# Regeocities: integration of shallow geothermal systems in urban planning

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**ABSTRACT**

The ReGeoCities project (01/05/2012 to 30/06/2015) worked on the integration of shallow Geothermal Energy at a local and regional level. It examined and promoted best practices and an intelligent regulatory framework, supporting cities to reach their Sustainable Energy Action Plans and the 2020 climate and energy goals.

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 was to present best practices of shallow geothermal projects 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.

The objective of this paper is to present the main project results and especially those regarding the integration of shallow geothermal systems in urban planning. The paper will describe where and when a Shallow Geothermal Energy system is favourable in a building and in a city. Therefore, analysis of the different aspects for consideration with respect to the integration of shallow geothermal systems in different typologies buildings and in different city zones will be made. The report consists of three parts, where the first part comprises integration of geothermal systems in buildings, especially during refurbishment and the second part comprises integration of geothermal systems in cities. The implementation of GSHP during the phase of refurbishment of existing buildings is considered very important since these actuations are expected to dominate the construction sector within the next years.

## 1. 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 second chapter provides a general overview of the technology, its uses, and 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 presents the ReGeoCities training activities on shallow geothermal and concrete cases studies.

## 2. INTEGRATION OF SHALLOW GEOTHERMAL SYSTEMS IN CITIES AND BUILDINGS

For shallow geothermal energy (GSHP and UTES), the overall installation growth is steady. It is estimated that at the end of 2015 the installed capacity was ca. 18,000 MWth distributed over more than 1.4 Mio GSHP installations.

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.

### 2.1 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 systems on H&C, so they suit perfectly to 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 to establish smart connections with the electricity grid and to participate to the future smart electricity grids management. Geothermal HP can balance the grid consumption and the UTES offers a perfect solution for storage.

**2.2 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.

## 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.

### 3.1 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 1 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.

### 3.2 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.

### 3.3 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.

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.

## 4. 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

### 4.1 Curricula overview and Advice for future training

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.

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.

### 4.2 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.

## 5. CONCLUSIONS

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.

## REFERENCES

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