Best Practice Analysis Report

Deliverable n° D 3.1 (Analysis of Best Practices)

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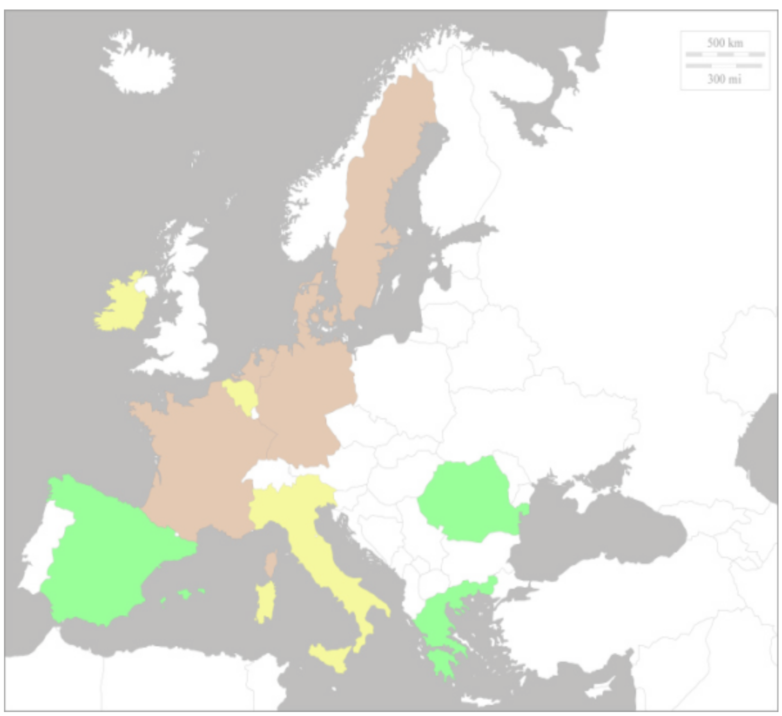
Authors: **R. Pasquali (SLR Consulting)**



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1. Introduction

The completion of national country reports in WP2 of the Regeocities project has highlighted the different practices for the regulation, promotion and management of Shallow Geothermal Energy (SGE) resources in the regions where the SGE market is mature. These practices are implemented at national, regional and local level. Regions where the SGE market is still under development have adopted some initial measure to regulate and sustain the deployment of SGE systems. The measures identified are, in most cases, an initial attempt to support the sector but also highlight was the requirement for additional, more comprehensive measures to be implemented. The lack of best practices in these regions has been identified as barriers in the national assessments and country reports.

This document reviews and categorises the best practices identified in the mature regions with a view to providing a background for the development of recommendations for the regulatory frameworks. This framework will be considered by local, municipal, regional, national and other authorities across the project regions.

Figure 1: REGEOCITIES Best Practice Categories

The identification of the best practices presented was achieved through a comprehensive review of the initial results of the Regeocities project identified by the project partners and local authorities in the target countries (figure 2).

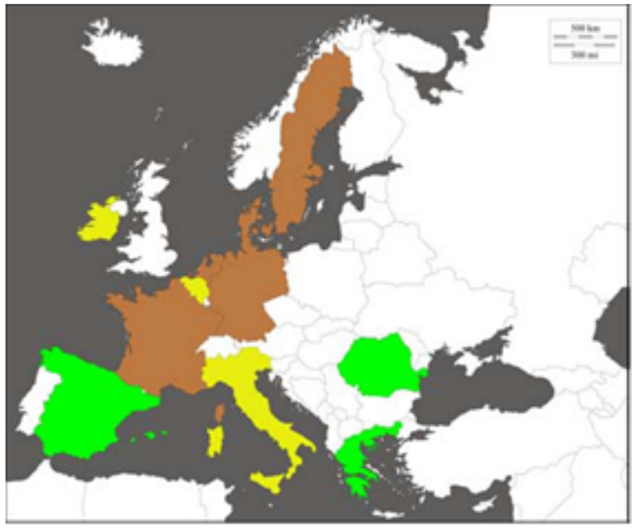

Figure 2 : Market situation in the Regeocities countries (brown = mature market, yellow = market in development, green = juvenile market)

Best practices are considered as the measures that are implemented at national, local and municipal levels in the different countries that facilitate the growth and deployment of SGE technology. As part of the completion of this report, the main focus of the identification was to consider the methodologies of implementation of the best practice categories (figure 1) in mature countries (Germany, France, the Netherlands, Denmark and Sweden) as well as some of the countries where the SGE market is under development (such in Italy).

In these countries, SGE system permitting, resource management and deployment objectives for SGE systems are present. This work was undertaken by reviewing the following main source of information:

- Regeocities National Report
- Regeocities Workshop Report Conclusions and Feedback discussion
- Sepemo Final Project Deliverables
- Project Meeting discussions on results and findings from individual partners

The review of the national reports has also demonstrated that methodologies for regulating, permitting and facilitating the deployment of SGE systems in the less mature regions of the project are not as advanced as the in the best practice regions. Some of the initiatives taken by individual regions and municipalities can also be considered as best practices. In these regions the deployment of SGE systems is significantly higher than in other regions of the same country. As some of these regions are committed cities to the project, these were also carefully considered and included as part of the best practice identification process.

2. Legislative & Regulatory

Definition of Shallow Geothermal Energy

Geothermal energy in the mature regions of the project (France, Germany, the Netherlands) is defined in legislation. Specific definitions for shallow geothermal energy are implemented in the Netherlands and Italy. Other regions favour the use of non-official definitions based on system installed capacity (France), depth of drilling (France, Sweden) or based on use (Denmark).

The implementation of a clear definition of shallow geothermal resources facilitates the implementation of SGE regulations and permitting conditions even when only an agreed definition of shallow resources is used. These definitions can be considered for:

- Depth of geothermal resources
- Installed capacity & System Size
- Temperature and utilisation of water or resources

Permitting and regulatory requirements

Permitting and regulatory requirements across the best practice regions of the project are considerably varied, with the implementation of different permitting and regulatory regimes relating to both the subsurface installations associated with SGE systems and with the above ground and heating system components that are installed in buildings.

This section presents a review of some of the key essential aspects that have been identified in the development of best practices associated with permitting and registration of SGE systems:

- Implementation of a local/regional/municipal digital register (database) of SGE system installations.
- Register and permitting of all drilling operations with respect to SGE systems (these may vary in complexity depending on the size and applications of the system).
- Register of operational information relating to energy produced and potential impact to the ground conditions and providing information for analysing the energy savings and the potential environmental impacts.

Small Domestic Systems

The effective implementation of a permitting and regulatory process for small domestic systems is applied at different levels in all of the project regions. The main consideration common to all Member States, committed cities and regions of the project is the implementation and need to simplify, as much as is reasonably possible, the registration and administrative process for smaller scale domestic SGE systems.

In many regions such as Sweden, Denmark and Italy (i.e. Lombardy Region) this is achieved through the use of an online application service for small size domestic installations with the local or regional authority providing the final permission to the applicant. In addition to simplified application systems, the use of a defined, and where possible short, consultation periods subsequent to the permit application such as in the case of 14 days as in Denmark for some systems, can significantly facilitate the completion of SGE systems.

Large Commercial Installations

Larger scale installations are largely exempt from this simplified application process where a careful evaluation of the subsurface conditions and environmental impact of the installations is required as part of the development process. Typical project development steps observed that are common in most of the best practice regions include:

- Early consultation or submission of an early application (official or unofficial) describing the proposed scheme and location of the installation.
- Completion of a feasibility study demonstrating the proposed SGE system construction, system size and proposed operation modes (including required heating and cooling demands).
- Full permit and application process including Environmental Impact Assessment - this application process commonly includes the submission of detail construction drawings, detailed methodologies for the drilling and collector completion phase and the confirmation of proposed selected contractors for the construction operations.
- Detailed monitoring and data submission programme.

This non-exhaustive list covers the applications for mainly groundwater heat pump system that is common to all of the jurisdictions reviewed by the Regeocities partners at the early stages of the project. In some cases these are also applicable to large closed loop system proposals, however these remain the exception rather than the norm.

Monitoring

Mandatory monitoring requirements are not widespread across the Regeocities partner countries, with monitoring most actively implemented in Denmark, the Netherlands, Germany and Greece.

In some cases mandatory yearly inspections from professionals are implemented in Denmark with verification and control of the operational efficiency of the system based on the SPF considered as part of performance guarantee schemes provided by the installers.

In Germany and the Netherlands, monitoring is implemented on larger scale systems only as a measure to ensure the protection of groundwater resources and to understand the hydraulic and thermal effects of the system on underground aquifers. This monitoring process also includes annual reporting of the SPF. Monitoring is however not the norm for smaller residential systems but is implemented in some German states.

The monitoring best practices identified as part of this initial analysis demonstrate the importance of the involvement of installer and researchers in the verification of the performance of installations where the performance is monitored against the calculated COPs and SPFs of the systems. Deliverable 4.4 of the SEPEMO project has extensively presented the recognised approaches of calculating the performance of SGE systems based on SPF values for heating and cooling modes and giving clear methodologies for calculating resulting CO_2 emissions and energy saving. These are discussed in detail in the *'Concept for Evaluation of CO_2 reduction potential'* (Deliverable 4.3).

Larger scale systems are more commonly monitored for compliance with existing environmental regulations and to prevent any adverse impacts on groundwater and surface water resources. Nonetheless, the implementation of adequate system monitoring measures remains limited to groundwater heat pump systems and in many cases, whilst the initial installations, are permitted for large closed loop systems the monitoring requirements are less stringent.

SGE Contributions to National and Local policies

The potential contribution of SGE systems are defined as part of Local Climate Change Policy (France) and Sustainable Energy Action Plans (SEAP). Defining these contributions at regional and/or municipal/local authority level has been identified as a progressive measure with respect to providing a clear policy in the development of SGE systems in the best practice countries.

The role of the deployment and utilisation of heat pumps is defined in many national policies through the targets set by all Member States in the NREAPs and at local level by cities and authorities including the ones that are signatories of the Covenant of Mayors.

As part of this commitment these regions have undertaken to set objectives for renewable energies and in some cases for SGE systems. The following cities/regions/counties are highlighted as examples for having comprehensive targets with respect to SGE systems:

- Denmark – Odense, Skaderborg
- Italy – Lombardy, Tuscany, Emilia Romagna (Italian regions have to contribute to the achievement of EU objectives for renewable energy by 2020, i.e. Decree for Burden Sharing)
- Germany - Bonn, Frankfurt, Hannover, Hamburg and Cologne
- France - Grenelle de l'Environnement (legally binding)
- The Netherlands - Breda & Amsterdam

Common to all of these regions are the implementation of objectives for the deployment of SGE systems and their contributions in local SEAPs or renewable energy strategies. Despite these targets having been set as legally binding for the deployment of SGE systems in some of the Member States, the deployment of the technology is recorded as significantly higher where clear objectives and contributions of SGE systems are set.

These policy measures are frequently coupled with comprehensive SGE system resources management measures, reporting requirements and where the policies are considered, with respect to clear objectives for the installation of these systems in new as well as refurbished buildings.

Integration Aspects of SGE systems in Urban Planning

Relatively little consideration in many of the Regeocities countries is given to the deployment of SGE systems in specific urban planning scenarios. Most of the more mature regions have comprehensive inventories of sub-surface infrastructures at national or local level.

Specific integration strategies to SGE systems in urban planning with specific implementations of these in different land zone classifications are not common in all regions. However some regions such as in Italy, make provision for specific planning instruments for which the deployment of renewable energies are favoured and SGE systems are included as part of these.

Whilst specific integration strategies for SGE systems cannot be considered as widespread in supporting the deployment of the SGE sector, it is important to note that many of the best practice regions that implement comprehensive registration of SGE systems, provide some guidelines and requirement with respect to the construction and completion of ground source heat pumps and avail of extensive datasets that are easily integrated at local authority and planning level.

The case considered as best practice for the city of Stockholm where the online system registration provides an adequate layer for the management of subsurface conditions. Similar datasets are also available in many other states and regions such as in France, the Netherlands (www.wkotool.nl) and Germany through the datasets provided by individual federal states.

Specific integration of measures relating to permitting and completion of SGE systems in urban settings are common in the Netherlands. An example of these measures are included in the city master plan for the city of Amsterdam, where clear guidelines and restrictions about the depth and the position of the wells are outlined. Similar considerations are given in France through the *'Schéma de Cohérence Territorial (Scheme of territorial Coherence)'* that considers the implementation of renewable energy technologies at regional level as part of the main urban planning documents.

Integration Aspects of SGE systems in Building regulations

The integration of renewable energy technologies in buildings as part of the national building regulations and energy agreements (e.g.: Denmark) are noted in all of the best practice countries. However, specific mention of SGE systems and their potential integration have been identified.

An initial analysis of the types of regulations and best practices in place in many of these countries, highlights that integration issues are, for the most part, related only to heating and cooling systems in general and address conservation issues and preservation orders with respect to historical buildings.

For many of these cases however specific targets and regulatory conditions with regard to the integration of SGE systems in buildings are less common. Regulations are focussed on thermal installations and energy generated from renewable energy technologies for heating, cooling and domestic hot water in the context of new buildings and for building refurbishment.

Local objectives related to the installation of domestic heating and sanitary hot water such as the gradual phasing out of oil fired and gas fired boilers as is currently proposed by some of the Danish local authorities, is identified as a significant regulatory step towards favouring the deployment of SGE systems.

In addition to these measures, the mandatory requirement for connection to local district heating network where these are available in countries such as Denmark, demonstrate how the deployment of heating and cooling technologies can be integrated into local policy to facilitate the implementation of Smart City objectives. SGE systems can play a key role in contributing to the roll out of Smart City district heating networks and should form an integral part of local policies.

3. Environmental Considerations

The deployment of SGE systems and the regulation of the environmental and ecological implications of these are considered at different levels in different jurisdictions. The regulation of environmental aspects are dealt with mostly through specific guidelines and regulatory recommendations that define thresholds for environmental conditions for different system types based on the local geological conditions, the aquifers characteristics and the use of subsurface resources by other end users.

The following technical aspects are generally considered in detail when regulating or managing the deployment of shallow geothermal systems in the best practice countries:

- System Type (open or closed)
- Existing Geological characteristics and Aquifer properties where systems are proposed
- System size and suitability of the ground conditions
- Heating or Cooling Capacity requirement and the ability of the local ground conditions to sustain these
- Other sub surface users with particular consideration of nearby groundwater users
- Temperature thresholds relating to re-injection or surface water discharge
- Thermal and hydrological effects with respect to the implications that the system operation may have on sub-surface resource – these could include other SGE system users, groundwater users or other infrastructures that may exist within the boundaries of the subsurface being considered
- Aquifer cross contamination
- Collector circulating fluid and leakage prevention measures and borehole construction requirements.

The implementation of these measures in different jurisdictions varies, with the main best practice regions based on the implementation of the requirements under various EU Directives. These are further discussed below.

Requirements under EU Directive

Careful consideration is given at national, regional and municipal level at the requirements for the implementation under the following (but not limited to) principal EU Directives that impact the installation of SGE systems in the ground:

- Water Framework Directive
- Natura 2000 Directive
- Groundwater Directive

- Surface Water Protection against Pollution under the Water Framework Directive
- Environmental Impact Assessment Directive

These require the use of measures that prevent the deterioration of groundwater and surface water qualities across all Member States. These measures affect the deployment of SGE systems and ensure that installed systems fulfil the requirements set out in the Directives through the use of best practices. Some of these best practices include:

- Guidance for SGE installations in the proximity of Public Water Supply and groundwater protection zone in the case of open and closed loop systems.

- Regulation and Licensing of large scale systems that may have impacts on Water Bodies and Natura 2000 sites adversely affecting the ecology, integrity or protected status of any of these areas – these are generally expressed as maximum temperature changes permitted with specific focus on the re-injection temperatures permitted (in the heating or cooling modes) for groundwater heat pump systems. These measures often include monitoring of inlet and outlet temperatures, periodic monitoring of chemical composition of groundwater and/or surface water (including water quality where contaminants are present) as well as hydrological effects that influence the water table.

- Guidance on the requirements for the discharge or re-injection of waters for groundwater heat pump systems based on the local conditions.

- Guidelines specific to borehole construction to prevent the cross contamination of aquifers in the installation of vertical systems. These include information on requirements for grouting and collector temperatures permitted.

- Heat transfer fluid percentage compositions for ground loop circuits permissible during system installation along with any other requirements that may be applicable in sensitive or protected areas.

- Leak prevention Measures – these will typically include the implementation of pressure testing and certification of a system before commissioning and the installation of early warning systems (pressure drop alarm and shut off mechanism) as part of preventing any possible leaks.

- Distances for the completion of boreholes neighbouring other third party properties. Particularly in the case of dense urban areas where system proximity can lead to adverse thermal interactions with other installations and sub-surface users.

- Multi-jurisdictional resources - the development of specifically groundwater heat pump systems in aquifers using underground resources that cross several national, municipal or local jurisdictional boundaries need to be given careful consideration and adequate management measures for these areas needs to be put in place.

4. Technical

Guidelines[1] & Standards[2]

The implementation of technical guidelines for the development of SGE systems in the Regeocities mature regions is varied. In most cases there is a framework of national guidelines that apply to the completion and installation aspects of SGE systems with few or less widespread individual guidelines being developed and implemented at in regions/municipalities or local authorities. However, these guidelines are not always mandatory (eg: Italy) and the level of implementation of these differs between different Member States and regions.

The guideline documentations described how to deal with several aspects of the implementations and installation of SGE systems. The following items are covered by specific technical documents in several of the mature regions:

- Design of ground source heating systems (DK, D, NL, IT)
- Borehole heat exchangers (F, SE, D, DK, NL, IT)
- Design of groundwater wells (NL, IRL, IT)
- Groundwater heat pumps (F, NL, IT)
- Technical manuals on GSHPs (F, D, B)
- Technical drilling guidelines (F, SE, NL, B & IRL - *under preparation*)
- Energy Performance in Buildings (D, IT[3], RO, ES, NL, B, IRL)
- GSHP licensing (D)
- Standards for Groundwater Protection (D, NL)

The best practice guideline documentation identified as fundamental to the support and development of the SGE sector into the mature regions includes:

- VDI 4640 (parts 1 to 4) in Germany
- VDI 4650 (parts 1 & 2) in Germany
- NORMBRUNN – 07 in Sweden
- "Geothermal heat pump borehole heat exchanger fields : guideline for design and implementation" (BRGM and ADEME, 2012) in France

[1] Guidelines are defined for the purpose of this document as technical guideline documents that are used in the context of best practices and defined in regulations as setting out the required or agreed level of quality or methodologies pertinent to the completion of SGE installations.

[2] Standards are defined for the purpose of this document as standards and certificates set out by a legally recognised national or international standards organisation that provides for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum quality.

[3] Voluntary standards are in place with the implementation of the recast of EPBD Directive is still ongoing.

- "Ground water heat pump: design and implementation" (BRGM and ADEME , 2012) - France
- 2004 : Best practice guideline for Drilling. application of arrêté interministériel du 11 septembre 2003 relatif à la nomenclature 1.1.1.0 de la nomenclature Eau. - France
- 1998 : Best Practice guideline for drilling in the respect of environment. Longin G., Daum J-R, Sourisseau B. edited by BRGM Guide de bonne pratique et de contrôle des forages d'eau pour la protection de l'environnement.
- Geothermal energy and heat networks. Guideline for operators (BRGM and ADEME, 2010) - France
- Ground source heat pumps (COSTIC, 2009) – France
- BRL SIKB 2100: Mechanical drilling - The Netherlands
- BRL SIKB 11000: Design, realisation, management and maintenance of the subsurface part of SGE systems - The Netherlands
- ISSO-publications 39, 72, 73, 80 en 81: For the technical implementations of the above ground part of an SGE system - The Netherlands
- NEN 7120: for calculating the EPC of a building - The Netherlands

The objectives of the guidelines discussed above and applied in the mature regions is to support outline standards and requirements considered as best practices. These objectives include:

- Technical specification guidelines for the design of SGE systems highlighting the importance of understanding and considering local subsurface ground conditions.
- Technical guidelines on system construction:
- Horizontal collector
- Borehole heat exchangers
- Groundwater heat pump systems
- Heat pump installation and building system integration
- Guidelines on the performance of SGE systems in buildings.
- Requirements for monitoring of existing operational systems.

Availability of Data

Based on the information presented with respect to the market status for SGE systems in many best practice countries, the availability of information has been highlighted as one of the principal practices that effectively support the development of the sector.

In many best practice regions the levels of availability of data are different, however common information with respect to systems has been highlighted:

- Subsurface geological and well drilling data
- Identification of SGE resources based on existing sub-surface information
- Record of installed systems and associated performance information
- Guidelines to Installation procedures for different system types

A review of the level of availability and promotion of data that facilitates the profiling of shallow geothermal resources is critical to the understanding of the potential for deployment of the technology. This is demonstrated in the best practice countries where extensive online datasets are available and frequently integrated with other administrative data layers at local authority, municipal and regional levels.

These data permit the clear understanding of the status of deployment of SGE systems to policy makers as well as providing the basis for understanding deployment options for closed loop and groundwater heat pump systems based on the local environmental, geological and sub-surface utilisation conditions. In many cases a comprehensive registration of existing and operating systems forms the basis for both the management of shallow geothermal resources in densely populated urban areas and the implementation of clear guidelines with respect to construction and potential operational restriction of SGE system types.

5. Training & Certification

Training Initiatives

Some training initiatives at national level in the mature regions have been identified and are considered effective when these are implemented at a regional level. There is however, a notable lack of local or regional training activities in the different Member States considered by Regeocities where national training activities are not present or where regulatory conditions differ from one administration to another. Many of the courses offered target specific professional groups involved in the design, installation, legal and regulatory as well as the financial aspects of SGE system installation and operations.

National training courses such as those offered in the Netherlands such as *BodemenergieNL, Euroform & Stichting PAO* offer basic courses as well as several specialised courses for different target group including drilling companies, advisors/consultants and local authorities.

A similar course in Denmark by the VIA University College, School of Technology and Business specific to Shallow geothermal energy system development and installation focuses on the different aspects related to SGE systems.

Many of the course initiatives are connected to the professional certification schemes available to SGE technology professionals. This is the case in Sweden. Many of the Member States are contributing to the development of the Geotrainet course programmes that will provide a common platform for training activities for SGE system professionals across Europe. The objectives of this programme will be to increase the skilled personnel and the quality of design and drilling operations for SGE systems in Europe. The Regeocities project objectives are focussed on including the best practices that are the subject of the Geotrainet training initiatives for professionals and including these as part of the training activities aimed at local and regional authorities that will attend the Regeocities training events.

This integration is an example of best practice, as it will ensure that both the experience of the mature regions where training activities are consolidated will be transferred to the less mature markets. In addition, this initiative will also ensure that both professionals involved in SGE system installation as well as the local authority personnel responsible for permitting and registering systems will be working towards the same standards of system completion and shallow geothermal resource management.

Certification

There are different certification schemes in place in the mature Regeocities regions. Common to all of the areas are certification schemes for professionals involved in the installation of SGE systems. These include ground works and drilling contractors that have a certification requirement in all mature regions at national level as well as in some of the juvenile and emerging markets where the national certification schemes are in place despite these not being necessarily dedicated to the requirements of SGE systems.

Ground works and drilling contractor certification schemes are mandatory in the Netherlands, Denmark and Germany with voluntary schemes in France and in Sweden also in place. Local certification schemes for borehole heat exchanger installations in France are in place but are not implemented in the other Regeocities countries.

In the majority of the mature regions certification for installers of surface installations are in place, but in many cases there are voluntary certification schemes at national level (with mandatory schemes in place in Spain at local level for surface thermal installations.

Certification covering aspects of borehole heat exchanger design and ground water well design are noted as not being implemented (voluntary or mandatory) in most of the mature regions with this exception of the Netherlands.

Certification of plant equipment (this includes both the heat exchanger and heat pump) is not the norm across the best practice countries with the only plant certifications being in place in France and Germany.

Identified best practices included as part of the certification process need to be considered both in terms of the training and certification of the staff completing SGE systems in Europe, but also in the provision of certificates of completion for installed plants. This certification should be closely related to system performance monitoring and taken into consideration as part of any economic support measures put in place both at national and local level.

6. Support Measures & Economic Aspects

Several financial support measures have been identified as facilitating the deployment of SGE technology in the mature regions. These are broadly categorised in measures to support the deployment of domestic/residential systems, separate to any measures supporting the deployment of commercial or industrial systems and insurance schemes. Some of the support measures outlined below require the installation to be carried out by approved certified professionals.

Grants-Subsidies

These have been mainly identified as not specific to SGEs in most cases and are targeted as overall measures to improve energy efficiency and upgrades to renewable energy technologies in existing buildings. This is the case in Denmark where there is an incentive for the conversion of individual heating systems to heat pumps as a replacement for systems based on fossil fuels, for the renovation of buildings switching to renewable energy technologies as well as a dedicated scheme for industrial processes. The exception to is the 'Fond Chaleur' in France that provides dedicated grants for the SGE systems using groundwater heat pump and closed loop collectors. A similar scheme dedicated to SGE systems is available through the GEOTCASA programme in Spain.

Tax Reduction

Tax reduction schemes are applicable to many different technologies and in different Member States, with some of these already in place outside of the matures regions identified in the Regeocities project. These schemes are generally applied at national level and have variable taxation savings based on the different jurisdictions. These appear to be the preferred scheme for supporting the installation of SGE systems in domestic and residential installations where the system owner can apply for tax reductions with the installation of an SGE system to a residential property. Current income tax reduction schemes for the installation of SGE systems are in Belgium, Denmark, Italy, the Netherlands (for energy contractors, investors, developers), Greece and Sweden.

Green-eco loans

Green-eco loans generally available for the capital investment of installation of green technologies as part of which SGE systems are included. These are not the most widespread form of support for SGE systems, however an example of these is the loans currently available in France.

Insurance

The availability of dedicated insurance schemes covering the short and long term operations an SGE system and the geological risk associated with the system are currently only available for groundwater heat pump systems in France under the AQUAPAC scheme for system greater than 30kW and with boreholes shallower than 100 m. The scheme covers the presence of an insufficient resource or the failure of re-injection as well as providing a long term production guarantee for a period of 10 years for a maximum amount of € 140,000. The Aquapac system is provided through a state guarantee fund.

In other mature regions, aside from the normal contractor liability insurance that is recommended for drillers and in some cases heat pump installers, no dedicated ground source heat pump scheme is currently available.

The AQUAPAC represents a best practice example of the implementation of a support measure, which facilitates the deployment of SGE systems but also helps guarantee the operation of the systems over a longer period of time.

Energy Saving Certificates (ESC or White Certificates)

Tradable certificates that demonstrate the energy efficiency measures of a user or energy producer are consistent with a pre-defined percentage of their annual energy deliverance. These certificates are usually proportional to the difference between baseline (i.e. benchmark) and improved (i.e. applicant) performances. SGE systems are a significant contributor to these measures where systems are deployed and demonstrate the adequate operation of a system. . In Italy, the Decree 28/12/2012 supports systems with higher installed power with an extended duration of the financial support.

Preferential Electricity Tariffs

Electricity suppliers and utility companies offering preferential electricity tariffs for the operation of ground source heat pumps such as those offered in Germany are considered to be a significant support for the operation of SGE systems. The tariffs are generally subject to the condition that SGE systems are switched off during peak power demand and operating mainly at night.

Carbon Tax

An EU-wide carbon price through the ETS system is not assigned to combustion installations below 20MW (this is currently in place in countries like Sweden and Ireland), which represents the largest part the sector. In order to internalise the carbon price of fossil fuels, a national carbon tax applying to all systems including small scale installations could be an efficient solution that would increase the uptake of renewable including SGE systems.

7. Regulatory Challenges

Model of operating regulatory frameworks and their applicability to different sizes of SGE system installations where analysed as part of this deliverables. Case studies and their regulatory requirements are presented in section 9 of this document.

The challenges associated with different types of regulatory systems were discussed in each of the cases presented. Whilst the regulatory requirements and procedures vary significantly in different regions but also in different project sizes, the challenges are discussed here in the context of the best practices highlighted in this document.

The challenges for smaller scale residential system regulations, examples from France and Sweden are presented below. Regulatory challenges that are observed in the permitting and operation of larger systems are described based on challenges experienced in the Netherlands and Germany.

Sweden - The city of Stockholm implements and online application system for closed vertical collectors, a number of key challenges have been identified. These include:

- Implementation of a borehole spacing distance of 20m - this is set based on the typical extraction rates of heat energy and associated borehole depth requirements to meet the demand of a single family house and ensures sustainable resource development. Maintaining this distance in a dense urban area environment is challenging and where closer borehole spacing distances are necessary, the heat extraction rates have to be compensated by using deeper boreholes. These however cannot be applied for through the online system and hence a longer permitting time is required.

- Systems with proposed specifications other than single boreholes are not accommodated through the online registration system with a more lengthy paper application being required.

- Regulatory interpretations, particularly relating to environmental conditions of a single receiving environment which covers several municipal jurisdictions can vary and hence the regulatory requirements and system completion requirements are different from one region to another.

- Application period - remain longer in the case of the implementation of a permitting process (up to 6 weeks in the case of Stockholm) as opposed to a registration process where times are shorter (up to 2 weeks).

France - The current status of the regulatory system in some of the regions of France is presented in the case studies which outline the requirements in place for SGE systems as defined in the national legislation for geothermal energy of 'minimal importance'.

These requirements are set out in the Géoqual' guidelines. The current permitting system is based on the completion to a notification (declaration) or a license based on the size of the systems, the depth of drilling (notably less than 100m deep and 232 kW in size) and the receiving environment. A legislative and regulatory review project is currently assessing some of the challenges associated with the current system and the results of this project are expected to include reforms that may be in place by January 2015. These include:

- Thresholds: a current review of the depth and installed capacity limits of projects that are considered as of 'minimal importance'

- Risk based maps for the development of SGE will to be completed on a regional basis that will consider the environmental and geological conditions of individual sites and on regional scale. These will determine the permitting requirements with respect to a simple notification or a license application and with the necessity for the involvement of expert advice for the completion of the project.

- Dedicated procedures for qualification and certification for drillers with the development of a quality charter

- The implementation of a central national, online registration system for SGE application

- Development of a predictive resource management tool aimed at estimating the hydraulic and thermal impact of SGE systems based on data from existing installations. This tool will allow estimates of the decrease and increase of water-table levels to be made, as well as the thermal effects of an operating SGE system. The web based service will be used by local authorities in charge of groundwater management to facilitate the authorisations (required by national regulation concerning SGE systems), in a first instance, for heavily exploited aquifers.

The Netherlands - An overview of the current permitting, regulatory and operational requirements for SGE systems in the Netherlands has been undertaken. Below is a summary of these considerations and their estimated impact on the deployment of SGE systems.

- *Permitting Procedure Time*: Permitting procedures that are associated with planning and construction permits are too long. Requirements for the permit applications to give operational start dates for the SGE systems are such that in the early phases of planning an SGE system and a project, the start dates are not defined and can vary during the course of changes to the building and design process. An initial permitting period of 9 months for SGE permit application of 9 months was considered too long and has been recently (July, 2013) reduced to a period of 4 months to facilitate the application process.

- *Receiving Environment:* the development of SGE systems requires that the installation and operation of these does not negatively impact the quality of the receiving environment and other groundwater users.

    - Regulations and permitting requirements are focussed on trying to fulfil this requirement, the completion of SGE systems in areas where there are several groundwater users or several aquifers present is more challenging and can increase the overall system costs and permitting times.

    - The completion of energy systems is based on the requirement of a system achieving an energy balance where the volumes of water abstracted and re-injected as well as the amount of energy abstracted in the heating and cooling modes do not result in thermal changes to the aquifer conditions. The requirements however need to be flexible and should take into consideration the details of the receiving environment and the seasonal variations that can occur in shallow aquifers. This has been addressed by promoting surplus cold storage in aquifers preventing regional aquifer temperatures below city centre areas from increasing.

    - Polluted groundwater aquifers are present in many cities. The development of SGE in polluted (or near surface aquifers) has historically not been allowed in these aquifers as a preventative measure to spread contamination. However, the use of open loop SGE system do not promote the spread of contamination when an abstraction and injection well in the same aquifer are used simultaneously. Recent studies and operational demonstrates that the circulation and/or heating up of polluted groundwater stimulates biodegradation. Many cities are now allowing applications for SGE systems confined to polluted aquifers.

    - Permitting systems also provide a greater level of security to permit holders safeguarding the resource for the operational lifetime of the project. This however also provides greater difficulty to new potential users in obtaining permits for the installation and operation of an SGE system.

- *Costs:* these have a significant impact on business case when and SGE system is being considered as part of a project. The costs that relate directly the permitting and licensing process include:

- Permitting costs - in most cases the permitting costs are acceptable for the this system size being proposed. However in some provinces the permitting costs include the undertaking of a complete risk assessment for the project at the application stage. This can be a disincentive in considering SGE technology solutions, particularly when the system considered is not large. A simplified risk assessment procedures (now applicable since July 2013) is preferable where smaller systems are being considered.

- Monitoring costs - in most cases monitoring of abstraction and injection volumes and temperatures are a requirement for the operational life of the project. These values can be monitored easily and require little investment for the operational phase. More extensive monitoring requirements, imposed in some provinces that include regular sampling and testing of water, represent a significantly higher operational cost which in many cases is not economical in the consideration of smaller systems. Recent published research by *Meer met Bodemenergie* concluded that the impact on the physical, chemical and biological parameters of soil and groundwater are very limited by using a SGE in a balanced heating and cooling mode, and hence the extra monitoring measures are unnecessary

8. Conclusions

The analysis of best practices in the different regions of the Regeocities project has demonstrated that the implementation of key measures associated with the deployment of SGE systems provide the required base for the development of the shallow geothermal sector at national, regional and municipal level.

The key measures identified are presented in this overview and are considered as potentially forming the basis for common regulatory framework recommendations in Europe. These key measures include:

- The development of adequate legislative and regulatory instruments for the management and deployment of SGE systems.

- Specific definitions of shallow geothermal resources in the context of existing legislation and regulations.

- Clear regulatory guidelines that for the deployment of SGE systems need to be developed in line with existing regulatory requirements that can ensure the sustainable development of SGE systems in their receiving environments.

- The development of a simplified permitting and application system for small domestic installations.

- Specific regulatory procedures for larger and more complex SGE systems (making a clear distinction between ATES and BTES systems) that have different environmental impacts as well as a clear implementation of the necessary regulatory measures for these schemes.

- Common technical aspects associated with the deployment of SGE systems form the basis for regulatory conditions and sustainable management of resources. These should deal with environmental issues, renewable energy deployment, energy efficiency, building and urban planning.

- Adequate monitoring requirements based on SGE system size and receiving environments need to be considered. These should include parameters that facilitate the end users as well as the regulating authority.

- National, but more importantly local policies, relating to specific objectives addressing the deployment of SGE systems are an essential driver to developing a thriving SGE sector. The implementation of these policies should, not only refer to the SGE technologies, but set out clear targets for system deployment.

- SGE system deployment scenarios should be comprehensively included as part of urban and underground spatial plans for cities and regions.

- Implementation of measures in building regulations that promote, as well as encourage, the use of SGE should be considered for both new build and retrofit scenarios.

- The availability of underground data for the receiving environment, of underground infrastructure and operational information of existing system to promote the safe and sustainable deployment of SGE systems.

- Economic and support measures are key to ensure that the higher capital investment costs of SGE technology can be supported. This can be achieved in several ways with many different incentives possible, however the use of loans and tax incentive measures are considered the most widespread.

- Education, training and certification measures common to all European regions are essential to ensuring that both higher and common quality standards of installation of SGE systems are promoted across Member States, but also to ensure that both professionals as well as regulators, decision makers and local authority personnel can ensure and promote the development of a sustainable SGE sector in the context of local environmental and socio-economic conditions.

- The active promotion and demonstration of SGE system technology and it's benefits by local, municipal and regional authorities should be undertaken through clear objectives for the inclusion of SGE systems in public sector buildings.

9. Case Studies - Best Practice Regions - optional for discussion

Case Study 1 - City of Stockholm (single closed loop domestic)

Country	Sweden	**City/Region:**	Stockholm
SGE System Type	Closed loop system	**Time in Operation**	One month
Systems Use	Heating and domestic hot water	**Heating Demand**	15000 kWh + 4500 kWh DHW
		Cooling Demand	None
Collector Details	One borehole with a depth of 150 meter. The collector is a single u-tube and no grouting is used.		
Plant Details	Wooden framed single family house 150 m^2, built in 1970. The heat pump unit includes a hot water storage tank of 180 L and the nominal heating capacity is 10 kW.		
Permitting & Application	- *The application time was 6 weeks using the Stockholm e-service application which is easy to fill in. It is a centralised application to the Environmental board that handles all other communication regarding the underground infrastructure and neighbours. The neighbours were informed on forehand.* - *The permission is valid for an installation that is completed within 2 years of the permit being granted.* - *No renewal is needed and there are no additional fees after installation.*		
Permitting Costs	Permission cost 4 900 SEK equivalent to € 520 (December 2013)		
Certificates	Requirement of the use of a certified driller		
Environmental & Technical Aspects	Receiving environment	Typical Swedish ground conditions; crystalline bedrock with granite, gneiss. No grouting is required	
	Thresholds	There are no thresholds parameters in the permit. No additional costs.	
	Proximity to other users	There are several similar sized systems in close proximity; the minimum distance to neighbouring boreholes is 20 meters.	
Monitoring & Data Compilation	*No requirements for monitoring and no extra costs.*		
Policy	- The main drivers for heat pump investments are low cost, small space requirements and limited maintenance for the operation. - High tax on heating oil has reduced the numbers of installations of oil boilers. Heat pumps are one of the key alternatives that		

	replace oil boilers. - Heat pumps are providers of free RES energy to buildings.
Technical Guidelines	Normbrunn07 – a procedure document for drilling that is used by certified drillers.
Support Measures	There are no subsidies dedicated to SGE systems only.
Comments	The general requirement in Sweden is a **notification** about the installation in single family houses (<20 kW). Stockholm requires permission for installations in the whole municipality. The administrative process is fairly simple thanks to the e-service for permit application.

Case Study 2 - The Netherlands (Groundwater heat pump Commercial System - ATES) - Utrecht

Country	The Netherlands	**City/Region:**	Utrecht
SGE System Type	Groundwater heat pump system: ATES	**Time in Operation**	4 years
Systems Use	Both heating &cooling	**Heating Demand**	4,500 MWh
		Cooling Demand	4,500 MWh
Collector Details	The system has 5 warm wells and 5 cold wells, with a depth of 50m. The max. flow rate of the total system is 350 m^3/h.		
Plant Details	The wells are connected to the building by a thermal heat exchanger. The system provides direct cooling and heating by using heat pumps.		
Permitting & Application	• *A risk assessment has been made to indentify the thermal and hydraulic impact on the environment.* • *The permit procedure takes 9 months (normal procedure), where other groundwater user around the project were involved.* • *The province has given the permit and from this day the system is also protected to other groundwater users.* • *Special attention should be paid to the groundwater pollution and therefore additional monitoring of the groundwater is required.*		
Permitting Costs	• Preparation of the risk assessment (€ 9,000) • Permit costs (€ 3,000) • Yearly monitoring costs (€ 4,000)		
Certificates	No specific certificates on the installation.		

Environmental & Technical Aspects	Receiving environment	The first aquifer is not protected and available for ATES systems (Provincial regulations). The existing groundwater pollution is a major point of attention. It should not be spread (National regulations).
	Thresholds	Max flow rate: 350 m^3/h. Max infiltration temperature: 25 ^oC. Minimal infiltration temperature: 5 ^oC. Max. water displacement: 1,500,00 m^3/year. There should be an energy balance and no negative thermal impact to others and the pollution may not be spread.
	Proximity to other users	There are 5 other large ATES systems in the vicinity (max 2,000 m distance). However, the thermal distance is large enough and you may not cause negative thermal impact. No closed loop systems known. Groundwater pollutions are close to the site and existing in the aquifer.
Monitoring & Data Compilation	Requirement to measure: flow rate, heat and cold delivery, abstraction and injection temperatures, min. and max. injection temp., amount of discharged water for maintenance. Frequency measurements: hourly; reporting yearly in an overview per month. To analyse: groundwater samples on macro-parameters, chlorinated compounds, aromatics and mineral oil. Frequency: 2 times per year.	
Policy	The national measure EPC (Energy Performance Coefficient) is applicable. This means that a new building has to get low level of energy consumption.	
Technical Guidelines	Design: NVOE guidelines for design of ATES systems Drilling: BRL guidelines 2100 and protocol 2101.	
Support Measures	None.	
Comments	The project is situated in the centre of a large city. Therefore, they have to take care for groundwater pollution.	

Case Study 3 - France (Closed Loop Domestic)

Country	France	**City/Region:**	SOUDAY (Loir et Cher)
SGE System Type	Closed Loop	**Time in Operation**	End 2008
Systems Use	Domestic Heating & Sanitary hot water	**Heating Demand**	Heat pump capacity: 14kW (heating)
		Cooling Demand	
Collector Details	4 vertical heat exchangers, 75 m depth, double U configuration 10m spacing between each exchanger		
Plant Details	Individual house (new one), 250 m^2 Production for: Heating, Cooling and sanitary hot water Ground level: heating and cooling floor (25°C) First floor : fan-coil unit (50°C)		
Permitting & Application	*Only a declaration is required* Realised in accordance with 'Géoqual' recommendations Geological Information transferred to BSS (National geological data base , managed by BRGM)		
Permitting Costs	no		
Certificates	no		
Environmental & Technical Aspects	Receiving environment	Rural Location Geology: Limestone & sand	
	Thresholds	Average Thermal capacity extracted from the ground: 36 W/m	
	Proximity to other users	10m between each exchangers No other user known within, at min, several 10 meters in every directions	
Monitoring & Data Compilation	No operating data collected		
Policy	Géoqual'= quality charter in Région Centre		
Technical Guidelines	Géoqual'= quality charter in Région Centre		
Support Measures	Géoqual Complying of best professional practices & best environmental advices Long-life boreholes & optimized cost with respect to the thermal requirements		
Comments			

Case Study 4 - France (Groundwater heat pump Domestic)

Country	France	**City/Region:**	Saint-Denis-en-Val
SGE System Type	Groundwater heat pump	**Time in Operation**	3 Years
Systems Use	Heating	**Heating Demand**	Up to 12 MWh/year
		Cooling Demand	
Collector Details	Aquifer doublet, Depth: 21 m (both), – Water level in borehole: 7 m - 2nd aquifer used because clearer as the upper level - Available water flow: > 10m³/h – 1.5m³/h used.		
Plant Details	Individual house - Completed 1970 - Up to 140m² heated - 120 kWh/m²/yr Previous system: oil fired Water source electrical heat pump (single-phased) – Heating power: 9 kW - System COP: 3 (heat-pump & borehole pump) – Operation: <2 000 hours per year (heating season) – Hot water heating buffer: 150 litres Distribution system: hot air (two fan coil heaters) – Low velocity air ducts.		
Permitting & Application	Realised in accordance with 'Géoqual' recommendations Information in BSS		
Permitting Costs	n/a only declaration		
Certificates	n/a		
Environmental & Technical Aspects	Receiving environment	Rural Location Aquifer interconnected with the Loire River Regionally Karstified Calcareous bedrock but not at site where the system is installed	
	Thresholds	Realised in accordance with 'Géoqual' recommendations	
	Proximity to other users	No other user known within, at min, 200 meters in every directions	
Monitoring & Data Compilation	n/a		
Policy	n/a		
Technical Guidelines	Complying of best professional practices & best environmental advices Long-life boreholes & optimized cost vis-à-vis the thermal requirements		
Support Measures	Tax credit (deduction from income tax)		
Comments	n/a		

Case Study 5 - Italy (Closed Loop Commercial)

Country	Italy		**City/Region:**	Corsico (Lombardy)
SGE System Type	Closed		**Time in Operation**	2008
Systems Use	Heating and cooling		**Heating Demand**	1557 kW
			Cooling Demand	1400 kW
Collector Details	There are 304 vertical heat exchangers which reach a depth of 125 meters and are made by HDPE (high-density polyethylene). Underground temperature is 15° C.			
Plant Details	The plant is located in an area of around 5000m^2 under the parking lot of IKEA store and is composed by three heat pumps with an overall power of 1400 kW.			
Permitting & Application	This installation was carried out before the approval of regional regulations for SGE systems and the establishment of regional heat exchanger register. The system was developed as a pilot project and has been useful to stimulate the local attention to this technology and to stimulate the development of the regional regulations.			
Permitting Costs				
Certificates	The thermal plant is awaiting for certification.			
Environmental & Technical Aspects	Receiving environment	IKEA made hydrogeological analysis in cooperation with Province of Milan		
	Thresholds			
	Proximity to other users	There is no information about the presence of other installations. The plant is located in a industrial area and is close to an aquifer.		
Monitoring & Data Compilation	The plant was monitored for the first two years in order to check its environmental performance.			
Policy	This SGE system was developed in close cooperation with Province of Milan. It was a sort of pilot project.			
Technical Guidelines	The realisation of this plant follows environmental regulations.			
Support Measures				
Comments	This SGE was one of larger commercial project in Europe.			