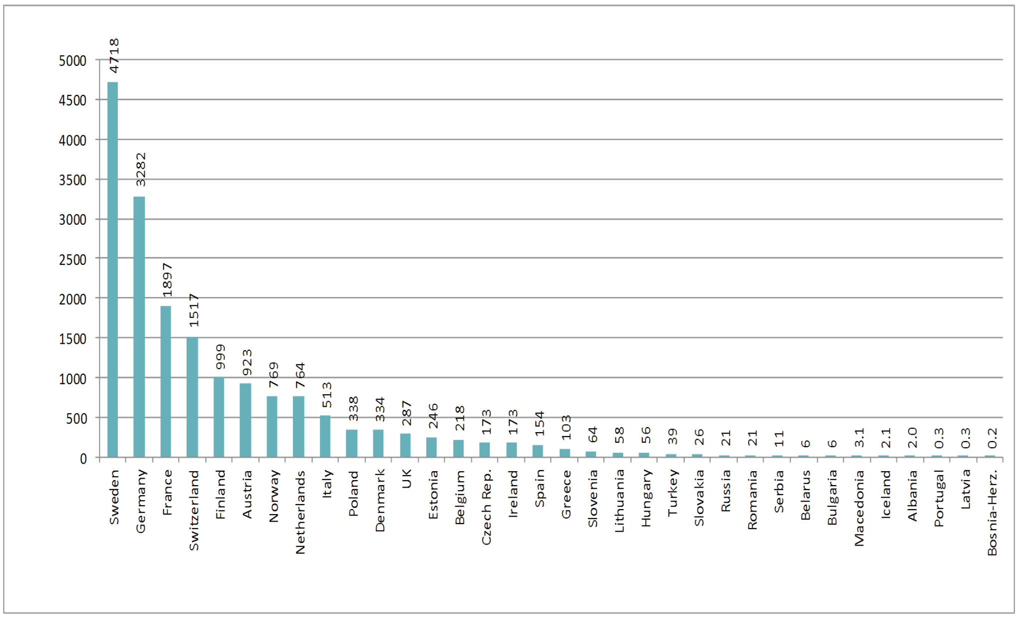
Market development

For shallow geothermal energy (GSHP and UTES), the overall installation growth is steady. It is estimated that at the end of 2013 the installed capacity was 17,700 MWth distributed over more than 1.3 million GSHP installations. As exact data for 2013 is only available for a few countries, this is based partly on some extrapolation, taking into account that in countries with a mature market, a growing share of the sales of new heat pumps goes into replacement of older units. Thus 5% was deducted from the total number of GSHP installed, to account for this replacement and for abandoned installations.

The countries with the highest amount of geothermal heat pumps are Sweden, Germany, France and Switzerland (figure below). These four countries alone account for ca. 64% of all installed capacity for shallow geothermal energy in Europe. Looking at the time period 2010-2015, these four big players will have the greatest increase in terms of number of installations. In relative terms, Italy, Poland and the Czech Republic are among the countries with the highest growth rate.

The European-wide growth rate of the market for shallow geothermal systems was steady for some time with new market actors filling the gaps left by others with decreasing sales. As shown in the figure overleaf, with this growth the renewable heat used through GSHP has increased further between 2012 and 2013; however, it might have been much bigger under more favourable circumstances!

Figure 4
Installed capacity in MWth of geothermal heat pumps in European countries (2012)



However, today the GSHP market today is 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. This is also obvious from the trend towards a higher share of air-source heat pumps in the total heat pump sales in Germany, resulting in an all-time low of 35% GSHP in 2013. The longer procedures and higher installation cost lure consumers to the seemingly cheaper air-source alternative, even with the need for electric resistance back-up for air source, and in light of the much higher efficiency of GSHP. The latest information gained from monitoring done in Germany by Fraunhofer ISE (Freiburg) shows an advantage of around 30% for the geothermal source.

Across Germany and some other neighboring countries, GSHP systems are becoming less competitive; as the cost of electricity (which is required to run the heat pump) increases, the use of fossil fuels such as natural gas for heating becomes more favorable financially. In developing markets, the growth rate is low, minus 20% sales in some countries, and juvenile markets are not really progressing. Here the aftermath of the economic crisis and the low rate of construction in some countries take their toll. With an economic recovery, a new increase in the GSHP market can be expected.

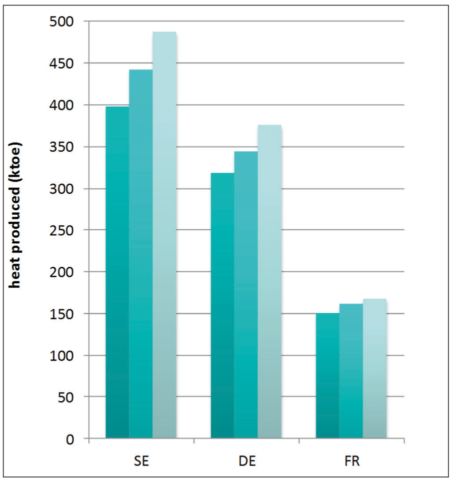
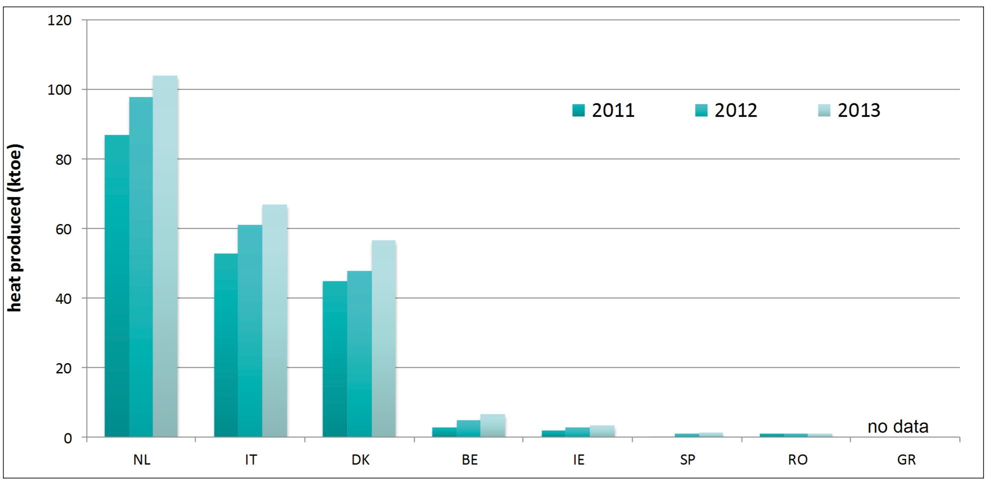


Figure 5-6
Heat produced by the existing geothermal heat pumps in the ReGeoCities project countries with mature (left) and emerging (bottom) markets for the years 2011-2012, after EurObserv'ER Heat Pump Barometer and EurObserv'ER Report #14 (values for 2013 calculated by EGEC, assuming the same production per unit as in 2012.)



What are the main reasons for the current lull in the market?

1. Insufficient awareness about this technology and its advantages. In particular, architects, the building sector, and local authorities need to be better informed.

2. High upfront investment is an issue. Because of the drilling, geothermal heat pumps can be considered as a capital-intensive technology in comparison with other small scale applications. The lifecycle analysis is not taken into account when comparing with alternatives

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 fossil fuel heating systems will allow the phasing out of any subsidies for shallow geothermal in the heating sector.

4. Regulations need to be simplified further.

5. Bad publicity from problematic projects in Germany and recently in France and The Netherlands.

2

Geothermal in smart cities and in smart rural communities

2 Geothermal in smart cities and in smart rural communities

Geothermal will be a key energy source both in smart cities and in smart rural communities, being able to supply both heating and cooling (H&C) and electricity. Shallow geothermal assisted by heat pumps produces H&C in urban and rural areas and will provide solutions for the future energy system by coupling smart thermal and electricity grids via underground thermal storage and heat pumps.

Suitable shallow geothermal technologies

Shallow geothermal systems are very versatile and can be adapted to almost every subsurface condition. Typically the ground system is linked to a heat pump to achieve sufficiently high temperatures. Ground systems can be classified generally as open or closed systems, with a third category for those not truly belonging to one or the other. To choose the right system for a specific installation, several factors have to be considered:

- Geology and hydrogeology of the underground (sufficient permeability is a must for open systems).
- Area and utilisation on the surface (horizontal closed systems require a certain area).
- Existence of potential heat sources like mines.
- The heating and cooling characteristics of the building(s).

In the design phase, more accurate data for the key parameters for the chosen technology are necessary, to size the ground system in such a way that optimum performance is achieved with minimum cost. GSHP systems (closed or open loop) or underground thermal energy Storage can be used as enabling solutions for energy system integration.

Geothermal heat pump systems for individual and tertiary buildings: small and large scale systems providing low temperature heating, cooling and domestic hot water to new near-zero-energy-buildings (NZEB) and to existing buildings when renovated

Shallow geothermal systems are very versatile and can be adapted to almost every subsurface condition. They can be used in different kind of structures, from small, residential houses to large individual buildings or complexes of buildings, such as offices, hotels, schools, shopping centres, and so on.

The residential sector generally employs heat pumps produced in larger series and with standard heating capacities from ca. 5 to 20 kW, while for the commercial sector the installation tends to be much larger. For large complexes, heat pumps with capacities from ca. 50 kW upwards are usually constructed individually or in smaller numbers, and adapted to the specific site conditions.

The range of application for GSHP is wide. They can be used everywhere at any time.

The maximum delivery temperatures typically are in the order of 50-55°C (with new developments offering increased values of 60-75°C for refurbishment of older buildings), and in cooling mode ca. 6-7°C.

Underground Thermal Energy Storage: Borehole Thermal Energy Storage (BTES) or Aquifer Thermal Energy Storage (ATES) for H&C storage (low and medium temperature)

The low temperature in the ground can also be changed artificially though storage of heat or cold, creating geothermal energy storage (or Underground Thermal Energy Storage, UTES). The highest storage temperature achieved in underground storage is about 90°C, the lowest (for cooling) ca. 5°C. The heat sources for storage can vary, however, waste heat or solar heat are typical. For cold storage, the cold ambient air in wintertime or during night is the cold source.

These two technologies can be installed for grid or off-grid H&C systems, so they perfectly suit the new energy approach of smart cities and communities. Shallow geothermal technologies will be developed in the new generation of District Heating: smart thermal grids.

Moreover, they allow the establishment of smart connections with the electricity grid and participation in future smart electricity grids management. Geothermal HP can balance the grid consumption and the UTES offers a perfect solution for storage.

Integration of shallow geothermal systems in cities and buildings

Shallow geothermal systems can be used in all parts of a city, at any scale, from individual single family houses to a whole city district as a part of a district heating/cooling network.

At building level, no legislative barriers or permit related barriers for implementation of shallow geothermal energy systems has been identified, besides historical buildings / buildings of cultural value which may have general restrictions in case of retrofit, installations of new distribution systems, etc.

In Greece, Italy and Spain building codes set minimum requirements on renewable energy sources including shallow geothermal when retrofitting. Regulations in Belgium, France, Germany, Denmark and Sweden take primary energy into account, electrically "heat pump heated" buildings including shallow geothermal-buildings have higher energy requirements than others in terms of "purchased energy" (lesser kWh/m2/yr). Most of the latter countries have not yet any specific energy requirements for refurbished buildings.

At a general level, the indoor installations are of the same size or smaller than a corresponding boiler system, but require on the other hand a centralised (hydronic) system for comfort heating/cooling as well as for sanitary hot water. For buildings with both heating and cooling demand, the equipment can be used for both, saving space and initial investment cost.

At a city zone level, there are several different aspects of shallow geothermal energy use to be considered, dependent on the area and its use. As an example, a small visual footprint and a low noise level (neither chimneys nor fan-coolers) is a benefit of shallow geothermal systems in general, however it is more important in areas where preservation is a key issue, like an old town, than it is for a new commercial centre. Other benefits in addition to low outdoor noise level and small visual impact are the lack of air polluting emissions and the elimination of the risks from legionella in evaporative roof coolers.

In denser areas, large shallow geothermal seasonal storage systems are more competitive or even necessary to grant everyone access to underground heat/cold. Large systems can also be shared between buildings. In denser zones with large buildings/ systems less densely built zones nearby like parks can be used for the underground part of the shallow geothermal installation.

In sparse urban settlements there is enough space between individual systems for a natural thermal recovery, while large systems needs to be thermally balanced as example by annually using as much heat as cold, or by recharging with a free source like a solar collector.

A general barrier for shallow geothermal is that the heating/cooling infrastructure in many cases is already in place in built areas. This is however more of a problem in older settlements and areas with special attention to preservation where a refurbishment of the infrastructure is not easily accomplished.

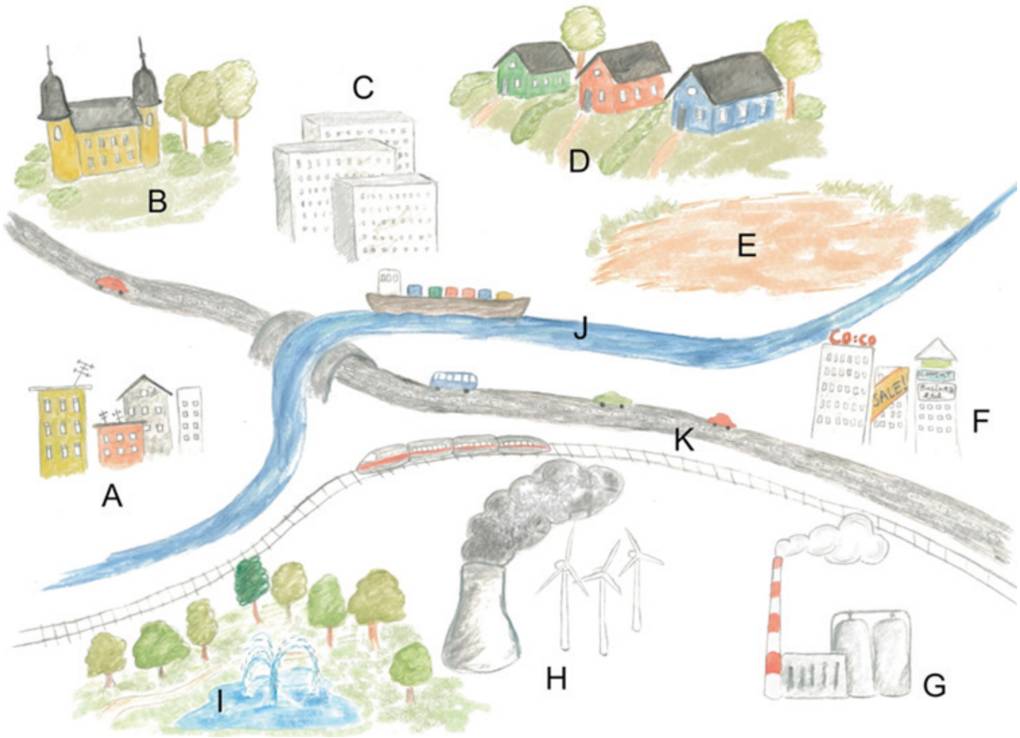


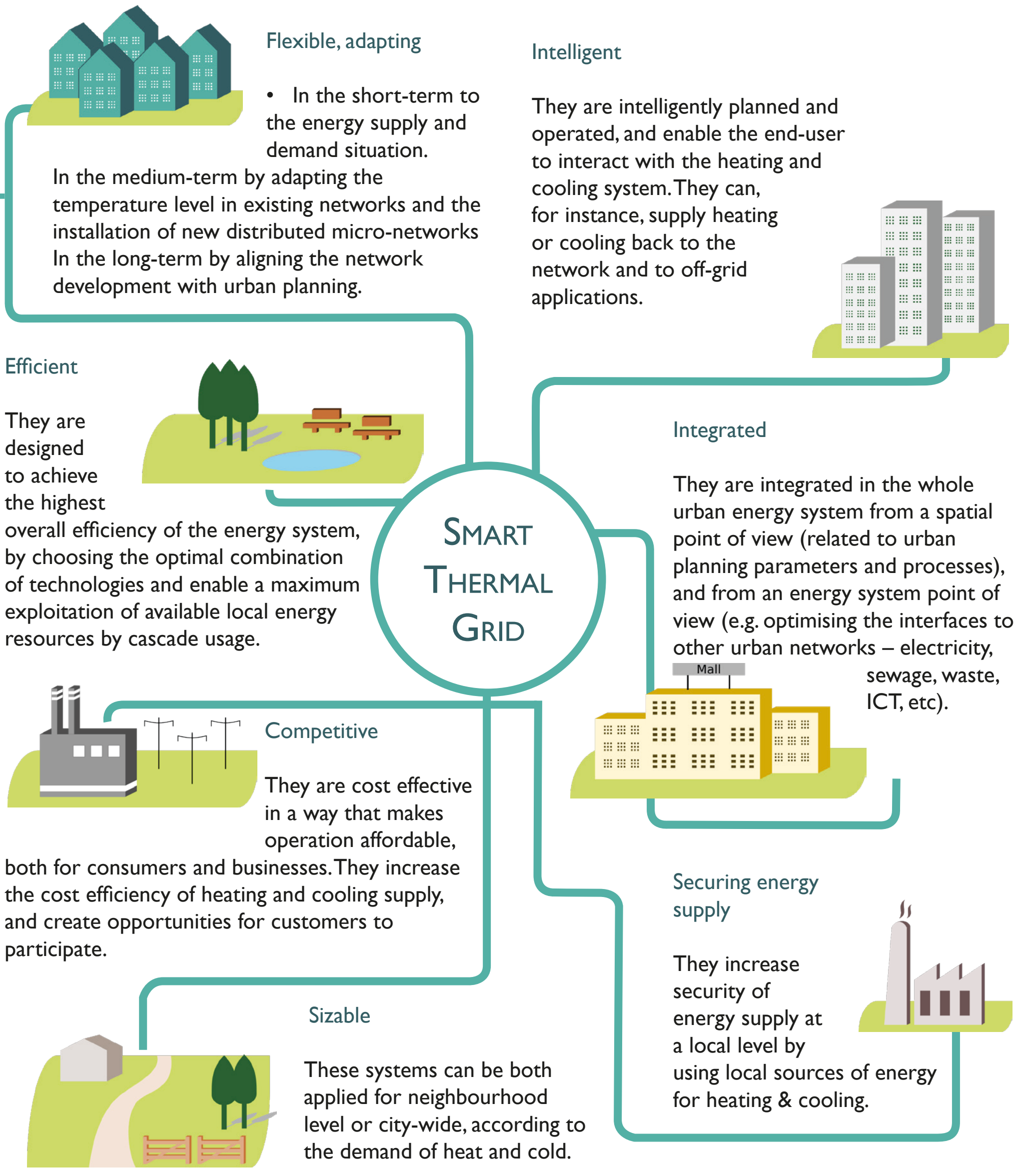
Figure 6
City zones from ReGeoCities land area classification

	Zone	Explanation
A	Older settlements	Older areas of the city, but without special attention to preservation. Different sizes and ages of buildings.
B	Areas with special attention to preservation.	For example cultural areas, environmentally protected areas, water protection areas etc.
C	Dense urban settlements	Suburbs, multifamily houses, public services, hotels
D	Sparse urban settlements	Single family houses with gardens and two floor terraced housing
E	Urban development areas	Areas with potential for new buildings
F	Commercial operation areas	Office complexes, commercial buildings
G	Industrial area	Terminal areas with logistic zones and manufacturing industries (Handling of goods, containers and so on), industrial settlements
H	Areas for the technical sustainment of the city	Energy production, sewage plants etc.
I	Park areas	
J	Water areas with waterways	
K	Main roads and railroad tracks	

Towards smart thermal grids

Smart thermal grids can play an important role in the future smart cities and communities by ensuring a reliable and affordable heating and cooling supply to various customers with renewable energy carriers like geothermal energy. Smart thermal grids have the following characteristics to make this possible:

Figure 7
Smart grid aspects



3

Regulations for shallow geothermal in cities

3 Regulations for shallow geothermal in cities

The ReGeoCities project has undertaken an analysis of the shallow geothermal energy market conditions in different regional, municipal and local jurisdictions across EU Member States with varying degrees of market maturity.

European legislative framework for geothermal

The framework of the EU action on climate change is based on the 20-20-20 goals, which are headline targets of the European 2020 strategy for growth:

1. Reduction of at least 20% in greenhouse gas (GHG) emissions compared to 1990 levels;
2. 20% of the final energy consumption to come from renewable sources;
3. Improvement of energy efficiency by 20% compared to 2007 projections.

Together with EU-wide and national targets - binding for GHG emissions reduction and renewable energy, indicative for energy efficiency - a set of legislation has been adopted with the aim of delivering the expected results by 2020:

- **Directive 2009/28/EC on the promotion of the use of energy from renewable sources (RES Directive)** has been the most significant piece of EU legislation for RES. Amongst other things, the RES Directive sets legally binding targets for member states. It also puts forward a number of measures aiming to overcome the following crucial barriers preventing renewables from entering the energy market: long and discriminatory administrative procedures, rigid local plans, lack of information, and shortage of skilled workers.

  Article 13(4)-(6) requires member states to introduce in their building regulations and codes appropriate measures in order to increase the share of all kinds of energy from renewable sources in the building sector. As of 2015 member states should in particular, and where appropriate, set minimum levels of renewables in new buildings and in buildings undertaking major renovations. This directive also places specific requirements on public buildings to fulfil an exemplary role (since 2012) and requires, in each EU country, training and certification schemes for small scale renewables, including GSHP.

- **The Energy Performance of Buildings Directive 2010/31/EU (EPBD)** is the main legislative instrument to reduce the energy consumption of buildings. Under this Directive, Member States must establish and apply minimum energy performance requirements for new and existing buildings. The Directive also requires Member States to ensure that by the end of 2020 all new buildings are 'nearly zero-energy buildings' (by 2019 for public buildings), which means that the low energy demand should be covered by renewable energy sources produced on-site or nearby.

- **The Energy Efficiency Directive 2012/27/EU (EED)** proposes new measures on buildings. For instance, Article 4 requires member states to develop renovation strategies for their entire building stock, while Article 5 sets out the obligation to renovate 3% of the total floor area of heated and/or cooled buildings owned or occupied by central government.

  Article 14 (3) provides that, for the purpose of this assessment member states shall carry out a cost-benefit analysis covering their territory based on climate conditions, economic feasibility and technical suitability in accordance with Part I of Annex IX. The cost-benefit analysis shall be capable of facilitating the identification of the most resource- and cost-efficient solutions to meeting heating and cooling needs.

- **The Ecodesign Directive (2009/125/EC) and Energy Labelling Directive (2010/30/EU)** are two of the most effective policy tools in the area of energy efficiency. Ecodesign aims to improve the energy and environmental performance of products throughout their life cycle, while energy labelling requirements aim to provide citizens with information about environmental performance of products and thereby incentivise industry in the development of further improved products and innovations beyond minimum levels. Against this background, it is worth highlighting that GSHP are amongst the very few technologies to achieve the highest category A+++ in the new EU labelling system.

EU countries have agreed on a new 2030 framework for climate and energy, including EU-wide targets and policy objectives for the period between 2020 and 2030. These targets aim to help the EU achieve a more competitive, secure and sustainable energy system and to meet its long-term 2050 greenhouse gas reductions target.

The targets for 2030 are:

1. A 40% cut in greenhouse gas emissions compared to 1990 levels.

2. At least a 27% share of renewable energy consumption.

3. A 30% improvement in energy efficiency (compared to projections).

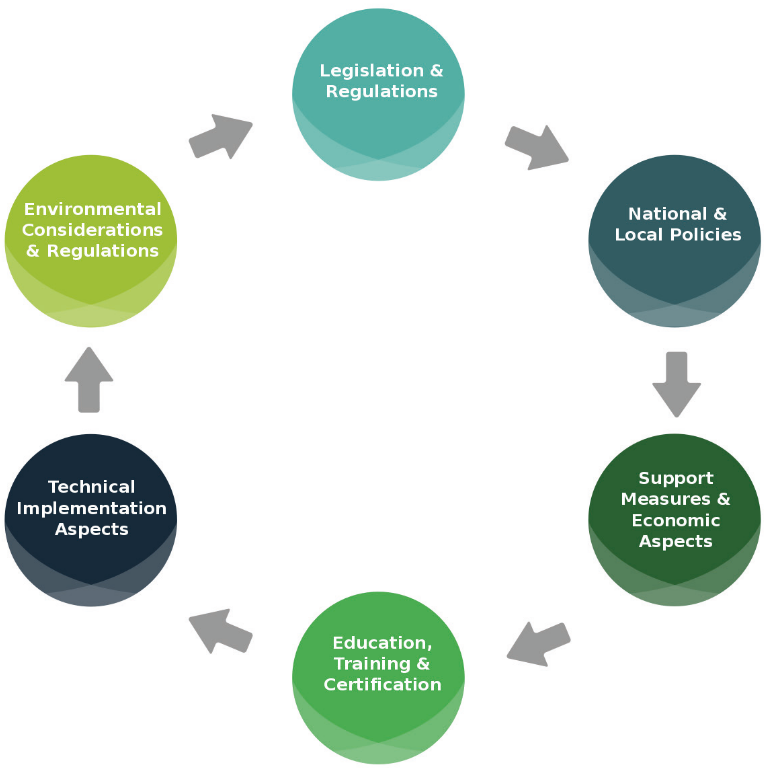
In the framework of the new climate and energy package the main directives presented above will be revised. One of the objectives will certainly be to set new measures aiming to overcome the persisting barriers and to ensure a continued market uptake of renewable and energy efficient technologies.

Regulatory barriers

A review of the different practices for the regulation, promotion and management of shallow geothermal energy resources in different local settings has highlighted the differences between mature and emerging markets. In more mature markets the administrative process is more complex and in some cases over regulated. Regions where the shallow geothermal energy market is still under development have adopted initial measure to regulate and sustain the deployment of shallow geothermal energy systems. The measures identified are an initial attempt to support the sector but additional, more comprehensive measures are required to foster future sustainable development and support civil servants from regional and local authorities involved in the permitting process for the approval of projects.

A common set of barriers preventing the sustainable growth and development of shallow geothermal energy in Europe were identified in the early part of the project. Six key aspects (figure 8) covering legislation and regulation, technical implementation of projects, environmental impact, and socio-economic aspects were considered with a view to identifying best practices implemented in the mature regions (Sweden, Germany, France, The Netherlands and Denmark) and to develop a set of common recommendations for the developing shallow geothermal energy markets.

Figure 8
Legislative, regulatory, technical and socio-economic aspects considered for the development of the shallow geothermal energy sector



Best practices and recommendations

The legislative and regulatory best practices identified in the mature regions including Sweden, Germany, France, The Netherlands and Denmark were used as a basis for developing transferrable guidelines and recommendations for the emerging markets. These recommendations are summarised in the schematic diagram below (figure 9).

In addition a set of common tools have been developed to simplify regulatory requirements and implement a transferrable methodology for registering data from shallow geothermal installations. These tools will allow local authorities to better quantify the potential for shallow geothermal energy deployment and provide a basis for improving energy planning at local level.

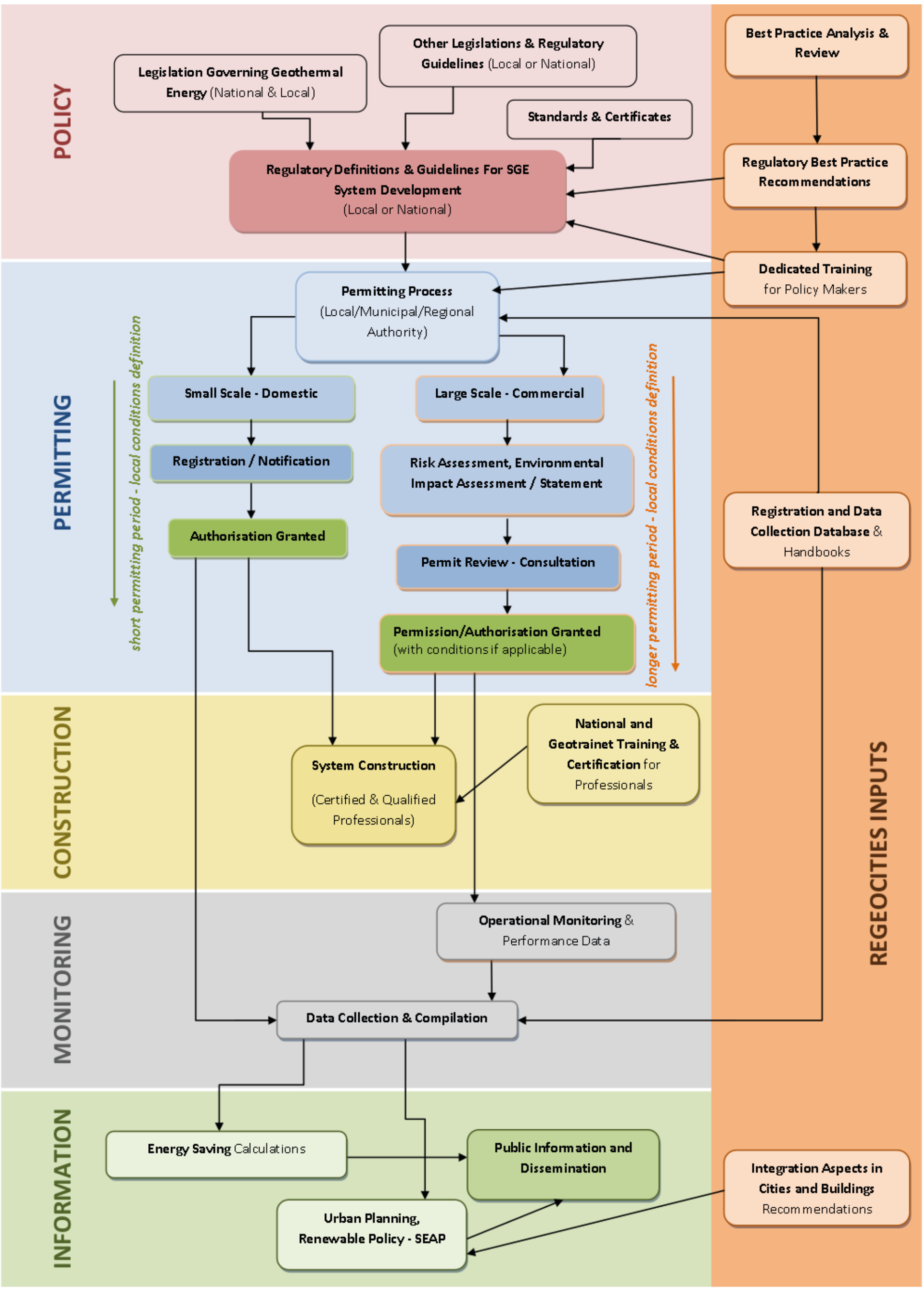
The regulatory guidelines developed in conjunction with the support tools that include a common database for registering and reporting systems (See report D.3.2 available at regeocities.eu), are aimed at facilitating local authorities in the implementation of the requirements under several EU Directives, as well as a common permitting and data collection structure for newly planned and operating systems whilst promoting the sustainable development of shallow geothermal resources and environmental protection.

The recommendations propose a centralised and streamlined administrative process, that differentiates the requirements for permitting of small domestic or residential systems through a simplified online registration or notification process. A more complex permitting system comprising risk assessment, environmental impact assessment, permitting, and subsequent monitoring is recommended for larger scale systems.

The implementation of these guidelines at local level facilitates the compilation of detailed information on shallow geothermal energy potential and utilisation. The guidelines will also provide a uniform methodology of calculating energy produced from shallow geothermal energy systems as well as promoting technology information dissemination amongst decision makers who are responsible for energy planning al local authority level.

More information on regulation is available at www.regeocities.eu

Figure 9
Regulatory Framework Recommendations - Schematic Diagram



4

Public acceptance

4 Public acceptance

Geothermal energy makes up one relevant component of the future energy supply in Europe. Its big advantage is that it can offer a wide range of applications in the field of both electricity, and heating and cooling, and it has a great potential for development in many European states. Therefore, it is an ecologically and economically worthwhile local energy solution for a very wide public (local communities, industry, and citizens and consumers,).

However, the advantages of using shallow geothermal for H&C, besides improving efficiency, are little known, and media reports focus more on disadvantages than advantages. As a result, political decision makers and investors have concerns about possible risks involved in implementing geothermal projects, and social resistance often results in practical obstacles - such as significant slowdowns - to the deployment of the projects.

To make sure that geothermal energy can play its role in Europe's future energy supply in an optimum way, it is essential to engage with strategic groups including political decision makers, possible investors in geothermal projects, the general public, and local communities in order to alleviate possible concerns which might hamper the increased use of geothermal technologies.

Geothermal is fully recognised to be a safe, reliable, environmentally benign renewable energy source. However, all human activities have an impact on nature, including the construction of shallow geothermal installations.

Environmental impact

Geothermal heat pumps contribute strongly to emission reduction and to primary energy savings, both big advantages for the environment.

However, any perforation into the underground carries a possible environmental risk, in particular concerning the groundwater. Because groundwater is a premier source of good drinking water, its protection has the highest priority when drilling for a BHE or a groundwater well for thermal use. Proper regulations to guarantee groundwater protection are in place in the countries with a developed GSHP market, and such regulations will also be required in all other countries.

Reliable groundwater protection and sustainable, clean installation and operation of a GSHP plant requires knowledge on the side of planners and installers (drillers), but also on the side of the authorities.

Education, training and certification are the key to guarantee a skilled workforce and responsible work.

The Heat Under Your Feet campaign

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 focuses on filling the awareness gap about the technology and on tackling some of the challenges and barriers that leave the potential of geothermal heat pumps unexplored or underdeveloped in many European countries.

The campaign uses mainly digital channels with the intent of reaching the widest audience possible, and aims at becoming an information hub and a reference point for shallow geothermal energy. The campaign website contains information on how the technology works, the benefits it can give, and useful factsheets are available for download. In a project showcase, examples of best practices illustrate how geothermal heat pumps, thanks to their highly efficient and highly versatile nature, are the perfect technology for future sustainable buildings. The campaign will continue to develop after the project conculdes, with more resources such as case studies and useful tools on financing and regulation added.

Campaign communication strategy

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 unsustainable situation. Their wide range of application, their efficiency, their reliability, all strongly contribute to provide affordable heat, to reduce emissions, and to save primary energy.

Campaign resources

The campaign resources can be found online at www.heatunderyourfeet.eu. The campaign can be contacted through twitter @heatunderurfeet

5

Financing

5 Financing

Costs and prices

It is possible virtually everywhere to drill for a GSHP, and the cost is not so much different from one location to another; the cost is site dependent, however the variation is not as great as it is for deep geothermal systems. Nevertheless, the investment cost of a GSHP is influenced by the geology of the underground. To drill in granite is easier and quicker because it is possible to drill with air and a downhole hammer, on the contrary it is slow to drill in clays and sands, where conventional rotary rig with mud and temporary casing might be required. The availability of groundwater limits the choice of open or closed systems and thermal properties of the underground control the necessary BHE length.

The operational cost is mainly influenced by electricity and fuel prices, and by the efficiency of the GSHP system (SPF). Systems used for heating and cooling can usually be more efficient than heating or cooling only systems, as the underground installation is used all year round. The price of heat and cold from a GSHP meanwhile falls into the same range as conventional alternatives, including the amortisation of investment cost. For large commercial installations with both heating and cooling needs, geothermal heat pumps or geothermal energy storage can result in substantial reductions in operational cost, with favourably short payback periods. In many cases the geothermal system can reduce the room required in the building for the heating and cooling system (e.g. by replacing cooling towers), and thus free valuable area for more profitable use.

Residential geothermal heat pumps with a capacity of 10 kW are routinely installed for around 1500-2500 € per kW for closed loop systems. When the capacity is over 100 kW (large residential and tertiary buildings, schools, museums), the cost range for open loop systems is 500–800€ per kW installed.

UTES systems for commercial and institutional buildings as well as for district heating and cooling have a capital cost of 100-150 K€ per MWth referring to Swedish and Dutch experiences. The operating cost is commonly 25-30€ per MWh (SPF varies normally in the range of 5-7).

Support schemes

Support schemes are here more for removing barriers like awareness; they can play a role in the promotion of geothermal. Financial incentives schemes are not available in all European countries for supporting ground source heat pumps, although the competition on the heating sector can be considered as unfair with fossil fuels still receiving subsidies.

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, loans with zero interest rate. They should have a link with quality, certification etc.

As geothermal heat pumps can be considered a mature and competitive technology, a level playing field with the fossil fuel heating systems will allow phasing out any subsidies for shallow geothermal in the heating sector.

In the geothermal heating sector, there is a predominance of investment grants, in certain cases accompanied with or substituted with zero interest loans. Operational aid similar to a feed-in tariff system is now beginning to be explored in some Member States, partly because of the inclusion of the sector into the European regulatory framework (20% target).

The table below gives some (non-exhaustive) examples of financial mechanisms in force for ground source heat pumps:

Financial Support to Geothermal Heating	
Investment grants	France (Fonds chaleur renouvelable) for collective office buildings; Germany; Hungary; Greece; Poland; Romania; Slovakia; Slovenia; Italy (Conto Termico)
Feed-in tariff	The Netherlands (SDE+); UK (Renewable heat incentive)
Operating aid	France: VAT reduction for DH, rebate on tax on revenues for individual houses; Hungary; Italy; Netherlands
Low or zero interest loans	France: for individual housings; Germany; Hungary; Netherlands; Poland; Slovenia; Spain
CO2 tax	Finland, Sweden, Denmark

Figure 10
Financial support schemes for geothermal H&C in selected EU countries

The complexity of the sector as well as the variety and the predictability of tools used to support geothermal heat technology do not make the analysis easy. It is perhaps for this reason that the policy makers often dismiss the issue with a few lines stating that the heat market is local and requires local solutions.

However, there a the need for an in-depth analysis of the sector, including the best practises to promote geothermal heat, the synergies between energy efficiency and renewable heating and cooling, and barriers to competition, including the existence of subsidies for fossil fuels and the long-standing regulated price for gas.

Risk insurance

Regarding shallow geothermal, one system exists in France (Aquapac). AQUAPAC is an insurance to cover the geological risk associated with aquifers up to 100 m depth. This scheme concerns only heat pumps with a capacity above 30 KW. It is a double guarantee, with two aspects:

- the research guarantee covering the risk to fail with lack of resources to run the installations;
- the perennial guarantee about the risk of resource deterioration, during a 10 years exploitation period.

Towards innovative schemes

For heating systems of buildings, if a competitive renewable source of energy such as geothermal is planned to be installed but has high capital costs, this barrier can be removed with the following measure:

- an ESCO takes the responsibility of the investment (for example, the boreholes for individual or collective buildings, and eventually the heat pumps);
- then, it sells to the customer the heat extracted for the borehole heat exchangers, via an adapted accounting system, at a fixed sale price, which is added to his electricity/gas invoice. Contractual conditions must be defined (duration for example).

Support schemes could cover the feasibility and design of such systems, while another possible innovative measure for geothermal heat pumps is the possibility of receiving discounts on the price of electricity.

Overall, geothermal heat technologies are, with some exceptions, heading for competitiveness. A level playing field with the fossil fuel heating systems will allow for phasing out any subsidies.

For instance, today a carbon price is not assigned to installations above 20MW, which is the largest part the sector. In order to fix the price of CO_2, a national carbon tax applied on all systems including small scale installations could be an efficient solution.

Life Cycle Cost analysis

The LCC of GSHP systems in Europe can be summed up as follows:

- The major costs of GSHP system are capital or investment costs that are mainly influenced by the drilling and in general by installation costs.
- The analysis of regulations and legal permit costs in some European countries showed the difficulty of estimate exact costs due to the fact that administrative fees vary at local level.
- These high initial costs are balanced by lower maintenance and operating costs (depending on electricity prices and heat pump efficiency)
- The investments without a LCC approach in the selection of the cost-effective technological solution for heating and cooling disadvantages GSHP systems.
- An effective set of regulations, guidelines and standards for the promotion of shallow geothermal systems and in particular GSHP systems has to consider the costs issues;
- The LCC instrument gives investors and policy makers the opportunity to better understand the characteristics of the compared heating and cooling systems / solutions / alternatives and the base to choose GSHP over other H&C technologies.

6

Training

6 Training

In Europe, a sustainable market for ground source heat pumps has only been established in some countries like Sweden, Switzerland, Germany and Austria. Research shows that one of the barriers to the development of a wider sustainable and growing geothermal market is the lack of appropriately skilled personnel, and occasionally unsatisfactory quality of design and works. To keep quality up, a certification programme for GSHP workforce is also required. There are four groups of professionals involved in a GSHP project:

- The designers (feasibility study: energy needs + design study), are often also the project managers: engineers (geologists, hydrogeologists, HVAC specialists etc.)
- The drillers who make the boreholes and install the ground heat exchanger pipes.
- The heat pump manufacturers who provide the HP
- And finally the providers of pipes (to connect the system) and of the manifold, finish the installations. Installers/building engineers to make the delivery of the heat/cold in the building possible.

Moreover, GSHP projects are accompanied by regulations and monitoring from local authorities. As a fundamental step towards the removal of most of the regulative barriers to shallow geothermal system growth, the ReGeoCities project developed a training program focusing on key personnel from local authorities, responsible for the management and development of shallow geothermal projects. The training action involved:

- The design of a curricula for defining training actions and content
- The organisation of training courses in fourteen countries. Feedback from these courses help to set recommendations on future training activities
- The establishment of a helpdesk for local authorities providing a set of information and technical materials, which is available online

Curricula overview

Many of the questions raised during training courses and workshops were similar, allowing for many common knowledge gaps to be identified by the project consortium. However, whilst general information can be given, national specificities mean that local authorities are the best placed to deliver accurate and up to date responses.

Next table describes the objectives, summary, contents and learning outcomes of ReGeoCities course.

Lesson 1	Shallow geothermal energy systems: an efficient and renewable energy source for thermal energy supply
Objectives	The objective of this lesson is introducing the attendants to the main ideas behind shallow geothermal energy systems and the actual situation of this technology at European and local level.
Summary	Starting from the general concept of production and distribution of thermal energy to buildings, the possibility of using the shallow underground with moderate temperatures for thermal energy supply will be explained. Actual situation of this technology across Europe will be presented, indicating the degree of penetration in the different European countries. Then, the potential of shallow geothermal systems, as well as limiting factors when it comes to apply them in practice, are considered.
Contents	Thermal energy supply in buildings This lesson revises general concepts about thermal energy supply in buildings, the different thermal energy production technologies currently available, and the importance of thermal energy in the European context.
	Shallow geothermal energy systems at European and local level Shallow geothermal energy systems are presented as one of the possible technologies for thermal energy production. Its advantages, as one of the most efficient and environmentally friendly thermal energy production systems from renewable sources, are highlighted. The actual situation in the market of this technology at European and local level is also presented.
	Potential of shallow geothermal systems Growth potential of this technology across Europe is presented, indicating the countries with higher growth possibilities, as well as the impact of this technology in national renewable actions plans. An overview of the 2020 European objectives in the area of renewable energies will be presented, arguing that thermal energy production from shallow geothermal systems can play a crucial role in the achievement of these objectives.
Learning outcomes	Main outcomes of this lesson will be a basic understanding about shallow geothermal systems as well as the actual situation and potential of this thermal energy production technology across Europe.

Lesson 2	Technical aspects and procedures involved in the development of a shallow geothermal energy project
Objectives	The objective of this lesson is the presentation of an overview of the technical aspects and procedures of a shallow geothermal energy project.
Summary	Starting from a revision of the different kinds of shallow geothermal systems, the lesson continues presenting the fundamental underlying concepts of this technology, underground heat exchange and storage. Then, the importance of an appropriate geological characterisation is indicated, pointing out the cases in which in situ tests for ground thermal characterisation are needed. Drilling technologies are presented. Finally, the lesson presents building integration of shallow geothermal systems.
Contents	Shallow geothermal systems classification. The different kinds of shallow geothermal systems are presented, discussing the concepts of GSHP and UTES. Possible options for coupling the systems to the ground are indicated, highlighting the advantages and disadvantages of both closed systems (BHE and open systems (groundwater wells)).
	Underground heat exchange, geological characterisation and drilling. Starting from a discussion on the main difference between conventional heating and cooling installations and ground source heat pumps (the use of the underground as source or sink of heat), the lesson goes on to cover how appropriate knowledge of the geological conditions where the GSHP is located, and the way of integrating ground thermal parameters in the system design, are key points for the correct development of a GSHP project. Basic concepts about underground heat exchange, a revision of the possible geological profiles and the different methods and techniques for ground thermal characterisation are presented are addressed. Shallow geothermal systems are mainly based on boreholes and wells. A description of characteristics and typologies is presented. Finally, the different drilling technologies available in the market are shown, indicating the differences between countries as well as the certificates and permits needed for drilling professionals.
	Building integration Underground heat exchange is coupled to a heat pump for upgrading natural low-temperature energy from the ground to useful temperatures. Heat pump technologies are widely used for residential and commercial space and water heating, cooling, refrigeration, and in industrial processes. This subsection revises relevant issues regarding building integration of ground source heat pumps, such as climatic conditions, building type, and demand energy profile. Finally, environmental impacts are indicated, pointing out the relevance of well-balanced systems not producing net heating or cooling effects in the surrounding ground.
Learning outcomes	Main outcome of this lesson will be the knowledge of the basis technical aspects and procedures regarding the development of shallow geothermal projects.

Lesson 3	Managing administrative procedures
Objectives	The objective of this lesson is reviewing the administrative procedures involved in the development of a shallow geothermal project.
Summary	This lesson starts by presenting the European situation regarding standardisation and normalisation in the development of ground source heat pump projects. Then, the lesson is focused on the situation at national and local level, presenting the particularities of the country in which the course is being held. Finally, the issues that are desirable to cover in any application for a permit or license to install a shallow geothermal system are presented, giving a set of recommendations suitable for a common regulative framework.
Contents	European situation. Geothermal heating and cooling is an immature market in Europe as a whole so there is little in the way of European level standardisation or normalisation of the design or installation of ground source heat pump systems. In some countries, the market has been in existence for longer and has developed to the point that there is a substantial market which has prompted development of the national standards for various aspects of the design and installation. This subsection sets out the situation on normative standards across Europe, and summarises the key aspects of the most important available standards.
	Local situation This subsection sets out the situation on normative standards for each country. Administrations involved in regulating the application of ground source system normative standards are identified, indicating their role in the project development. Participants are shown examples of project execution indicating when and how the regulating administration are involved.
	Licenses and permits – Looking for a standard application for permit for ground source heat pump system This subsection starts presenting the licenses and permits needed for the execution of shallow geothermal projects specific for the country and region in which the course is given. Then, an overview of the differences with other countries and regions is presented, highlighting the best practise cases. Finally, a set of recommendations for improving the application procedure for permit is presented. The way forward in the development of a standard application for permit for ground source system is identified for discussion.
Learning outcomes	Main outcome of this lesson will be the knowledge of the actual situation regarding the development of a shallow geothermal project, including common rules affecting all European countries as well as rules particular to the country in which the course is given. A solid knowledge of key points recommended to be included in a standard application for permit to install a shallow geothermal system will also be learning outcome of this lesson.

Advice for future training

The expected acceleration in the development of geothermal energy utilisation and the demand from industry show the present need for a fast increase in highly qualified specialists in the industry and in the public regulatory authorities. Indeed the geothermal energy sector is growing world-wide and there is an increasing demand of geothermal experts.

This assessment has led to the preparation of a proposal to help develop the workforce, with the following objectives:

- Development of education and of appropriate training structures (A training board and several training institutes) in all EU member states.
- Creation of an EU-wide certification scheme for both planners and installers of GSHP, as requested by the RES Directive.
- Defining of and assistance in development of the necessary EU-wide technical standards.
- Dissemination of results through operation networks.
- Creation of new geothermal businesses and sustain a growing market.
- Life Cycle Costs use in funding new applications.

Figure 11
Training activities overview at ReGeoCities final event, 16th June 2015

Helpdesks for local authorities

Throughout the project's interactions with local public stakeholders, two recurring themes have emerged:

- There is the need to support local authorities in regulating efficiently, and in monitoring properly and in planning smartly the development of shallow geothermal systems in cities and communities.

- There is also a general lack of knowledge about where to find for more information about shallow geothermal energy: technical data, regulations, etc. The need to have one stop-shop approach has been identified.

Local information hubs or helpdesks are understood to be the most effective in addressing these needs. In order to facilitate their development, the ReGeoCities project has developed an online pan-European helpdesk which will act as a springboard for local authorities to create their own. It provides a guiding structure and initial information which the relevant authorities can build on according to local demand and requirements.

The helpdesk, which can be accessed through the ReGeoCities website, contains:

- Key project results in form of reports, most likely to be used by national and regional authorities, specifically:
  - Database Handbook (providing guidance on the use of the database tool developed to help local authorities record and monitor installations)
  - Integration in Buildings
  - Integration in Cities

- An FAQ section, based on the subjects most commonly raised during training courses and workshops

- A contact form for visitors to submit their questions. These questions will be directed to the relevant national body.

7

Case studies

7 Case studies

European Southern Observatory (ESO) Headquarters

The headquarters of the European Southern Observatory (ESO) was built between 1976 and 1980. In 2008, Munich-based architects Auer Weber were appointed to extend the complex with office and conference facilities, plus a technical building for ESO's most advanced instruments.

The extension has been designed to be in keeping with and to respect the original building. Both new buildings have been labelled green buildings as their energy consumption will be significantly lower than is typical for buildings of this size. This is due to the well-insulated façade and because the office building is heated and cooled through concrete core activation — for which groundwater is used together with a heat pump — and supported with district heating using geothermally heated water, in case the groundwater system would not supply the required amount of energy.

Category: Office building

Where: Garching bei München, Germany

Year of completion: 2013 (renovation)

Architect/Design: Auer Weber, Munich

Implementation: BAM Deutschland

Photo: Roland Halbe

Green Lighthouse

The Green Lighthouse is a carbon-neutral building located at the University of Copenhagen in Denmark. Designed by Christensen & Co, the structure is the first public carbon neutral building in Denmark.

To achieve carbon neutrality, many green design features were incorporated to reduce energy use and provide a healthy indoor environment for students and faculty.

A heat pump ensures that solar heat, geothermal and cooling circulates around the building. This optimises the utilisation of district heat, which only comes into use if there is no solar heat in storage.

Category: Public building

Where: Copenhagen, Denmark

Year of completion: 2009

Architect/Design: Christensen & Co Arkitekter

Implementation: Hellerup Byg / COWI

Photo: Adam Mork

TNT Headquarters

The TNT building in Hoofddorp has been in use since September 2011. The design is characterised by sustainability, transparency, and connectivity.

The energy that is needed is generated sustainably by the building itself. This is done by means of heat and cold storage in aquifers in the soil. The bio-cogeneration plant required for this process runs on organic residual waste, among other things. The geothermal heat storage process supplies the heat and cold required for the building's climate control system. The heat stored is used to heat the complex in winter and the cold to cool it in summer. The building is 17.250 m2, achieved a LEED Platinum rating and a Greencalc+ rating of 1005 points and has won several prizes for its superior sustainability.

Category: Office building

Where: Hoofddorp, The Netherlands

Year of completion: 2011

Architect/Design: Architectenbureau Paul de Ruiter

Implementation: Van Rossum Raadgevende Ingenieurs B.V. / Deerns Raadgevende Ingenieurs B.V. / DGMR / BBN Adviseurs

Photo: Pieter Kers

8

Policy recommendations

8 Policy recommendations

Based on project results, The ReGeoCities consortium suggests four main drivers for shallow geothermal development in Europe:

1. Increase awareness amongst decision-makers

with communication campaigns such as "The heat under your feet"

When analysing local plans such as the Sustainable Energy Action Plans of the signatories for the Covenant of Mayors, it appears that the more commonly adopted actions are training activities and information campaigns for the deployment of energy efficiency and renewable energy sources, followed by pilot projects and installations for the development of shallow geothermal energy systems at local level.

These findings show that municipalities want to raise awareness about the possible options for the development of renewable energy sources and energy efficiency amongst citizens, and then to provide tangible projects in order to remove scepticism towards shallow geothermal energy systems.

Some SEAPs integrate more than one action that foster the development of shallow geothermal energy in order to strengthen the effort to overcome technical and non-technical barriers to the development of this renewable energy source.

The ReGeoCities analysis shows that integration of actions for the promotion and development of shallow geothermal energy systems in SEAPs is a step-by-step process that involves the municipality and its organisation, all local economic actors, as well as citizens.

The first efforts should be to solve the issue of the lack of information about benefits, possible risks, potential, and operation of shallow geothermal energy systems, and overcome related scepticism and opposition, because shallow geothermal energy is still little known amongst civil servants and citizens.

The ReGeoCities help desk, and the further development of local and regional helpdesks will help to overcome this barrier.

In particular, the assessment of local geothermal resource potential can be a crucial step in development because it can stimulate public and private investors. Therefore, policymakers should assume crucial role in starting the spread of knowledge and skills related to the promotion of shallow geothermal energy systems.

2. Establish a level playing field in the heat sector

A level playing field is not yet in place. Firstly, the heat sector is dominated by heavily subsidised fossil fuels, ensuring the control of markets by incumbent historical operators. As an example, the recent European Commission (EC) study "Subsidies and costs of EU energy" highlights that subsidies to natural gas amounted to €6.5 bn, while support to an emerging technology such as geothermal only reached €70 million. Fossil fuels subsidies must be phased-out with the utmost urgency.

Secondly, in most EU countries there is no carbon price, as 90% of the heat sector falls outside the scope of the ETS, and only a limited number of countries have a carbon tax in place in non-ETS sectors. Where a carbon tax is not politically feasible, and in order to offset this market failure, fuel switch to renewable sources of heating should be supported.

Thirdly, in order to achieve a truly competitive EU internal energy market, full competition should be guaranteed beyond electricity and gas markets to include the heat sector.

3. Develop a suitable regulatory framework

The recommendations propose a centralised and streamlined administrative process, that differentiates the requirements for permitting of small domestic or residential systems through a simplified online registration or notification process. A more complex permitting system comprising risk assessment, environmental impact assessment, permitting and subsequent monitoring is recommended for larger scale systems.

Transparent, reliable, and coherent legal framework conditions and their implementation secures the investment in the sector. A reduction of legal barriers may be obtained by implementing clear/standardised administrative procedures to obtain licences.

4. Integrate shallow geothermal as a key technology for smart cities and communities

Shallow geothermal systems can be used in all parts of a city, at any scale, from individual single family houses to a whole city district as a part of a district heating/cooling network.

Smart thermal grids can play an important role in the future smart cities by ensuring a reliable and affordable heating and cooling supply to various customers with renewable energy carriers like geothermal energy.

Geothermal energy is a key technology for providing and balancing energy supply and demand in smart cities.

Moreover, in smart cities, the smart electrical grid has to be combined with the thermal grid: here too, geothermal is a good solution by providing both heating and cooling and functioning also a storage technology with underground thermal energy storage (both in low and high temperatures and shallow and deep depths). Geothermal energy can provide heating & cooling for district heating, small and large buildings, and some other low and medium temperature applications.

Appendix

List of figures

List of abbreviations

ATES: Aquifer Thermal Energy Storage

BTES: Borehole Thermal Energy Storage

CO2: Carbon dioxide

EED: Energy Efficiency Directive

EPBD: Energy Performance of Buildings Directive

ESCO: Energy Service Company

GHG: Green House Gas

GSPH: Ground Source Heat Pumps, also known as Geothermal heat pumps

H&C: Heating and Cooling

HP: Heat Pump

LLC: Life Cycle Costs

NREAP: National Renewable Energy Action Plan

RES: Renewable Energy Sources

SEAP: Sustainable Energy Action Plan

SPF: Seasonal Performance Factor

UTES: Underground Thermal Energy Storage

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