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Main aspects for integration of SGE systems in Cities and Buildings

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Abbreviations

Technical:

ATES	Aquifer Thermal Energy Storage
BHE	Borehole Heat Exchangers
BTES	Borehole Thermal Energy Storage
COP	Coefficient of Performance
DHW	Domestic hot water
GIS	Geographical Information System
GSHP	Ground Source Heat Pump
H&C	Heating and Cooling
HVAC	Heating, Ventilating, and Air Conditioning
RES	Renewable Energy Sources
SGE	Shallow Geothermal Energy
SHW	Sanitary hot water
SPF	Seasonal Performance Factor
EIA	Environmental Impact Assessment

Administrative:

EPBD:	European Performance of Building Directive
RES Directive:	Directive on the promotion of the use of energy from renewable sources

Introduction

The objective of this report is to describe where and when a Shallow Geothermal Energy (SGE) system is favourable in a building and in a city. Therefore, analysis of the different aspects for consideration with respect to the integration of SGE systems in different typologies buildings and in different city zones was made. The report consists of three parts, where the first part comprises integration of SGE systems in buildings, especially during refurbishment and the second part comprises integration of SGE systems in cities. The third part comprises analysis of committed cities in the REGEOCITIES project.

The implementation of SGE and typically 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. Furthermore, according to the recast of the EPBD, the main market for “nearly zero” objective in 2020 are the refurbished buildings. For this reason, in the first part specific aspects which can govern the implementation of SGE during the refurbishment of buildings are defined. Also, the regulative framework for refurbishment of buildings is considered in the different targeted regions in order to decipher any potential interference with the licensing or installation of SGE.

Cities can be subdivided in different zones and the zones have different potential for SGE. First, typical zones for a medium/large city were established in order to analyse the implementation of SGE in cities. The REGEOCITIES zones are used for the analysis of the potential use of the ground. The aim of the analysis of zones is to find out about special aspects and conditions that can be taken into consideration for the implementation of SGE systems. Both barriers and possibilities are discussed. The analysis of city plans is made for the committed cities and regions by the participating countries and reported in the Appendices. For cities where the zoning is different from the REGEOCITIES zones, a table shows how to associate these with each other. The access to the ground in the different zones is analysed in order to identify zones with low, average and high availability for future recommendations of implementation.

SGE in buildings

The implementation of SGE in buildings is dependent on the type of building and also on the availability of the ground. The underground aspects for different zones in a city are covered in the next chapter. For the building aspect a list of parameters that differentiates different building types has been developed. These are used to assess the possibility for GSHP deployment, especially during refurbishment of buildings, and the compatibility of SGE with a specific building type.

REGEOCITIES building classification

In table 1, generic building typologies are presented. The building types are categorised as residential, commercial, public and historical. The categories and the explanation describe the use of the building, which influence the heating and cooling demands and therefore sets requirements on a SGE system.

Table 1 Building typologies.

Category	Building	Explanation
Residential	Single family building	House with garden
	Multi-family building	House with apartments
Commercial	Office building	Building primarily used for offices
	Commercial – Retail	Shopping mall, supermarket, department store etc.
	Hotel	Provides lodging
Public	School, Library, Hospital, Central and local authorities'headquarters	Building designed for certain activity
Historical	Historical building, church	Protected building structure

Challenges for SGE installations in existing building stock

Table 2 summarises general aspects for consideration regarding SGE integration in buildings. These aspects, explained in the following text, are to be used for analysis of SGE potential in existing building types and for comparison with other heat sources such as gas boilers, district heating etc.

A detailed analysis of the energy demand and system design parameters such as those outlined in Table 2 is essential when evaluating different building types. The first section with parameters in the table considers energy demand and energy balance. The energy demand for heating, cooling and sanitary hot water determines the requirements and the size of the SGE-system. The buildings energy demands depend on the climate as well as the technical characteristic of the building, building type and construction. Where a balanced heating and cooling demand exists for a building or a neighbourhood, a BTES or ATES system can be considered suitable where the energy demand is high.

Table 2 Analysis of building typologies.

Parameter	Proposed answers for evaluation of building
Energy demand	
Estimated heating and/or cooling demand	XX-XX kWh/m^2 ,y heating and XX-XX kWh/m^2,y cooling
Sanitary Hot Water (SHW) demand	XX kWh/year
Energy balance	Heating and cooling relation
System design	
Available space in building for GSHP apparatus	Poor/Good/Excellent
Existence and covering rate of distribution system; centralised heating system (Hydronic system, also known as wet heating, typically radiators) and centralised cooling system	Yes/No How common?
Heating system supply temperature; *Above 61 C - high* *Below 60 C – average* *About 35 C – low*	Low/Average/High
Existence of centralised SHW system	Yes/No
Potential for GSHP integration with existing systems	Low/Average/High
GSHP requires new heat distribution system	Yes/No
Potential for low temperature system, 35 C (under floor/ceiling coil deployment/ radiator fan coil unit)	Low/Average/High
Competing heat sources	Examples
Overall SGE potential	Low/Average/High

The system design is covered in the second section of the table. The design of the existing heating system affects the potential of installing a SGE system, provided that there is space available in the building for the heat pump unit, storage tank etc.

A centralised distribution system is needed for space heating. The temperature level in the distribution system is here ranged from high to low, where a low temperature system is the most favourable option (highest potential performance) when planning an SGE installation. The heat pump can in most cases also provide sanitary hot water. However, this also requires a system design for centralised hot water heating.

Refurbishment could be an opportunity to install a centralised heating system. An under-floor heating system is typically designed as a low temperature system. Another alternative low temperature system for single family houses without an existing hydronic system is a fan coil unit. That solution requires less piping work for installations.

By considering all the listed parameters in Table 2, an overall potential for a building can be developed. The underground potential beneath (or near) the building is partly due to geological (and hydrological) conditions, partly due to constraints by the surrounding city. The constraints by the city are discussed in

the next chapter "SGE in cities". Geological conditions for various European cities are not included in detail this project.

Regulations for refurbishment and regulations for GSHP installation

Regulations and frameworks for refurbishment of buildings have been investigated for interference between refurbishment and SGE installations. A conflict between the applications of SGE in the refurbishment of buildings has not been seen. The main framework and regulations that currently covers the installation of SGE systems is in the transposition of the EPBD.

In **Sweden, Denmark, Netherlands, Belgium, Germany** and **France** the building code sets energy requirements of delivered energy for new buildings. For refurbishment of buildings there are requirements on components such as isolation and windows that improve the building energy efficiency.

In **Sweden**, new buildings are considered heated with electricity if the installed power for heating (including heat pumps) is more than 10 W/m^2. Buildings heated with electricity must use less purchased energy than buildings heated with other purchased energy carriers (oil, district heating, etc.).

In the **Netherlands**, new buildings have to have a minimum Energy Performance Coefficient (EPC). The EPC says something about the minimal energetic quality of a building. The value of the minimum EPC is regulated by law. SGE systems contribute significantly in obtaining this minimum EPC. However, there are no rules about how to obtain the minimum EPC. The constructor is free to choose the methods: extra insulation, better installations or the application of renewable energy, like SGE.

In **France**, the final energy calculation is expressed in primary energy requirements and not in final energy. The conversion coefficient is 2.58 for electricity and it is only 1 for oil and gas.

Also in **Belgium**, the energy performances of new buildings are expressed through primary energy and the PEF for electricity used is 2.5. The three Regions; Flanders, Wallonia and Brussels have their own transposition of the EPBD. Since January 2014, Flanders imposed a minimal share of RES production in every new building. For Heat Pumps the obligation in case of installation is the covering at least 50 % to 75 % of the heating demand and an SPF above 4.

The **German** regulations include limits for specific primary energy use both for new and refurbished buildings. Because GSHP can achieve primary energy savings over gas boilers etc., the result is an incentive for using geothermal heat pump technology.

The **Greek, Spanish, Italian** and **partly German** regulations include quantitative targets for renewable energy (included GSHP installations) concerning new buildings and major renovation of buildings. In Greece and Spain there are for example requirements on 60 % of the DHW supplied by RES systems, that

could be heat pumps that fulfils the requirements on SPF. As above, regulations for refurbishment are focussed on improved energy efficiency measures.

One German state, Baden-Württemberg, has established an obligation that when refurbishing (defined as the replacement of the core components of a heating system), a minimum of 10 % of the annual heat demand has to be provided from renewable sources. This is considered as being fulfilled if a heat pump with a minimum of 3.5 is installed to cover the whole heating demand; with this SPF, typically a GSHP will be the only solution.

In **Ireland** the compliance of building regulations for domestic buildings and regulations for SGE systems sets out operating parameters including COP (2.5) and minimum contribution of a heat pump to the overall heating and sanitary hot water (10kWh/m^2/yr or better) for new build developments.

The Irish requirements for new non-residential buildings over 1,000m^2 are slightly different with consideration of alternative energy systems. This includes: decentralised energy supply systems based on renewable energy, Combined Heat and Power (CHP), district or block heating or cooling and heat pumps.

In **Romania,** the current legislation set that the specific energy consumption for heating in rehabilitated buildings should be below 100 kWh/m$^{2/}$/yr. The regulations on energy audits and Certificates are setting the same limit. The current average yearly consumption for heating in Romanian buildings is 265 kWh/m^2/yr (compared with 125 kWh/ m^2/yr European average).

SGE in cities

In this section, the different city zones are defined and a common analysis for all cities regarding SGE implementation in the different zones is presented. The analysis of participating countries is presented in Appendices 6-10.

REGEOCITIES land area classification

SGE systems can be deployed more or less favourably in different parts of a city. The underground is used for extraction and/or storing thermal energy and for each building supported by SGE system a certain volume of underground is needed. The underground space requirement of an SGE system is determined by geological and hydro-geological, properties, the heating and cooling demand of the building and the use of closed loop boreholes or ground water wells. In urban areas SGE deployment can be limited by geo-technical installations and systems (including archaeological), as well as climatic, environmental, socio-economical and legislative constraints. The layout of this infrastructure and services ultimately determines the feasibility for deployment of SGE systems. It is therefore of outmost importance for the municipality to have thorough understanding of the location of such installations.

The built environment can be classified in numerous ways based on the land use density (exploitation rate, percentage of land use and average building level). This includes residential, commercial and industrial zones. The REGEOCITIES project uses the classification in Table 3 to analyse the potential for SGE deployment in different parts of a city. The different city zones are also shown in Figure 1.

In this chapter, the (hydro-) geological characteristics of the underground are not taken into account.

Table 3 REGEOCITIES land area classification.

Zone	Zone	Explanation
A	Older settlements	Older areas of the city, but without special attention to preservation. Different size and age 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	

Conclusions

SGE 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 SGE 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 SGE when retrofitting. Regulations in Belgium, France, Germany, Denmark and Sweden take primary energy into account, electrically "heat pump heated" buildings including SGE-buildings has 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 centralized (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 city zone level, some general aspects on SGE-systems can be found for almost all city zones, even if they are more significant in some areas compared with others. As an example, a small visual footprint and a low noise level (neither chimneys nor fan-coolers) is in favour for SGE systems in general, however it is more important for an area with special attention to be preserved, like an "old town", than it is for a new commercial centre. Other examples besides low outdoor noise level and small visual exterior footprint stated above, is no local air polluting emissions (no chimneys) and the elimination of risk for legionella from evaporative roof coolers.

In denser areas, large SGE 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 nearby less densely built zones like parks can be used for the underground part of the SGE installation.

In sparse urban settlement 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 SGE 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.

Table 4 is a compilation of all general aspects on SGE in different city zones; it gives an overview, while the national reports in the appendices gives the details. The different city zones are shown in Figure 1 below.

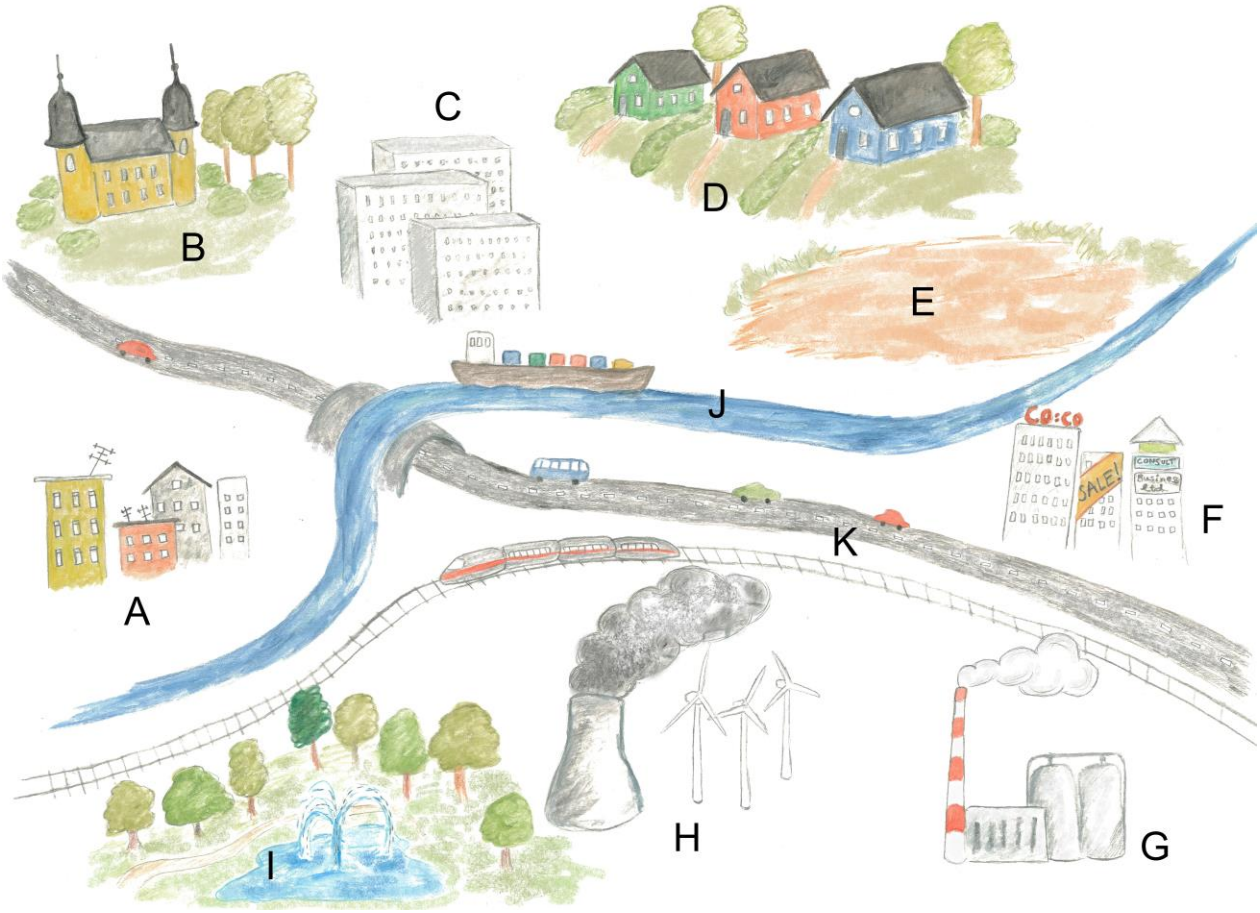


Figure 1 The city zones from REGEOCITIES land area classification.

Table 4 Compiled aspects of SGE potential in cities – a compilation of general aspects.

Zone type		In favour for SGE	Barriers for SGE
A	Older settlements	Low visual impact no sound impact compared to other technologies. No outdoor fan coolers (for chillers/air-condition) or chimneys. Heating and cooling are possible with only one system. If district heating solutions are already used, the implementation of large scale SGE applications can use the preexisting distribution network. In certain cases, "open" technology applications (ATES) or BTES, can be implemented by drilling in building's basement.	Heating and/or cooling infrastructure already in place. Older settlements may have infrastructure not plotted on drawings, making drilling risky. Older settlements may have narrow streets etc. making it difficult to get the drilling equipment in place. Few spots suitable for wells / boreholes can be another difficulty. Existing/lack of distribution system might limit SGE deployment (i.e. lack of centralised/hydronic/wet heating system) depending on level of refurbishment.
B	Areas with special attention to preservation.	Low visual impact, no sound impact compared to other technologies. No outdoor fan coolers (for chillers/air-condition) or chimneys. Heating and cooling are possible with only one system. No delivery of fuel by truck.	Heating and/or cooling infrastructure already in place. Buildings may be extra sensitive to vibration from drilling. Therefore drilling restrictions or extra precautions may be needed. Restoration of courtyards and other exterior areas after installation can be costly. However restoration might be needed after any form of refurbishment. Drilling and digging restrictions due to archaeological importance. Installation of main flow and return pipes through the exterior walls or using existing or new holes may not be possible. However, this could be done below ground level instead with no visual impact.
C	Dense urban settlements	Higher density favour use of large ground area efficient SGE-systems (ATES / BETES), one system for several buildings instead of individual systems alternatively common ground water distribution with individual heat pumps connected. Low visual impact, no sound impact compared to other technologies. No outdoor fan coolers (for chillers/air-condition) or chimneys. Elimination of health problems related to *legionella* from evaporative condensers/cooling towers.	Risk for thermal interference between individual (closed loop) systems due to their closes proximity can limit SGE deployment options. This can also be valid for ATES but the risk can be overcome with proper design. Existing or planned sub-surface infrastructure like metros etc. has the potential to restrict deployment options. Therefore, few spots can be suitable for wells / boreholes. If unbalanced heating/cooling: a balancing source will be needed (i.e. solar collector, cooler or lake/stream)

Zone type		In favour for SGE	Barriers for SGE
D	Sparse urban settlements	Higher availability of space for wells/boreholes Enough space between SGE systems for recovery w/o balance source. Ease of access for equipment and installation. SGE systems generally less restricted.	In some cases, short distance to neighbours (townhouse / terraced house area)
E	Urban development areas (including brownfields, i.e. old industrial areas)	Buildings (individual or neighbourhoods) can be designed for SGE from scratch. This approach covers both heating and cooling needs from the very beginning. Investment in SGE instead of other infrastructure (i.e. gas network) and heat generators (boiler) and cooling system. Low visual impact, no sound impact compared to other technologies. No outdoor fan coolers (for chillers/air-condition) or chimneys. Possibilities to plan large district heating systems with SGE as heat source in early master plan. Possibility to decontaminate soil and underground water in industrial areas by implementing SGE / ATES systems. Possibility of planning small district heating scheme at very low temperature.	Possibilities for planning large district heating systems (with other source than SGE) in early stages of planning If large scale (large systems and/or many systems) SGE is expected, some organisation of the subsurface is needed in order to prevent negative interference between systems and to assure that every building has the possibility to drill. EIA are often needed for large systems. This is time consuming and costly. Risk of toxic leakage from contaminated soil (from old industrial sites) to groundwater.
F	Commercial operation areas	In cold climate: There will be balance between cooling/heating, in favour of large storage (BTES/ATES). Large buildings as shopping malls with high thermal loads; both heating and cooling. Possibility to plan large district heating systems with SGE as heat source in early stages of planning. Offices have high cooling demands -free cooling with COP up to 20 is possible in that kind of building. New buildings can be designed for SGE from scratch. Elimination of health problems related to *legionella* from evaporative condensers/cooling towers.	Permits and authorization procedures for SGE can be pretty heavy and not in phase with Building permit procedures. EIA are often needed for large systems. This is time consuming and costly.

Zone type		In favour for SGE	Barriers for SGE
G	Industrial area	New buildings can be designed for SGE from scratch. Combination of SGE and heating recovery from industrial processes. Possibility to decontaminate soil and underground water in industrial areas by implementing SGE / ATES systems. Possibility to plan large district heating systems with SGE as heat source in early stages of planning.	Risk for ground water from contaminated but stable layers of soil with toxic waste SGE systems are restricted in the temperature ranges they can supply to industrial processes. Many of these have high temperature requirement. Soil contamination even after remediation could be a constraint for permits.
H	Areas for the technical sustainment of the city	Heating and cooling recovery from industrial processes that can be used in H&C GSHP solution.	
I	Park areas	Large areas of open space are suitable for SGE collector deployment if buildings are located in the vicinity.	No buildings to supply with thermal energy in the park area. Sensitive ecosystems of protected area.
J	Water areas with waterways	Water is a very good balancing source for heating as well as cooling of ATES/BTES. SGE can be used directly in water bodies or in the underground beneath the water.	SGE heat transfer fluid can be incompliant with requirements for waterways' safety considerations and water protection Lack of adequate information regarding the quantitative and qualitative thermal effects in specific areas, due to overexploitation of aquatic environments from ATES systems. In most cases no overexploitation. Ground water abstraction might hinder the drilling for geothermal boreholes in drinking water protection areas.
K	Main roads and railroad tracks	SGE could be used to melt/de-ice roads (or only parts of them, especially ramp or slope areas of the road, in winter or when it is needed) by placing collector loops under the road. In summertime, the asphalt serves as a solar collector. This zone favours deployment in road completion or refurbishment projects.	Road infrastructure design could restrict deployment options.

Introduction to Appendices

Reported in the first part of Appendices (1-5) are analyses of different aspects for implementation of SGE in the city zones. This includes examples from committed cities. Analyses of city plans were made for the committed cities by the participating countries. For cities where the zoning is different from the REGEOCITIES zones, a table shows how to associate these with each other.

The analysis in the second part of Appendices (6-11) gives a general overview of different aspects for implementation of SGE in cities in participant countries or specific regions.

Part 1 - Detailed examples from committed cities

Appendix 1: Sweden - Analysis of SGE in cities

In this section the challenges for SGE in the city of Stockholm and Karlstad are analysed including existing regulatory examples.

Land area classification

The REGEOCITIES zones are applicable to the two cities. The city of Stockholm (approx. 900 000 inhabitants) and Karlstad (approx. 90 000 inhabitants) has been used for the analysis.

A. Older settlements
B. Areas with special attention to preservation
C. Dense urban settlements
D. Sparse urban settlements
E. Urban development areas
F. Commercial operation areas
G. Logistic zones and manufacturing
H. Areas for the technical sustainment of the city
I. Park areas
J. Water areas with waterways
K. Main roads and railroad tracks

Analysis of the potential for SGE in the zones

In general there are no restrictions/barriers for SGE systems in a specific or typical for zone A-K. In Stockholm there are some areas with secret installations surrounded by a “secret zone”, mainly in central parts.

There are restrictions for drilling in water protection areas, which include built environment in both Stockholm and Karlstad, also in central parts (all type of scenario zones). In Karlstad a permit is required for GSHP (and not only a notification) in water protection areas. In Stockholm, a permit is obligatory everywhere for GSHP installations.

It is possible drill on ground not owned by the SGE owner, including municipal owned ground like streets and parks. This requires an agreement, a utility easement, with the property owner whoever it may be. There are several examples of this in Stockholm both ordinary GSHP installations and larger aquifer storage used by district cooling utility as short time storage. Utility easements are as example used for streets in central Stockholm (zone for zone A and C). It is also possible to utilise the underground under main roads and railroads (zone K), but for practical reasons the installation/drilling is probably made at the side of the infrastructure. The same goes for underground with tunnels, power cables, water pipes, etc. Only a few properties are 100 % blocked by such infrastructure, but sometimes controlled drilling with better

precision must be used near those objects. Underground garage could be used for installations of wells and boreholes, and is not a problem by itself.

Old historical settlement (zone G) like the old town of Stockholm has restriction to minimize vibrations from drilling. Water drilling with lesser vibrations than pneumatic drilling is prescribed in the permit by Stockholm City.

The availability of the ground

The underground is suitable for GSHP from a geological point of view in most parts of Sweden. Only a small percentage has thick layers of clay (as example parts of Gothenburg and Göta Älv valley) or other less suitable underground conditions like the island of Gotland that is mainly lime rock. Around 15 % of the ground in Sweden consists of permeable ground suitable for ATES systems.

Besides the geological conditions, lack of space between boreholes can become a limiting factor as well as lack of thermal underground volume. For zone D (sparse urban settlements), i.e. zones with low heat energy density (low building heat energy demand per ground area) like single family houses and two floor terraced housing, the distance between boreholes can become the limiting factor. The recommendation in Sweden is 20 meters, and detached/terraced housing might have small plots. Despite this, close to 100 % can drill and install even in these zones. In Stockholm common drilling plans are made for some of the tighter terraced housing areas to ensure that everybody gets a chance to drill even though the 20 meter distance is not reached. A shorter distance than 20 meters can also be allowed if the SGE-system owner can prove it will be compensated for by a deeper borehole or active recharge.

Zone C (dense urban settlements), such as areas with multifamily buildings, is slightly more complex to analyse than just looking at distance between boreholes. For larger buildings the maximum practical borehole depth is utilised, typical about 200 meters. The regulatory 20 meter recommendation to neighbours is still valid, but for heat regeneration a 15 meter minimum distance might work for passive heat recharge depending on local conditions. For these areas an average distance between boreholes can be calculated as a measure of tightness for GSHP installations. This has been made in a table below. For zone C zones with a high ratio of built ground it can also get tricky to find locations for the boreholes, but in most cases can locations be found on sidewalks, courtyards, etc.

For zone C but also F and G, borehole thermal energy storages could be used. The key for BTES is a balance between heat and cooling demand. Residential floor area alone will not get this balance in Sweden making the investment less feasible, but residential floor area in combination with office, shops or other commercial floor area with comfort cooling demand might work regardless if it is in the same buildings or a couple of buildings in a block sharing BTES. In a BTES up to eight times as many holes are drilled per area compared with GSHP and

because of recharge more energy can be extracted per gross ground area than for a GSHP. Also in this case it is possible to calculate how much of the underground in a zone that must be used as storage volume of total available underground as a measure of thermal tightness. The table below give an indication of when it starts to tighten up for GSHP respectively BTES if ALL buildings were to be supplied in different built city typologies/zones.

The following table show an indication of "Thermal underground tightness" for GSHP and BTES for different zones, depending on their Floor Area Ratio (FAR) and building energy performance. Floor Area Ratio is the total Gross Floor Area divided with total Gross Ground Area.

For GSHP the recommendation is 20 meters between each installation, but it will start to tighten up earlier since the holes can't be drilled with even spacing all over a zone. For BTES a percentage of the underground covered is shown. Please observe that BTES the boreholes can be drilled with an angel utilising heat in the underground below a building. It is also possible to use nearby areas, such as parks, water ways, etc. (Zone H, I and J), besides sidewalks, parking lots, garages, etc., for BTES installations. In both cases it is calculated as if ALL buildings were to be supplied by SGE. A typical central city district with "large city blocks" have about 3-6 floor buildings. Typically the Floor Area Ratio (FAR) is about 1.2-2.5 and maybe 25-60 % of the ground area is built. As can be seen in the table, the average distance is only 14 meters for average energy performance building with a FAR of 1.25. BTES has better possibilities to provide heat and cooling for a good part of the buildings, but underground utilised is exceeds 100 % already at a FAR of 1.75 for the average building. With new/energy refurbished or energy efficient buildings BTES could provide heat and cooling for all buildings.

A zone with "small town blocks", usually have 2-3 floors, a FAR from about 0.6 to 1.5 and about 20 % to maybe 50-60 % built ground area. The heat energy demand is still too high for 100 % GSHP zone coverage with current building standard, but for zones with new or energy efficient buildings and low density, GSHP could actually supply up to 100 % with some planning of borehole locations.

"Million programme" zones, built 1965-1975, is characterized by three to ten floor buildings, an FAR of 0.70 to 1.5 and about 10-20 % built ground area. In these areas there are in general easy to find drilling locations between the buildings and if not too poor energy performance or too high FAR, GSHP could provide heat for about 50 % or more of the buildings in a zone. However BTES with recharge (from solar collectors) can supply all buildings.

"Medium high open zones", usually 2-3 floor, ranges from FAR 0.4 to 0.7. These zones have less tightness than above zones and good possibilities for SGE.

A "garden town", characterised by dense but low buildings, have a FAR between 0.2-0.4 and 15-20 % built ground area. As can be seen, the underground tightness is low, with a long average distance between holes if all holes are 200 meter deep. If there are many smaller

Garden town

buildings, the number of holes will increase not because of the zones energy density, but because of the number of individual installations. This can make it tighter between boreholes, just as it is for detached housing zones. Still close to 100 % should be able to drill.

Building performance	Poor	Average	New/ Refurb.	Energy efficient
Heat/Gross Floor Area (kWh/m2, year)	240	160	80	50
Seasonal Performance Factor (SPF)	3,5	3,5	3,8	4,0

	GSHP average borehole distance (m)				BTES area coverage of gross ground area (%)			
	Building energy performance				Building energy performance			
FAR	Poor	Aver.	New	EE	Poor	Aver.	New	EE
3,00			13	16	290%	190%	100%	65%
2,75			14	17	265%	175%	90%	60%
2,50		10	14	18	240%	160%	85%	55%
2,25		11	15	19	215%	145%	75%	45%
2,00		11	16	20	190%	130%	65%	40%
1,75	10	12	17	21	170%	110%	60%	35%
1,50	11	13	18	23	145%	95%	50%	30%
1,25	12	14	20	25	120%	80%	40%	25%
1,00	13	16	23	28	95%	65%	35%	20%
0,90	14	17	24	30	85%	60%	30%	20%
0,80	15	18	25	32	75%	50%	25%	15%
0,70	16	19	27	34	65%	45%	25%	15%
0,60	17	21	29	37	60%	40%	20%	15%
0,55	18	22	30	38	55%	35%	20%	10%
0,50	19	23	32	40	50%	30%	15%	10%
0,45	20	24	34	42	45%	30%	15%	10%
0,40	21	26	36	45	40%	25%	15%	10%
0,35	22	27	38		35%	20%	10%	5%
0,30	24	30	41		30%	20%	10%	5%
0,28	25	31	43		25%	20%	10%	5%
0,25	26	32	45		25%	15%	10%	5%
0,23	28	34			20%	15%	5%	5%
0,20	30	36			20%	15%	5%	5%
0,18	32	39			15%	10%	5%	5%
0,15	34	42			15%	10%	5%	5%
0,13	37	46			10%	10%	5%	5%
0,10	42				10%	5%	5%	0%
0,09	45				10%	5%	5%	0%
0,08					5%	5%	0%	0%
0,06					5%	5%	0%	0%
0,05					5%	5%	0%	0%

Large city blocks
Million programme
Small town blocks
Medium high zone
Garden town

Alternative heat sources

There are two main competing heat generators, district heating and air source heat pumps.

The majority of multifamily buildings are connected to district heating, about 80 %, as well as many commercial buildings in city centres. High heat demand density favours district heating, but it is even more favoured by a large total heat delivery. The larger the total delivery is, the more cost efficient will the production in general be, like combined heat and power plants or waste-to-heat boilers. Single districts can because of this get district heating regardless of their heat demand density. Low heat density villages can be connected by several kilometre long pipes from a larger town. District heating is however not always the number one alternative, there are examples of multifamily buildings disconnecting from district heating and drilling for GSHP in central parts of Stockholm.

For single family houses air source heat pumps are the most popular choice, especially for newer houses with higher energy efficiency and a relative low heat energy demand. Air source heat pumps are an alternative that have a lower investment cost than GSHP and somewhat lower SPF values of operation.

Commercial buildings have a cooling demand besides heating. District heating in combination with district cooling are competing technologies for these kinds of buildings.

Outside district heating areas traditional electrical chillers and boilers are the competing alternatives. Currently electricity is cheaper than heating oil (after environmental taxes) for these buildings making most of them run on electric boilers. Some larger commercial complexes use wood pellet fired boilers.

Appendix 2: Netherlands - Analysis of SGE in cities

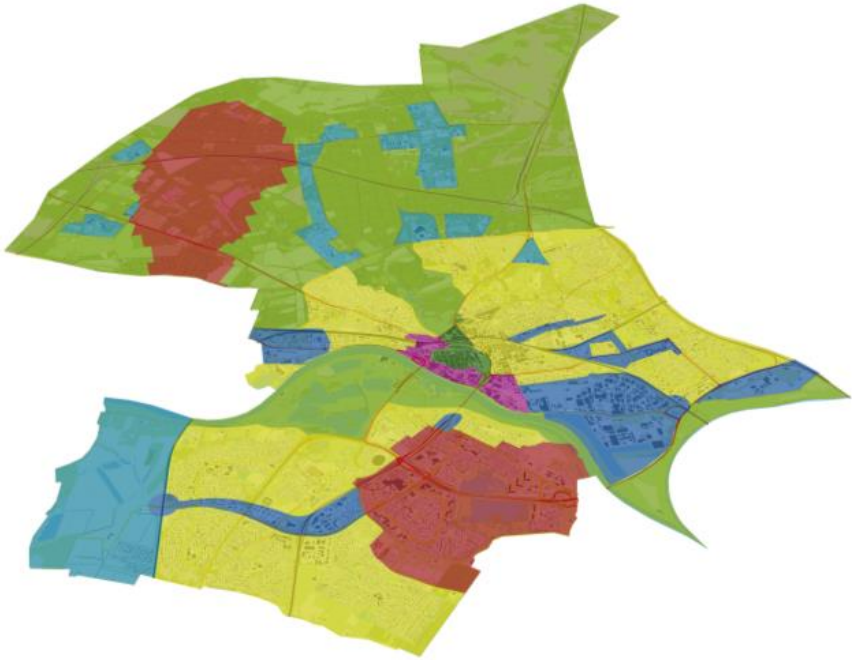
In this section the challenges for SGE in the Netherlands and existing regulatory examples are analysed.

Land area classification

The REGEOCITIES zones are applicable to the most cities in the Netherlands. Based on land classification, the cities of Arnhem and Breda have made an SGE planning map for (a part of) the city. These examples are shown here.

Municipality of Arnhem

For the municipality of Arnhem, a land area classification map is made. The municipality is divided in 8 categories:



Restrictions

- groundwater protection area: SGE is not allowed
- master plan area: realization follows rules in master plan

ATES areas: in these areas ATES is preferred

- urban area, existing buildings
- suburban area
- urban, area, new building

BTES areas: in these areas BTES is preferred.

- urban area

No preference

urban area
suburban area

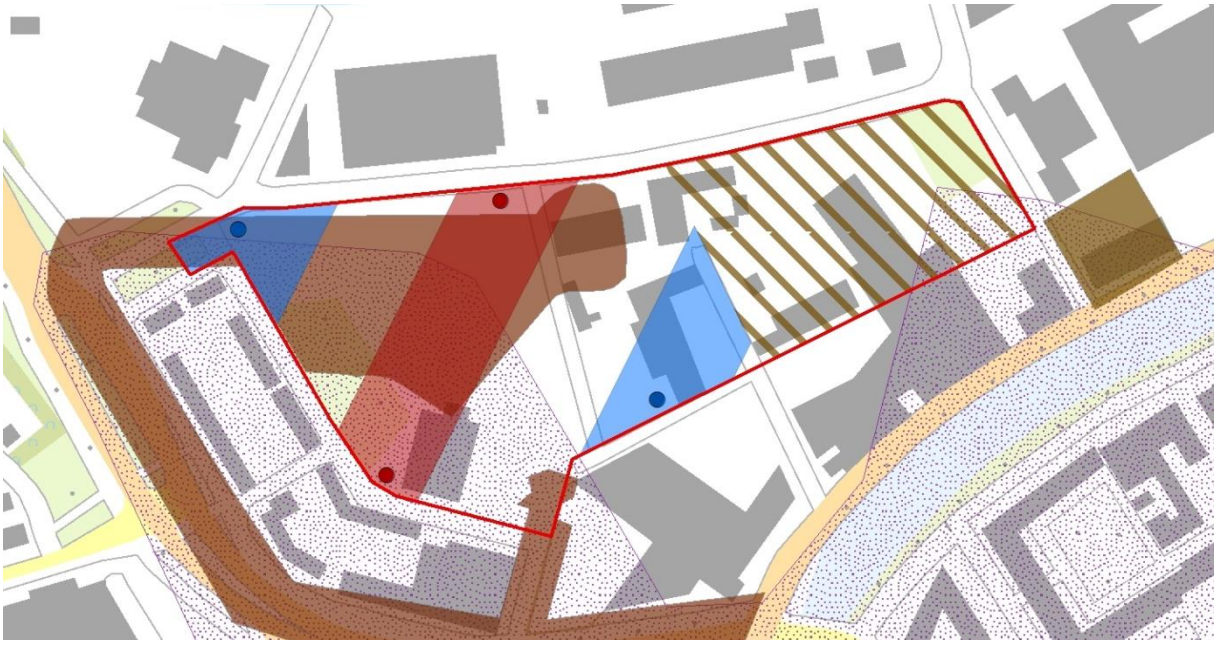
For the division in these categories, the following aspects are taken into account:

- high or low energy demand in the area
- potential of the subsurface
- type of development (residential, commercial, etc.)

For the realization of SGE systems, a set of guidelines has to be followed. Each category has its own set of guidelines.

Municipality of Breda - Master Plan Triple O Campus

For an area in the municipality in Breda a Master Plan is made in order to organize the subsurface for SGE. The organization is needed due to the presence of other interests, like contaminations and archaeological sites.



Master Plan area

interests

contaminated
possibly contaminated
former landfill
high archaeological expectation

wells

cold well
warm well

designated areas

cold well
warm well

New wells have to be positioned in the designated areas for cold and warm wells. In addition, each new system has to meet some extra guidelines that are added to this map. These rules are (for example):

- maximum capacity of a well is 100 m3/h
- maximum depth of each well is 100 m below ground level

Analysis of the potential for SGE in the zones

This section describes how the situation in general is in the Netherlands.

In the Netherlands, we distinguish the following barriers for SGE system. For every aspect is described in which type of zone it can be present.

Groundwater protection areas

These are in most cases not situated in urban areas, so it is not relevant.

Other SGE systems

This can be relevant in situations where a lot of SGE systems are already present or expected. This is mainly in areas with a lot of new buildings (houses for BTES, offices and commercial buildings for ATES). This corresponds to zones C, E, F and G.

Archaeology/monuments

Mainly relevant in (old) city centres (even without special attention to preservation, general archaeological rules apply). This corresponds to zone A, but sometimes this archaeology and monuments are also present in zones C, D and I. In the countryside there are specific monumental/archaeological sites too. Those sites generally have a special status, so zone B.

Nature

Are in most cases not situated in urban areas, but sometime nature areas are adjacent to urban areas. Only when they have a special status, it can be a barrier for SGE systems, so zone B. In most cases though, nature is not a restriction for SGE. You only have to pay a little bit more attention to the design of you system.

Soil/groundwater contamination

This is relevant in former industrial areas and locations where chemical drycleaners were situated, where contamination with chlorinated hydrocarbons (tetrachloroethylene, trichloroethylene) are common. Former industrial areas are often development areas (zone E). The former chemical drycleaner are often located in older urban areas (zones A, C and D).

Trenches, dams and other structures for protection against water

Because a big part of the Netherlands is below sea level, we have a lot of structures that protect us from the water. These structures are situated in all possible places (not only next to water ways). All zones are relevant here.

Infrastructure

Special precautions have to be taken for drilling next to big infrastructural object like highways, train and metro tracks, which corresponds to zone K. For drilling you also have to pay attention to underground garages (zones C, E and F) and cellars (zones C and D). And for ATES system you have to pay attention to all these aspects, because of the influence an ATES system can have on the groundwater table.

Cables/pipelines

This aspect is mainly relevant for the incorporation of drillings in the subsurface. Mainly in dense urban areas (zone C); the subsurface is already full with cables and pipeline (gas, electro, sewerage, telecom, etc.). This makes it difficult to find location for the wells or loops of SGE systems.

In most cases all systems have the same regulative framework. Only in dense areas, where a lot of SGE systems are already present or expected, or where there are other barriers present (for example when the space available for drilling is scarce due to cable and piping present in the subsurface) the authority can develop a so-called master plan. These are plans that organize the subsurface. These plans often contain extra rules for the application of SGE systems, for example a maximum drilling depth or a minimum distance between systems. Also, locations for warm and colds wells are sometimes designated. These plans are often made for locations in zone C, E, F.

When you want to drill in municipal land or a neighbour's property, you always have to ask for permission of the municipality/neighbour. Only when you get the permission, you are allowed to drill. This rule always apply, there is no difference between the different zones.

The application process of ATES systems is different from the application process of BTES systems: the provinces are the authority for ATES systems and the municipalities for BTES system. In general all ATES have the same framework and all BTES too. There are some small differences between provinces and municipalities, but these differences are related to the hydrogeological aspects (soil structure and groundwater quality) of the subsurface and not to the different zones.

For ATES systems are two permitting procedures present: if the situation is complex (many interests) a longer procedure (6 months) is used, in a simple situation a short procedure (8 weeks) is used. These are two types of standard procedures, which are defined in national legislation.

For BTES the following national rules apply: a large system (> 70 kW) needs a permit, a small system (< 70 kW) only a registration.

The availability of the ground

The underground is suitable for SGE from a geological point of view in most parts of the Netherlands. Only a small percentage has thick layers of clay (around Enschede) or other less suitable underground conditions (province of Zeeland).

Besides the geological conditions, lack of space between boreholes can become a limiting factor. In the table below there is an estimation of percentage of the space that is available in a certain area for the drilling of holes.

A.	Older settlements	50-90 %
B.	Areas with special attention to preservation	0 % (groundwater protection area) 95 % (environmental protection area)
C.	Dense urban settlements	50-90 % (depending on how many SGE initiatives there are present)
D.	Sparse urban settlements	100 %
E.	Urban development areas	80-100 % (depending on how many SGE initiatives there are present)
F.	Commercial operation areas	80-100 % (depending on how many SGE initiatives there are present)
G.	Logistic zones and manufacturing	80-100 % (depending on how many SGE initiatives there are present)
H.	Areas for the technical sustainment of the city	80-100 % (depending on how many SGE initiatives there are present)
I.	Park areas	100 %
J.	Water areas with waterways	100 %
K.	Main roads and railroad tracks	100 %

Alternative heat sources

In general traditional electrical boilers are competing alternative heat sources.

In some municipalities, district heating network are created by energy supply companies. Often, these networks are co-financed by the municipalities. Due to the high investment costs in these networks, there is a preference for the use of these networks. However, this doesn't mean that SGE systems are not allowed. Mainly ATES systems are seen as a complementing technique on district heating: heat is supplied by the network, cold by the ATES system.

Appendix 3: Ireland -Analysis of SGE in South Dublin and Cork City

Land area classification

Based on the initial zones agreed in the REGEOCITIES project for consideration with respect to the integration of SGE systems in cities, the land zoning classification have been considered for Cork City and South Dublin as outlined in the current development plans. This process is somewhat facilitated by the national Generalised Land Zoning (GTZ) categories in Ireland that have been developed and these are implemented across all local authorities.

The general category classifications are as follows:
P - Primary Sector
C - Commerce / Industry / Enterprise / Economic Development
S - Community Services / Facilities
N - Networks and Basic Infrastructure/Utilities
R - Residential
G - Green / Recreation / Conservation
M - Mixed Use
O - Other

The individual descriptions of each category are provided below and the relevant subcategories are also included.

Primary Sector - In essence this high level GZT category is intended to provide for zones which deal mainly with exploiting the physical resource base.

Agriculture (P1) is a sub-category intended to provide for zones directed at farming and related activities.

Forestry (P2) would include for example zones where growing trees for commercial gain would be the main use. It would exclude zones for the protection of natural wooded areas as these zones would have a nature conservation or related intended main use.

Aquaculture and fishing (P3) would for example include zones which cover land or water areas which are intended to be used for fishing or aquaculture purposes.

Quarrying/mining (P4) is a sub-category to provide for zones where extraction of stone or aggregate is the main intended use.

Mixed/general primary sector uses, including rural (P5) is a sub-category intended for zones which have as a main purpose the provision of any two or more of the other listed Primary Sector purposes (agriculture, forestry etc.). Zones which fall into this sub-category would not indicate any preference between the zones which fall into the other listed sub-categories.

Other primary sector (P6) is a catchall sub-category which is intended to cater for any Primary Sector zones which do not fit well into any of the other sub-categories within this Primary Sector GZT category. It is not envisaged that this sub-category will be often used as in particular the mixed sub-category (P5) would cater for many of the zones which do not easily fall within the other sub-categories (i.e. P1 to P4).

Commerce / Industry / Enterprise / Economic Development

Commercial, retail would include any form of commercial or retail zone where the main aim is to sell goods or services to the public.

Commercial, retail (C1.1) would provide for any zoning which has commercial and/or retail activities as the main purpose. However retail warehouses would be excluded from this sub-sub-category.

Retail warehouse (C1.2) given the prevalence of retail warehouse zonings and the particular conditions associated with this use, this type of zone is identified as a sub-sub-category.

Industrial, enterprise, employment refers to zones where manufacturing and the provision of related services are the primary intended uses.

Industrial, enterprise, employment (C2.1) would provide for any zoning which has these uses as the main purpose. However general industrial zones would be excluded from this sub-sub-category.

General industry (C2.2) zones would provide for industrial uses which could have a substantial amenity and other impact and thus this type of industry is specifically identified as a separate sub-sub-category. Sometimes the term 'heavy industry' is used to describe the types of industrial uses which would occur in this zone type.

Office, business/technology park and related (C3) is a sub-category for zones where office or technology/research facilities are the main intended uses.

Warehouse (C4) is a sub-category where the primary use would be the storage of goods, equipment etc. Retail warehouse zones are not included in this sub-category due to their significant retail function.

Tourism and related (C5) would for example include zones where the main uses would be hotels, marinas or other types of uses which are directed mainly at servicing tourists/holiday makers.

Mixed/general commercial/industrial/enterprise (C6) sub-category would cater for zones where there is a mix of one or more of the other specific sub-categories (C1 to C5) in a way where there is no clear preferences or predominance for any one of the uses indicated in these other sub-categories.

Other commercial/industrial/enterprise/economic development (C7) is a catchall sub-category intended to cater for any commerce/industry/enterprise/economic development use which does not fit into any of the other sub-categories C1 to C6. It may be expected that this sub-category would be infrequently used given the range of other sub-categories (C1 to C5) and the mixed sub-category (C6).

Community Services / Facilities - In essence this broad GZT category is intended to cater for the range of social or community services or facilities which are provided mainly but not exclusively by the public sector.

Education (S1) would for example include all types of zone where the land would primarily be used for teaching or training and would include any type school (pre-primary, primary, secondary), as well as land zoned for university, institute of technology or other post school proposes. The means of provision, public or private, is not a relevant factor when viewing zones in this sub-category.

Health and related (S2) would for example include hospitals and clinics, whether provided through public or private means.

Community facilities (S3) would for example include nursing homes, cemeteries, community halls and any other facility which are intended to provide some form of community service. Public or private delivery is not a factor in this case.

General public administration (S4) would for example include local authority or government department offices and non-commercial state agencies uses.

Mixed/general services/community facilities (S5) would include cases where the zone indicates a range of different possible uses of a community services/facilities nature (ie more than one of the S1 to S4 sub-categories).

Other community services/facilities (S6) is a catchall category which would probably only be used very occasionally but would provide for zones which provided some form of specific community service/facility which is not covered by the other categories (S1 to S5).

Networks and Basic Infrastructure/Utilities - In essence this GZT category is to provide mainly for the physical engineering services which are needed to support modern living and working.

Transport is a sub-category related to the movement of people or goods. It is one of the sub-categories which is subdivided into lower level categories (sub-sub-categories), mainly because of the very significant difference between the uses in these sub-sub-categories.

Road (N1.1) would cover roads but also for example include service stations and bus depots. It would also include cases where 'proposed road' is indicated on a zoning map.

Rail (N1.2) would in addition to rail lines include stations and marshalling yards.

Airport (N1.3) would include landing strips. Major airports can be a source of considerable enterprise development. However the primary purpose of an airport zone is to provide for air travel and thus the zone should be categorised into this sub-sub-category.

Seaport/harbour (N1.4) would for example include quays, loading/unloading areas and storage areas which are used mainly for goods storage. It would include facilities related to commercial fishing and docking of cruise liners or ferries, but would exclude marinas where the intention is to provide mainly for small pleasure craft. Seaports/harbours can provide for substantial amounts of enterprise activity but as the primary purpose is of a transport nature they should be categorised into this sub-sub-category.

Mixed general transport (N1.5) provides for the case where a zone would have as a main use two or more of the above uses (ie of N1.1 to N1.4).

Other (N1.6) is the catchall sub-sub-category which would be used when a zone intended to provide mainly for transport uses does not fit well into any of the other sub-sub-categories (ie N1.1 to N1.5).

Water/Wastewater is a sub-category intended to cater for any zonings which related mainly to the purification, storage and/or the distribution of water.

Water (N2.1) would include reservoirs, processing plants, pump station areas. It would include dams where the primary purpose is as a source of raw water.

Wastewater (N2.2) would provide for zones which relate to sewerage treatment works, pump stations or other related facilities.

Mixed/general water/wastewater (N2.3) would apply when no distinction is made between water and wastewater related facilities.

Other water/wastewater (N2.4) uses is the catchall sub-sub-category which may be expected to be used only infrequently given that virtually all water and wastewater related zones should be covered in one of the above three sub-sub-categories.

Gas and electricity

Gas (N3.1) would provide for any zones which relate mainly to the storage, processing or distribution of gas.

Electricity (N3.2) would provide for any zones which provide mainly for the generation or distribution of electricity. Wind farms, pump storage electricity generation facilities would be included into this sub-sub-category. If power line routes are designated as zones then they would fall within this sub-sub-category.

Mixed/general gas and electricity (N3.3) would provide for the probably unlikely case of zones which provide for both gas and electricity uses.

Other gas and electricity infrastructure/facilities (N3.4) is the catchall category to cater for any zones which relate mainly to gas and electricity matters but which fall outside of the sub-sub-categories N3.1 to N3.3.

Telecommunications (N4) would for example provide for zones which relate to telecommunications masts.

Solid waste (N5) would provide for example for zones where the main use would be solid waste disposal sites, incinerators, bring banks, etc.

Other networks and basic infrastructure/utilities (N6) is the catchall sub-category which may be expected to be used only infrequently given that virtually all network and services/utilities related zones should be covered in one of the other sub-categories or sub-sub-categories (N1 to N5).

Residential (R) - New/proposed residential,

Strategic residential reserve (R1) is a sub-category which applies where the zone relates only to undeveloped land where the intention is for residential development to take place.

Existing residential (R2). Some plans distinguish between residential zones where the land involved is undeveloped, and where there is existing housing. The zones related to this latter category are most frequently termed 'Existing Residential', or some very similar name. Such zones would be classified into this sub-category.

Residential, mixed residential and other uses (R3). This sub-category provides for cases where residential zones do not fall directly into one of the sub-categories R1 or R2, or when there is a distinct component of the zone which enables other residential type or related uses to occur in the zone. It is a catchall sub-category which could be used in the case of zones which have a primary or strong residential intention but which straddle the other residential sub-categories

Strategic residential reserve (R4). A number of plans identify areas which are intended for residential development at some future date. Normally no details regarding the density or form of residential development which should occur in these areas are set out in the Plan.

'Green' / Recreation / Conservation (G) - In essence this broad GZT category is intended for zones which cater for 'green', recreation and conservation related issues.

Open space, park (G1) would cater for zones where the intention is to retain areas as undeveloped and for mainly passive open space related activities. The open space/park areas could of course contain active play facilities such as children's play areas but these would be only a smaller component (say under 30 %) of the overall area involved. Judgement calls may be required if the active component exceeds say 30 % as to whether the zone falls within this category or the Active open space category (G4).

Walkway, cycleway, bridal paths (G2) is a sub-category for zones where the main intention is to provide for travel by foot, cycle or horse. They most frequently occur alongside rivers but

could of course occur elsewhere. In some cases they occur as buffer corridors and could be classified into the sub-category G3 mentioned below, but in such cases it would be more appropriate to place these zones into this sub-category where there is specific mention of their role in relation to walking, cycling or horse riding.

The Conservation, amenity or buffer space, corridor/belt. landscape protection (G3) sub-category is intended for zones where the main aim is to provide some level of conservation, whether of biodiversity, visual amenity or quite. Natura 2000 sites or other designations in terms of EU Directives would not be recorded as part of this GZT exercise as this is information which will be available in DevPlanGIS from other sources.

Active open space (G4) is a sub-category into which zones which provide for stadia, GAA pitches, golf courses, rugby or soccer fields etc. should be placed. If these facilities are part of a much larger open area zone then a judgement call is required to determine if the zone falls within this sub-category or the Open space, park sub-category (G1). As a general guide, if more than 30 % but less than 50 % of the area would be taken up with the facilities mentioned above then it is probably the case that the zone should be classified into this sub-category, with a judgement call being required to make the final determination. However if more than 50 % of the land area would be so taken up then the zone would definitely need to be classified into this sub-category.

Mixed/general 'green', recreation and conservation and other (G5). This catchall sub-category is intended to cater for those cases where a zone contains objectives which explicitly straddle two or more of the other sub-categories (G1 to G4).

Mixed Use (M) - Mixed Use, general development, opportunity/proposal site (M1) is a sub-category which is intended to cater for zones which are specifically mixed use in nature (eg named 'Mixed Use') or which although having some other name are in effect general mixed use zones (eg 'General Development'). In the case of Opportunity Sites or Proposal Sites a judgment would need to be made regarding whether or not the intention is to provide for a wide range of uses, or to give clear preference to a specific or more focused type of development (eg residential, commercial), in which case the opportunity/proposal site zone would be more appropriately allocated to one of the other GZT categories/sub-categories/sub-sub-categories.

City/Town/Village centre or central area (M2). This sub-category is intended for those zones which cover central parts of cities, towns or villages. In virtually all cases a mix of uses is encouraged in these zones.

District, neighbourhood centre (M3) is a sub-category into which various forms of zonings related to the establishment of mixed use nodes away from the central area.

Built up area (M4) is to cater for zoning designations which occur only occasionally and which are intended to cover the wide range of uses which occur in areas which have already been built. The 'Existing Residential' zones which occur in some Plans would not be allocated into

this sub-category as they invariably have objectives which relate to protecting/enhancing only one objective, namely, residential amenity.

Other mixed uses (M5) is the catchall sub-category which can be used in the case of a zone which clearly has a mixed use objective but which for some reason does not fit easily into the above mixed use sub-categories (M1 to M4).

Other (O) - This is a final catchall category which would only be used if a zone did not fit comfortably into any of the other categories, sub-categories or sub-sub-categories. .

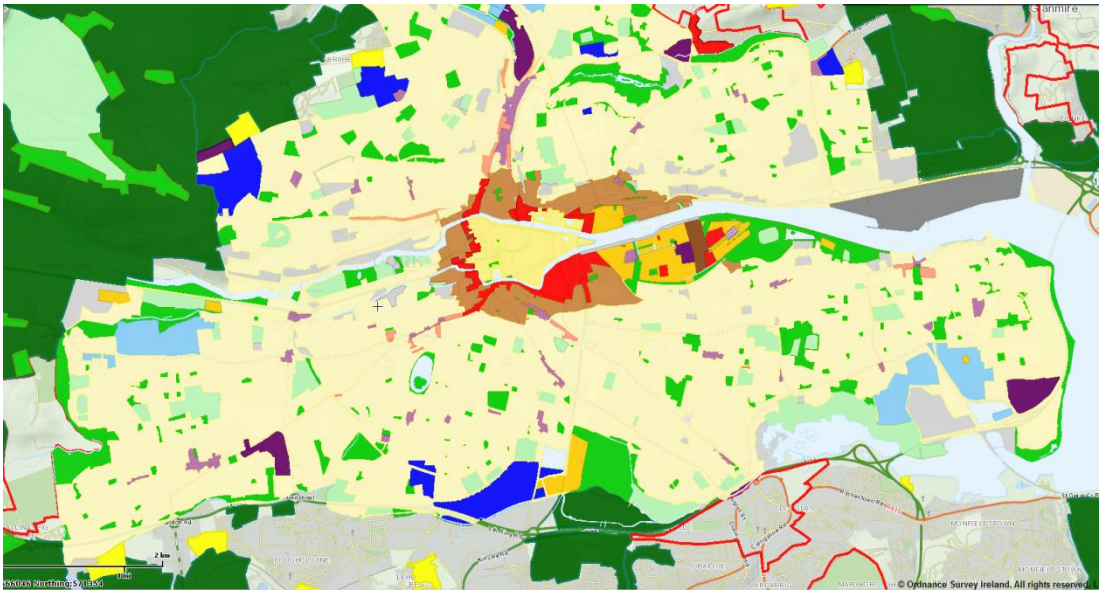
Strategic Reserve, white land (O1) is to cater for those cases where land is zoned for development at some time in the future but no objectives or specific controls are indicated. White land is sometimes the term used for land which falls into this sub-category.

General (O2) This is the final catchall sub-category which is intended to be the place where any zone which does not fit into any of the other sub-categories or sub-sub-categories can be allocated. Given the extensive nature of the overall GZT classification scheme set out above it is not expected that there would be many classifications into this sub-category.

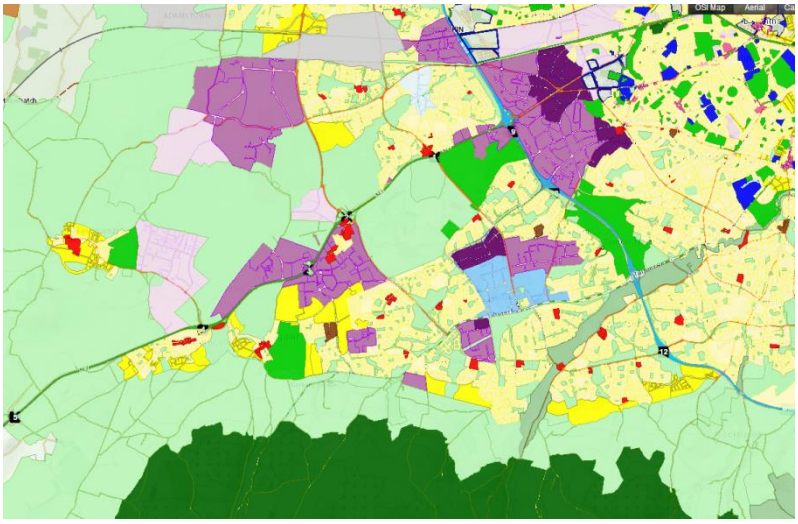
Based on an analysis of the overview of the categories provided for the REGEOCITIES project, an assessment of the land zoning sub categories in Ireland has been considered. The analogies between the GZT subcategories and the REGEOCITIES categories are described in the table below.

REGEOCITIES Zone	Name	Other categories - GTZ Categories - Ireland
A	Older settlements	M2
B	Areas with special attention to preservation.	G3
C	Dense urban settlements	S2, S4, S3, M4 (S6-R3-M5)
D	Sparse urban settlements	R2
E	Urban development areas	R1, R4, M1, O1
F	Commercial operation areas	C3, C6, C1.1 (C7)
G	Industrial area	C1.2, C2.1, C2.2, C6 (C7)
H	Areas for the technical sustainment of the city	N2.1, N2.2, N2.3 - N3.1, N3.2, N3.3, N3.4 (N2.4 - N3.4 - N.6)
I	Park areas	G1, G2 (G5)
J	Water areas with waterways	
K	Main roads and railroad tracks	N1.1, N1.2, N1.3, N1.5 (N1.6)

The maps below represent an example of the zoning categories in Cork City Centre and in South Dublin.



(Extract from myplan.ie - Cork City Zoning - Development Plan 2009-2015)



(Extract from myplan.ie - South Dublin Zoning - Development Plan 2011-2017)

Underground infrastructure information in Ireland is available through the statutory undertakes in the case of telecommunication, electricity, gas and water. With respect to underground tunnels and road infrastructure which only occurs in Cork City centre and Dublin City centre, information lies with the National Roads Authority and the Council.

The information with regard this infrastructure is available upon request and application. Where public consultations have taken place with respect to the development of any underground services, the information with respect to these and planning process would be publicly available (however this is really only the case for strategic infrastructure).

There is currently no register of SGE systems in Ireland. An ongoing initiative by the Geological Survey of Ireland is in the process of trying to establish a national database of SGE systems. Current information of large SGE schemes that require and EIA and open loop systems require discharge license will be the only ones that are known to local authorities.

Analysis of the potential for SGE in the zones

No specific regulations or guidelines in Ireland exist with respect to deploying SGE systems in different land zone areas when considering other subsurface users. The potential barriers in the different zones are discussed throughout this document.

The regulatory framework in Ireland requires that some considerations are given in all land zone areas where open loop geothermal systems are proposed. These include the consideration of re-injection to a groundwater aquifer or to a surface water body. Larger scale systems proposing to pump above a certain threshold are required to obtain a discharge license from the relevant County Council. Any application will take into considerations the

proposed discharge water temperature and chemistry. This process would be applicable to all land zone classifications considered.

Specific to the development of open loop systems in urban areas and in the case of Cork city and Dublin city centre, most of these exploit river gravels associated with the river Lee and Liffey. Both of these rivers have a tidal influence and salt water incursion in this shallow aquifer is common. Groundwater quality for open loop systems needs to be carefully considered in advance of developing an open loop system as these waters; whilst of interest as a result of the urban heat island effect may be of poor quality. These could therefore present problems in terms of corrosion and fouling to the heat pump if used directly but also in the case of the discharge.

Cork City Council reviews planning application for a new building which include the installation of an open loop geothermal system in the extensive buried gravels of the River Lee the extend across the city centre. New applications therefore need to be considered in the context of existing operating open loop systems. A large scale or commercial system would be asked to supply pumping test data to demonstrate that there would be no adverse impact on other operating geothermal systems or other users of the same aquifer.

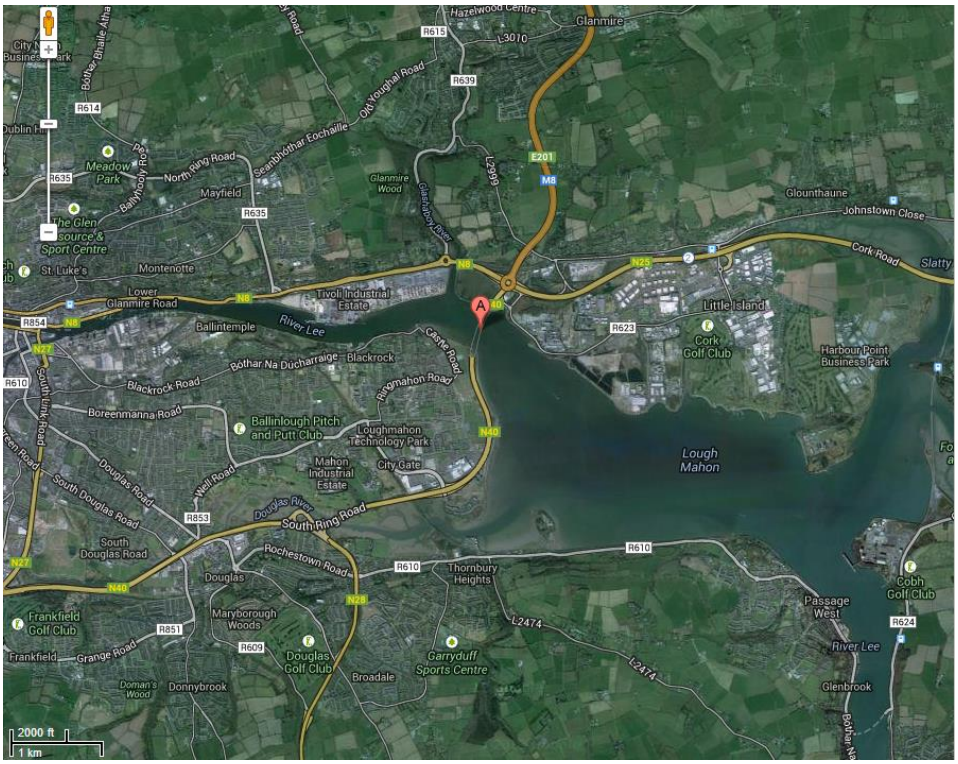
Drilling under third party lands is not currently covered by any specific or legislative framework for SGE systems. This would generally require consent from the adjacent land owner and no exemptions can be assumed.

There are no special permissions required at the moment for SGE system installations other than the ones that are discussed in the previous section which include compliance with the building regulations, planning permission regulations and EIA requirements for large systems.

Current legislation requires that all discharges from open loop systems above a threshold are licensed by the Local Authority (both in South Dublin and in Cork City). These discharge licenses must be obtained in advance of systems being commissioned and starting operation and must specify the temperature and chemistry of the proposed water discharge. For closed loop system permitting is currently not in place.

There are no official underground zoning maps for either of the two committed cities and little of no large scale transport infrastructure such as metro or other facilities. The Jack Lynch tunnel (as well as the Dublin Port tunnel even though this is not located in either of our committed cities) is located on the eastern side of Cork City and crosses the River Lee. The land is currently zoned as C 2.2 (General Industry land) equivalent to REGEOCITIES category G.

Even though there are no specific restriction in the case of this are, Cork City Council would have to carefully consider any proposed SGE system installation that potentially could have an impact on the tunnel structure. This could possibly be the case for any large scale open or closed loop system involving large abstractions or multiple borehole systems.



With respect to any new building planning the installation of an SGE system, drilling would expected to be restricted in any area where major services (telecoms, gas, electricity or water) may be present, however these cannot be separated out solely based on the land zoning categories. Any proposal for new building in land zone H would have to consider existing underground services and structures and demonstrate that the proposed system will not interfere. In the case of retrofit systems this is less clear as planning for an SGE system is not required. Therefore the responsibility remains with the owner of the installation (and also the liability in the case that something goes wrong) to ensure that services of any kind are not interfered with.

Based on the categories considered in the GZT categories and the Regeocities categories, special consideration with respect to drilling boreholes for SGE systems would have to be given for categories A, D, F, G, H, J, K. Other land use areas would be considered to be less affected by the presence of underground uses where land is not currently development or where settlement is sparse.

The availability of the ground

The coverage and location of SGE systems of Ireland at present is currently very poor (from a Local Authority, government agency, or sector organisation). We have little knowledge where most systems are with the exception of large scale systems.

It is therefore difficult to estimate percentages of available space to drill in city centre areas. One would assume that for categories H, I, J the % of space would be very high, however as a result of the types of categories there are unlikely to be any SGE system (present or future) for the majority of these areas.

With respect to categories A to G, the % of available space is very difficult to estimate but generally one would consider less space to be available in categories A, C, E and F in this order as a result. The table below represents a best guess estimate of space availability for SGE system collectors in the different city zones proposed.

A.	Older settlements	50-60 %
B.	Areas with special attention to preservation	20 % (groundwater protection area or areas where group water schemes are present) 95 % (environmental protection area)
C.	Dense urban settlements	50-60 % (depending on existing services and use of the underground including other SGEs)
D.	Sparse urban settlements	100 %
E.	Urban development areas	60-70 % (depending on existing services and use of the underground including other SGEs)
F.	Commercial operation areas	80-90 % (depending on existing services and use of the underground including other SGEs)
G.	Logistic zones and manufacturing	80-90 % (depending on existing services and use of the underground including other SGEs)
H.	Areas for the technical sustainment of the city	80-100 % (depending on existing services and use of the underground including other SGEs)
I.	Park areas	100 %
J.	Water areas with waterways	100 % (except in areas of NHAs or SACs)
K.	Main roads and railroad tracks	100 %

Alternative heat sources

There are two main competing sources of heat in the city centre locations that can undermine the installation of SGE systems. These include district heating systems and air source heat pumps.

District heating networks are not common in either of the two committed cities, but rather limited to individual ddevelopment sites which in some cases can be apartment blocks or residential housing. Some very minor large scale district heating section have been installed in parts of Dublin and Cork City centres where the fuel is mostly waste heat from CHP plants and individual biomass boilers.

Air source heat pumps are currently the most significant competitor to SGE systems and are being favoured as a result of lower installation costs and the more suitable mild climatic conditions.

Appendix 4: Spain - Analysis of SGE in Valencia

In this section the challenges for SGE in the city Valencia and existing regulatory examples are analysed.

Land area classification

In the committed city of Valencia, there is a detailed description of the urban zones depending firstly on the classification of the land. According to the typology of land, five different categories are distinguished:

Urban land; Programmed developable land; Non-programmed developable land; Non-developable land; and general services in any type of land.

Each category is subdivided into a series of zones that are analogous to the described zones that could be standards for any type of European city and have been described in this deliverable. In this way, it can be established that:

Zones in urban land:

- Protected Historical center (CHP Conjunto Histórico Protegido)
- Expansion areas (ENS Ensanche)
- Open building (plurifamiliar houses) (EDA Edificación Abierta)
- Single-family houses (UFA Vivienda Unifamiliar)
- Terciary buildings (TER Terciario)
- Industries and storage areas (IND Industrias y Almacenes)

Zones in Programmed developable land:

- Programmed for residential uses (PRR Programado de uso dominante Residencial)
- Programmed for terciary uses (PRT Programado de uso dominante Terciario)
- Programmed for industrial uses (PRI Programado de uso dominante Industrial)

Zones in non-programmed developable land:

- Non-Programmed for residential uses (PRR Programado de uso dominante Residencial)
- Non-Programmed for terciary uses (PRT Programado de uso dominante Terciario)
- Non-Programmed for industrial uses (PRI Programado de uso dominante Industrial)

Zones in Non-developable land

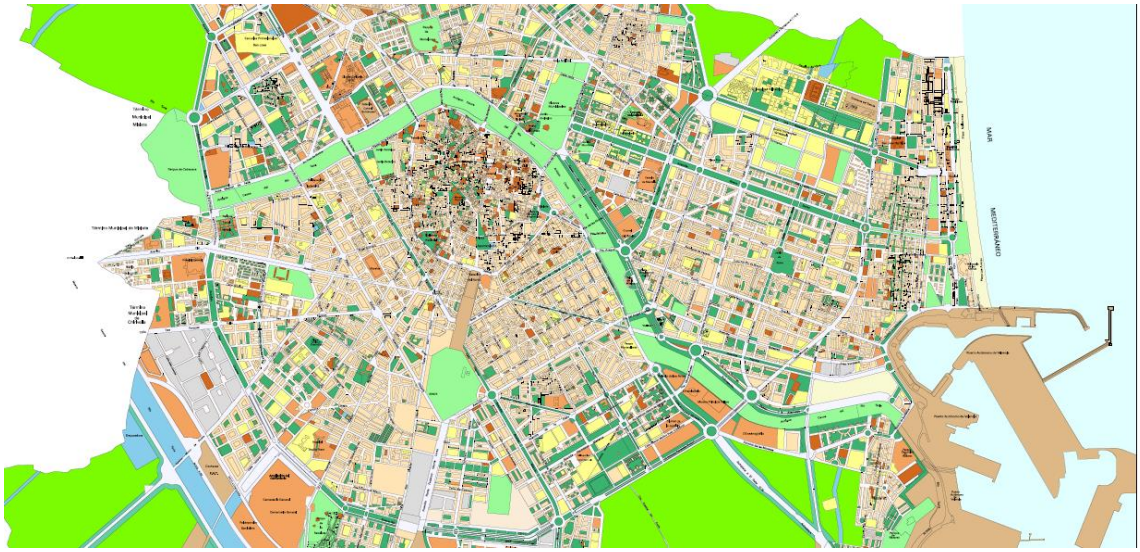
- Rural settlements (AR Asentamientos Rurales)
- Agricultural protection (PA Protección Agrícola)
- Ecological and environmental protection (PM Protección Ecológica y Medioambiental)
- Historical-artistic, archaelogical and landscape protection (PH. Protección Histórico-artística, arqueológica y paisajística)

- Protection of infrastructures (PI Protección de Infraestructuras)

General services in any type of land:

- General system of road network (GRV Sistema General de Red Viaria) (urban streets, roads, etc)
- General system for transport (GTR Sistema General de Transporte) (train stations, bus stations, port,…)
- General system of open spaces (GEL Sistema General de Espacios Libres) (Metropolitan park, urban park, historical garden,…)
- General system of educational-cultural and University (GEC Sistema General Educativo-cultural Universitario) (University campus, schools,…)
- General system of public services (GSP Sistema General de Servicios Públicos) (Hospital, sport facilities, etc.)
- General system of urban services (GSR Sistema General de Servicios Urbanos) (Fire brigades and cementery)
- General system of basic and service infrastructures (GIS Sistema General de Infraestructuras básicas y de servicios) (gas, electricity, telecommunications, water,…)
- General system of Defence and security forces (GFS Sistema General de Defensa y fuerzas de seguridad) (military barracks, commissariat,…)
- General system of coastal áreas (GLT Sistema General del Área Litoral) (beaches, cliffs and coastal zones)

Zone	**Name according to REGEOCITIES classification**	**Other categories identified in the urban planning of Valencia**
A	Older settlements	(CHP and eventual PH)
B	Areas with special attention to preservation.	(mainly considered as PH, and AR, PA, PM, PI)
C	Dense urban settlements	(ENS, EDA,TER, GTR,GEC, GSR, GIS)
D	Sparse urban settlements	(UFA, TER, GEC, GIS, GFS, GSP)
E	Urban development areas	(PRR, PRT, PRI)
F	Commercial operation areas	(TER, IND, PRI, PRT)
G	Industrial area	(IND, PRI, GTR)
H	Areas for the technical sustainment of the city	(GIS, GSR, PI)
I	Park areas	(GEL and some type of PM)
J	Water areas with waterways	(GLT, and in some cases GTR)
K	Main roads and railroad tracks	(GRV)



The general urban map of Valencia

Analysis of the potential for SGE in the zones

Shallow geothermal systems could be considered as a very positive solution for shopping centers, office buildings, industries, hotels and other tertiary buildings, schools and universities, museums and singular buildings, logistic terminals (airports and nautical port) etc. to be included in the planning of new infrastructures. Moreover, SGE systems have been traditionally used in other regions for providing thermal energy to single or multi-family houses with considerable energy savings respect to traditional systems. The integration of SGE in the other types of zones and city areas is not considered in this analysis because the incidence is significant lower than in the described applications.

An exhaustive analysis of the document compiling all the urban rules and norms for Valencia has been done in this study. In the analysis, we have not found any specific barrier for the installation of SGE. Nevertheless, the special conditions of the urban zones makes unfeasible to perform the installation due to several reasons, such as the unavailability of empty space for drilling the borehole field; the presence of unknown or poorly controlled old underground infrastructures; the preservation of historical buildings and archaeological remains, etc. In this way, the Older settlements – (CHP and eventually PH) and the Dense urban settlements – (ENS, EDA,TER, GTR,GEC, GSR, GIS) are examples of zones where the lack of available space, multitude of underground infrastructures and the presence of historical buildings and archaeological remains make difficult the integration of SGE.

According to the main limitations for implementing SGE systems, it can be stated that the most suitable areas for performing installations are the sparse urban settlements – (UFA, TER, GEC, GIS, GFS, GSP); Commercial operation areas – (TER, IND, PRI, PRT), and Logistic zones & manufacturing industries – (IND, PRI, GTR). The availability of space for the installation of the borehole field and the presence of multitude of buildings with important demands of H&C make those areas ideal zones for carrying out SGE projects. In case that intense refurbishment of building is tackled, other additional areas of the city could be considered as suitable place for implementing the technology taking into account that the installation does not affect to other buildings or underground infrastructures.

After our analysis, we have not found differences in the regulative framework for the different zones because the installation of SGE is not contemplated in the urban planning regulation. Nevertheless, those rules indicate that the drilling operations require licenses and permissions. Those permissions are presumably issued by the section of Mines depending on the regional Department of Industry (http://www.indi.gva.es/portal/opencms/es/energia/Mineria.html). For this reason, it is necessary to present a project contemplating the drilling plan. This project is analysed by the municipal technicians to provide the permission in case that the drilling operations are not in direct conflict with other infrastructures, issues or administration.

There are not special concerns, in the regulative framework, related to the environment. Nevertheless, there are areas (Agricultural protection (PA Protección Agrícola); Ecological and environmental protection (PM Protección Ecológica y Medioambiental); Historical-artistic, archaeological and landscape protection (PH. Protección Histórico-artística, arqueológica y paisajística) which are subjected to special conditions. In those areas, the drilling operations could be avoided due to the protective framework.

It is possible to drill in municipal or neighbouring land, theoretically, the permission for drilling will be issued by the Mine section and, therefore, as far as there are not interferences with other issues related to the urban development, such as the presence of other infrastructures, the protection of the area, etc. the regulative framework will be equivalent.

In any case, this situation is not very clear in the current regulative framework for this Autonomous Community and the local or regional authority could ask for different conditions or requirements for drilling depending on the location of the borehole field.

Valencia City will develop a municipal bylaw that will be partially based on the results of the REGEOCITIES project. For this reason, there is not, at this moment, any special processing of SGE application in the different zones.

The urban rules and codes compiled in the municipal plan for urban development do not contemplate the special permits for installing SGE and therefore, the protocols for the applications are based on the standard procedure valid for Spain. According to this procedure, as it was described in the national report, the protocol for licensing could be resumed as follow:

- Planning and design of the system according to the thermal demands of the building and the desired characteristics of the installation. Planning is done considering the results of the pertinent tests for unravel the suitability of the underground.
- Application for permits for drilling to the local mining department and eventually to the regional services for managing underground waters when the borehole is under the groundwater level or it is intended to install an open system. Sometimes, it is not necessary to apply for permission to the mining authorities, specially, in those case that the depth < 200 m. In other cases a study of Environmental impact may be required. It occurs frequently for large systems when several boreholes are planned and the depth of the boreholes is > 200 m.

The regulation of the thermal installations will be managed by the Technical Construction Code, which makes a direct reference to the RITE (Reglamento de Instalaciones térmicas en edificación). This document is used for the regulation of the thermal installations in buildings. The document compiles a series of requirements that should be achieved in order to fulfil the conditions of the installation.

In the RITE, several phases or steps are contemplated for the licensing of the installation. During the first phase, namely as Project phase, the requirements and objectives of the installation are described. Then, the main suitable installation is introduced and finally a document for justify that the decided installation fulfil the stated requirements is included. During second phase, known as execution phase, the selected installation is placed into the building. After finishing the installation, the possible modifications respect to the previous phase, project phase, should be communicated to the authorities or public administrations (normally municipalities). The third phase is called legalization phase that refers to the final inspection of the authorities. This inspection includes the documents and the real installation performed in the execution phase. If the installation is in concordance with the presented documentation, a favourable report is issued by the authorities. After the approval of the authorities, the final user is responsible of the use and maintenance of the installation and buildings.

The availability of the ground

Zone	Name according to REGEOCITIES classification	Other categories identified in the urban planning of Valencia	Availability of the ground in the zones
A	Older settlements	(CHP and eventual PH)	Very low availability—Multitude of underground infrastructures and possible presence of archaeological remains.
B	Areas with special attention to preservation.	(mainly considered as PH, and AR, PA, PM, PI)	No possible to carry out implementations in this zone
C	Dense urban settlements	(ENS, EDA,TER, GTR,GEC, GSR, GIS)	Low available space. Underground infrastructures (METRO) but during large refurbishment the implementation may be considered if there is not conflict with any other underground infrastructure
D	Sparse urban settlements	(UFA, TER, GEC, GIS, GFS, GSP)	Medium-high availability for implementing the systems. Most of the underground infrastructures are not under the buildings but under (GRV)
E	Urban development areas	(PRR, PRT, PRI)	High availability of ground with good properties for SGE
F	Commercial operation areas	(TER, IND, PRI, PRT)	Depending on the location medium to high availability of ground for implementation of large scale SGE. Probably one of the most interesting options for the city of Valencia
G	Industrial area	(IND, PRI, GTR)	Normally, the industrial areas are located at industrial estates
H	Areas for the technical sustainment of the city	(GIS, GSR, PI)	The thermal energy demand of these zones is negligible
I	Park areas	(GEL and some type of PM)	No applicable, Only considered for district heating purposes which are currently no planned in Valencia
J	Water areas with waterways	(GLT, and in some cases GTR)	No applicable
K	Main roads and railroad tracks	(GRV)	SGE are not required in Valencia for those zones

In Valencia there is basically not energy balance.

Average values of energy demand for single and multi-family houses in Valencia (information supplied by IDAE) Energy demands*

Locality	Heating demand for single house kWh/m^2	Heating demand for multi-family house kWh/m^2	Cooling demand for single house kWh/m^2	Cooling demand for multi-family house kWh/m^2	DHW for single house kWh/m^2	DHW for multi-family house kWh/m^2
Valencia	79.1	64.5	31.5	22.3	17.1	12.5

Emissions*

Locality	Heating emissions kgCO^2/m^2	Cooling emissions kgCO^2/m^2	DHW emissions kgCO^2/m^2	Total emissions kgCO^2/m^2	Primary energy for heating consumption kWh/m^2	Primary energy for cooling consumption kWh/m^2	Primary energy for DHW consumption kWh/m^2	Total consumption kWh/m^2
Valencia* single house	37.8	7.9	6.5	52.2	154.3	32.3	26.8	213.4
Valencia ** Multi-family house	29.4	5.7	4.8	39.9	127	22.8	19.6	169.4

* Source: “Escala de calificación energética para edificios existentes” published by IDAE, May 2011

Valencia type of building versus energy consumption*

Single Houses

Energy Demand kWh/m²	Heating	Cooling	DHW
Percentile 50 %	79.1	31.5	17.1
Percentile 10 %	70.9	30.4	17.1
Percentile 90 %	103.3	35.1	17.1
$R_{50/10}$	1.12	1.04	1
$R_{90/10}$	1.46	1.16	1

Emissions $kgCO^2/m^2$	Heating	Cooling	DHW	Total
Percentile 50 %	37.8	7.9	5.4	51.1
Percentile 10 %	32.1	7.2	4.5	43.8
Percentile 90 %	46.6	8.7	5.5	60.8
$R_{50/10}$	1.18	1.10	1.2	1.17
$R_{90/10}$	1.45	1.21	1.22	1.39

Primary energy consumption kWh/m²	Heating	Cooling	DHW	Total
Percentile 50 %	154.3	732.3	24	210.6
Percentile 10 %	146.1	29.3	23.5	198.9
Percentile 90 %	196.2	35.5	24.4	256.1
$R_{50/10}$	1.06	1.1	1.02	1.06
$R_{90/10}$	1.34	1.21	1.04	1.29

Multi-family Houses

Energy Demand kWh/m²	Heating	Cooling	DHW
Percentile 50 %	64.5	22.3	12.5
Percentile 10 %	60.2	21.1	12.5
Percentile 90 %	65.6	22.3	12.5
$R_{50/10}$	1.07	1.06	1.00
$R_{90/10}$	1.09	1.06	1.00

Emissions $kgCO^2/m^2$	Heating	Cooling	DHW	Total
Percentile 50 %	27.7	5.7	4.0	37.4
Percentile 10 %	26.2	5.3	3.3	34.7
Percentile 90 %	29.9	5.8	4.0	39.7
$R_{50/10}$	1.06	1.09	1.24	1.08
$R_{90/10}$	1.14	1.10	1.24	1.14

Primary energy consumption kWh/m²	Heating	Cooling	DHW	Total
Percentile 50 %	120.7	22.8	17.8	161.3
Percentile 10 %	107.9	21.0	17.2	146.1
Percentile 90 %	128.7	23.1	17.9	169.6
$R_{50/10}$	1.12	1.09	1.04	1.10
$R_{90/10}$	1.19	1.10	1.04	1.16

Alternative heat sources

In the city of Valencia and, in general, the majority of the Spanish cities there are several alternative solutions that are widely more used than shallow geothermal energy. Probably, the most common system for heating and cooling are the conventional air/air heat pumps. For heating applications gas chillers are also very common; whereas in rural areas, the traditional systems of chimneys and wood heaters (biomass heater) are common. Large shopping centres and tertiary buildings (hotels, sport centres, etc.) are generally air-conditioned by means of heat pumps and cooling towers. District heating in Valencia are nowadays not installed.

Since the entry in force of the technical code of construction, multitude of thermal-solar panels have been installed, especially for supplying the thermal demand for DHW. It is regulated by the Spanish building code that at least 60 % of the thermal demand for DHW must by supplied by thermal panels or any other alternative renewable source. It triggered that most of the final users, due to the general lack of knowledge and information about other alternatives, decided to install solar panels.

Appendix 5: Greece -Analysis of SGE in cities

Land area classification

The land area classification in Greece differs from the Regeocities classification. For this reason the following encoded table has been constructed to correspond the various categories of the Greek legislation to the Regeocities classification.

Zone	Name	Other categories
A	Older settlements	A.I.1, A.I.8
B	Areas with special attention to preservation.	A.I.7, A.II.12
C	Dense urban settlements	A.I.2, A.I.3
D	Sparse urban settlements	B.II.D
E	Urban development areas	A.I.4
F	Commercial operation areas	A.I.9, B.I
G	Industrial area	A.II.10, A.II.11
H	Areas for the technical sustainment of the city	B.II.B
I	Park areas	A.III.13, A.III.14
J	Water areas with waterways	A.III.15
K	Main roads and railroad tracks	B.II.A

According to the Greek legislation and the general and special urban planning, the land uses are classified in general and in special uses[1].

[1] **GENERAL CATEGORIES OF LAND USES**

A.I. Urban developed areas or under urban development

1. Exclusive Residence
2. Pure Residence
3. General Residence
4. Urban Planning Center – Central City's Operation - Local Neighbourhood Center
5. Touristic Places – Entertainment – Holiday (second) Residence
6. Utility Activities
7. Urban Green Spaces – Free Spaces
8. Low and Medium Disturbance – Special Productive Facilities
9. High Disturbance – Special Productive Facilities

A.II. Areas with special building status

The case of the General Urban Plan for Athens (GUPA) is given as a descriptive example for the land uses and the activities authorized in the city of Athens. In the same way, every committed city has elaborated its own GUP"X" in order to determine the allowed uses.

The land uses authorized in Athens, as presented in the following multi-coloured map, fall into specific categories in compliance with the relevant Presidential Decree (PD/23-2-87, FEK-166) and the amended draft of 19.12.2011.

10. Business Parks
11. Business Parks of intermediate organization level
12. Settlements (*i. with population < 2.000 residents, ii. established before 1923*)

A.III. Areas with no possibility for urban planning or with intention to future integration in urban planning according to protection level.

13. Areas of Particular Uses – Urban Infrastructures
14. Controlled Areas - Areas of Building restriction and Land Uses limitation
15. Areas of Special Protection
7. Urban Green Spaces – Free Spaces

B. SPECIAL CATEGORIES OF LAND USES

B.I Main uses (residence, social assistance, education, sport centres, religious sites, cultural places, commercial stores, personal service shops, offices, banks, insurance agencies, utilities, management, healthcare, public venues, refreshment rooms, restaurants, clubs, bars, hotels and other touristic facilities, complex touristic accommodations, parking up to 2.5 tons, gas stations, car washing machines, car lubrication stations, transfer stations of public transportation means, heliports, auto repair shops, storage houses, logistics, business incubators, technological business support centres, professional labs of low, medium and high disturbance, commercial and industrial facilities, bus interurban stations, cargo terminals, vehicle technical control centres)

B.II Special uses

B.II.A Transportation means facilities (airports, heliports, railway stations, port zones passenger of commercial, fishing, industrial, tourist activity, railway depots, train repair units and marshalling yards, spaces depots, bus, trolley, suburban railway, metro and tram repair units etc., bus urban and interurban stations, trolley stations, parking places for tourist bus, trucks and trailers, vehicle technical control centres, cargo terminals)

B.II.B Urban infrastructure facilities (waste transfer centre, landfills, treatment and sewage disposal areas, water tanks – desalination, reservoirs, power stations, power grids, water facilities, telecommunication facilities, waste treatment units, RES units, infrastructure service places, highway service stations and relevant facilities)

B.II.C Other facilities (army facilities, cemeteries and incineration centres, mortuaries, prisons, immigrants reception facilities, car cemeteries, hippodromes, exhibition centres, car and motorbike racing circuits)

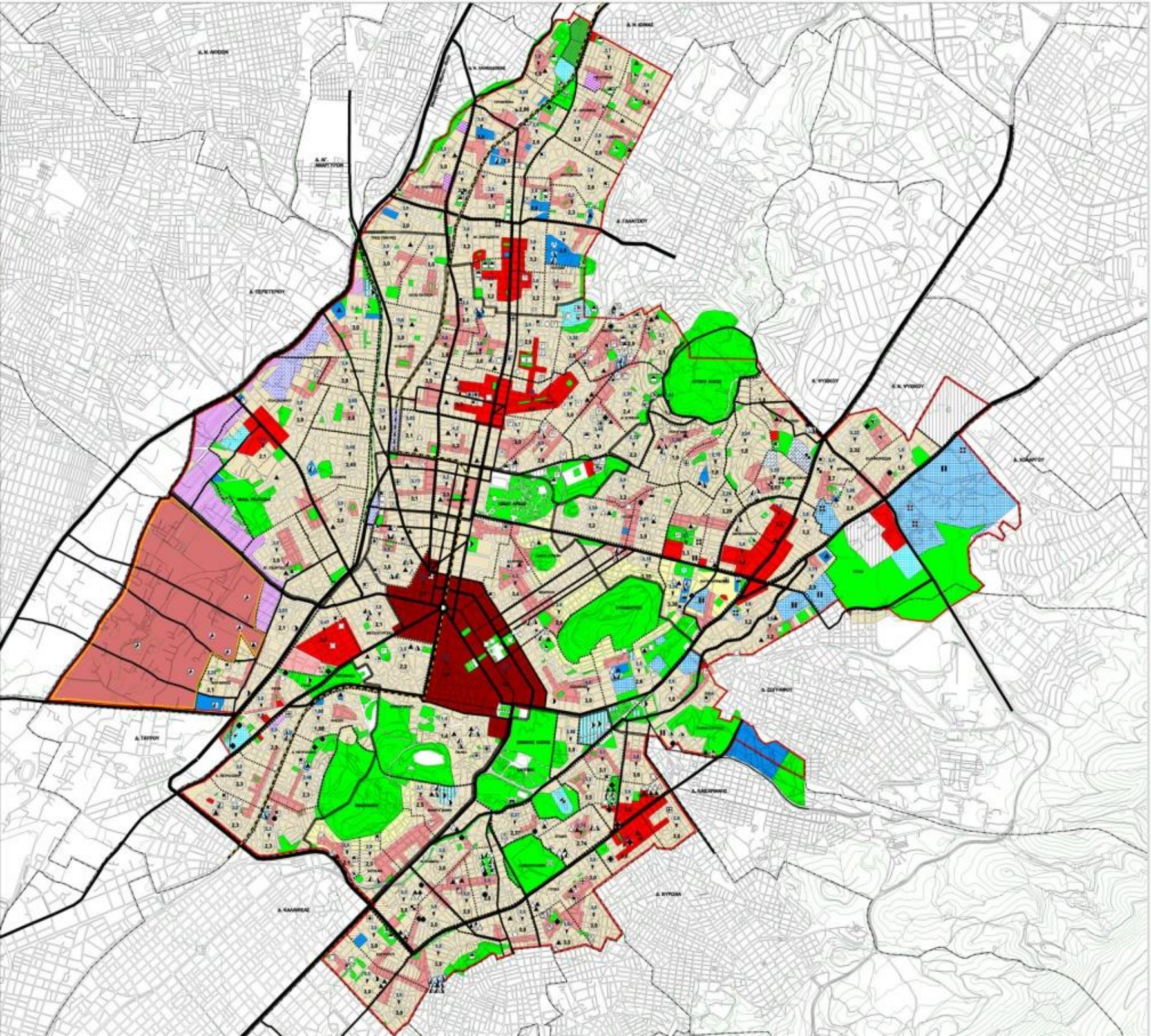
B.II.D Agricultural, forestry, livestock, fishing and other rural facilities (agricultural storehouses, cow houses, piggeries, poultry farms, sheep pens, fish farms, mines-quarries-mining, greenhouses, water tanks, farms)

According to this map, the urban environment of Athens includes:

Areas of residence intended to cover the local demands of the residents. These areas fall into the **Category 1** "***Exclusive Residence***" and **2** *"**General Residence**"* of PD where only limited spectrum of activities from houses and dwellings to small sport installations, religious places, mini markets, educational services (etc. kinder gardens, primary schools, and high schools), are authorized while Renewable Energy Sources (RES) units are **not** compatible with the prescribed land use regime.

- Ultra-local municipality centres, the municipality centres, the local neighbourhood centres, the urban planning centres with restrictions in uses (level 1 & 2) fall into the **Category 4** of PD "***Urban Planning Center – Central City's Operation - Local Neighbourhood Center***" where RES units are **not** authorized.
- Touristic and entertainment places in Athens belong to the **Category 5** of PD "***Touristic places – Entertainment – Holiday (second) residence***" where RES units are **not** authorized.

- Places of social assistance and healthcare including day nurseries and nurseries, nursing homes, orphanages, health centres, hospitals, the sports activity places including sport fields, stadiums, natatoriums, fitness centres, shipping facilities and the places of cultural facilities including museums and libraries fall into the **Category 6** of PD "***Utility Activities***" where RES units are **not** authorized.



ΥΠΟΜΝΗΜΑ

- Όρια Δήμων & Κοινοτήτων
- Όρια Γενικού Πολεοδομικού Σχεδίου
- Όρια Επέκτασης
- Όρια Εγκεκριμένου Γενικού Πολεοδομικού Σχεδίου
- Όρια Γειτονιάς
- Όρια Συνοικίας
- Όρια Διαμερίσματος
- Υπερτοπικό Κέντρο Δήμου
- Κέντρο Δήμου
- Τοπικό Κέντρο Γειτονιάς
- Κατοικία
- Γενική Κατοικία
- Εγκαταστάσεις Μεταφορών
- Γεωργική Γη
- Αστικό Πράσινο - Ελεύθεροι Χώροι
- Περιαστικό Πράσινο
- Κοινωνικές εξυπηρετήσεις
- Βιοτεχνικό Πάρκο - Βιοτεχνικές Εγκαταστάσεις μη Ιδιαίτερως Οχλούσες
- Πολεοδομικό κέντρο με περιορισμό σε χρήσεις
- Πολεοδομικό κέντρο με περιορισμό σε χρήσεις (2)
- Βιοτεχνικό Πάρκο προς εξυγίανση
- Βιομηχανικό Πάρκο - Βιοτεχνικές/Βιομηχανικές Εγκαταστάσεις μη Ιδιαίτερως Οχλούσες
- Ζώνη Βιομηχανίας - Βιοτεχνικές/Βιομηχανικές Εγκαταστάσεις Οχλούσες
- Βιομηχανικές Εγκαταστάσεις που Παραμένουν
- Χονδρεμπόριο
- Τουρισμός - Αναψυχή
- Ιδιαίτερες Χρήσεις
- Στρατός
- Νεκροταφεία
- Αρχαιολογικοί Χώροι
- Ελεύθερη - Ταχεία Λεωφόρος
- Πρωτεύουσα Αρτηρία
- Δευτερεύουσα Αρτηρία
- Συλλεκτήριο
- Αστικές Σιδηροδρομικές Γραμμές
- Προαστιακή Σιδηροδρομική Γραμμή
- Υπεραστική Σιδηροδρομική Γραμμή
- Χώρος Στάθμευσης

ΟΡΓΑΝΙΣΜΟΣ ΡΥΘΜΙΣΤΙΚΟΥ ΣΧΕΔ
και ΠΡΟΣΤΑΣΙΑΣ ΤΟΥ ΠΕΡΙΒΑΛΛΟ

ΓΕΝΙΚΟ ΠΟΛΕΟΔΟΜΙΚΟ ΣΧ

ΔΗΜΟΣ ΑΘΗΝΑΣ

ΕΓΚΡΙΣΗ ΓΠΣ: ΦΕΚ 80Δ/88

1η ΤΡΟΠΟΠΟΙΗΣΗ: ΦΕΚ 538Δ/96

2η ΤΡΟΠΟΠΟΙΗΣΗ: ΦΕΚ 730Δ/04

3η ΤΡΟΠΟΠΟΙΗΣΗ: ΦΕΚ 1063Δ/04

4η ΤΡΟΠΟΠΟΙΗΣΗ: ΦΕΚ 19ΑΑΠ/07

5η ΤΡΟΠΟΠΟΙΗΣΗ: ΦΕΚ 90ΑΑΠ/2010

6η ΤΡΟΠΟΠΟΙΗΣΗ: ΦΕΚ 142ΑΑΠ/2012

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Β Δ Α

- Urban and suburban green spaces i.e. the city's parks and the parks in the city's borders, only low activities and common activities of public benefit are authorized. In these places falling into the **Category 7** of PD "***Urban Green Spaces – Free spaces***", RES units are not authorized.
- In handicrafts areas and installations of low and medium disturbance, as well as the same areas ready for rehabilitation/restoration and areas where educational foundations (universities, technical schools etc.) exist, RES units are **authorized**. An exception constitutes the areas of wholesale and logistic centres where RES installations are not compatible.
  All these activities fall into the **Category 8** of PD "***Areas of low and medium disturbance – special productive installations***".
- Industrial areas – handicrafts/industrial of high disturbance and existing Industrial installations, fall into the **Category 9** of PD "***Areas of high disturbance – Special productive installations***". Alike, these areas **authorize** the RES units' installation.
- Areas of transit/transport installations, army services, cemeteries, roads (highways, main roads, second roads) and railways (urban railways, suburban railways, international railways) fall into the **Category 13** of PD "" where RES are **not** authorized.
- Agricultural land falls into the **Category 14** of PD "***Areas of build control and uses' restriction***" where RES units are not authorized. Exception is given in special cases as for example, the installation of PV systems which is authorized in agricultural land of high productivity in a coverage percentage of 1 %.
- Archaeological sites and other places subject to special regime of decrees or regulations fall into the **Category 15** of PD "***Areas of special protection***", where any RES unit is not authorized.

Analysis of the potential for SGE in the zones

In the Greek SGE Market since the market is still remaining small the barriers mostly concern regulatory and/or structural restrictions and secondly technical ones due to particularities of each zone. Therefore, the regulative restrictions are independent from the established zones for SGE systems integration in the cities and buildings. The technical restrictions are common in the most cases while in some others not.

Here below, see a brief analysis in three axes.

A. Technical aspects in general and according to established zones
B. Environmental barriers
C. Regulatory framework and restrictions and,

A. Technical and structural restrictions affecting the established zones.

a. Older settlements - older areas of the city, without special attention to preservation and Dense urban settlements – Suburbs, multifamily houses, public services and hotels (Zones: A, C)

In the older areas (A) as well as in the dense urban settlements (C) of a city all SGE applications present some technical difficulties. Briefly, those difficulties focus on:

- Non compatibility with the old heating and cooling units (heating panels) installed in the old buildings adding an extra cost for replacement.
- Limited ground space due to the absence of free space around the buildings
- Not localized underground utility networks
- Common agreements between the owners since most of the dwellings are flats belonging to different persons. In Greece, the building manager is not an independent company with technical background and that constitutes a structural distortion of the Greek real estate market which affects the decision making.

b. Areas with special attention to preservation – Cultural areas, environmentally protected areas (Zone B).

Areas of special attention, cultural areas and environmental protected areas (B) are subject to a special status with numerous services involved (archaeological services, CUPAC[2], forestry services, management bodies of environment etc.).

As regards the buildings and auxiliary installations, the archaeological service and the local CUPAC may play key role to the permit procedure facing unexpected obstacles due to non-uniform and sometimes subjective judgment. For example, the local Archaeological service responsible for the archaeological sites may suspend the works for long time if some findings are discovered during the excavations or drilling works. In the same way, the local CUPAC involved in the procedure for traditional settlements may judge subjectively and based on different criteria as long as there are not certain guidelines and rules oriented to every technology and level of protection (e.g. areas of absolute protection and areas of partial protection).

Up to date, depending on the level of protection, some building activities are compatible and some others non compatible with the local spatial urban planning. The following guidelines are generally applicable regardless of the type of work performed without further specifications.

- In case of interventions in existing preserved buildings or buildings of remarkable architectural interest and to preserve the character, morphology and historical significance of the building, the provisions of the Regulation on Energy Performance of Buildings (KENAK) might be not applicable in entire or part. This restriction comes into force with the new General Construction Regulation (art. 6, par. 11 of the L. 4067/2012) and involves the acquisition of a positive opinion of the Architecture Council, issued upon the owner's request accompanied by explanatory and technical report for required interventions resulting from the energy study.
- No intervention in the building's façade is authorized including auxiliary works which misquote the traditional character of the building without the permission of the local archaeological service endorsed by the Minister of Culture (L. 3028/2002, art. 14).

[2] Committee for Urban Planning and Architectural Control (CUPAC)

c. **Sparse urban settlements – Single family houses with gardens** (Zone D).
The only limitation concerns the exclusion of individuals in utilizing the surface water (water basins and streams). It is the most widespread deformation in the GSHPs market in Greece. (See also par. g).

d. **Urban development areas – Areas with potential for new buildings** (Zone E).
With regard to the areas of capacity for new buildings and new developed areas, no provision exist for implementing an effective urban and spatial plan in relation to the right integration of GSHP systems and the rest underground infrastructures (pipelines etc.) for spreading the DH & C network.

e. **Commercial operation areas – Office complexes** (Zone F).
In the case of large commercial facilities (shopping centres, office complexes etc) located in the urban environment, it has been noticed limited ground space for installing a central system or multiple smaller systems of GSHEX or boreholes to meet the high building demands in heat and cool.

As a consequence of the limited space, additional traffic inconvenience might be noticed during the installation period and drilling works due to small scale urban arrangements and potential interventions on public places (roads, pavements etc.).

f. **Logistic zones and manufacturing industries – Terminal areas (Handling of goods, containers and so on), industrial settlements, Areas for the technical sustainment of the city – Energy production, sewage plants and so on and Park areas** (Zones G, H, I)**.**
In all these areas no technical or regulative restrictions regarding the RES installation exist.

g. **Water areas with waterways** (Zone J)
There are not technical restrictions. The restrictions concern only regulative aspects regarding the access and the terms of waterways use. The most significant is that the access in waterways utilization concerns only professionals and companies and not individuals.

h. **Main roads and railroad tracks** (Zone K)
In the case of main roads and railways, the definitive distance limits are specified from private properties, infrastructures and public utility networks as described below.

These distance limits need to be re-considered in order to correspond in the different system types, system size and possible configurations (open loop, closed loop, horizontal, vertical etc.)

The regulative framework in Greece is not differentiated according to the system typologies, system size and possible configurations. It is uniform and not dependent on different zones.

Regarding the environment, there are not decisions oriented to GSHP installations due to incomplete and ineffective regulative framework which has not yet applied provisions for geothermal heating and cooling systems. Moreover, the existing regulations make no reference in the integration of SGE

systems in the underground city's utility network. At present, the environmental provisions for SGE systems follow the general provisions established for RES technologies and water irrigation.

In the context of Decision No D9B,D/F166/OIK18508/5552/207 of the Ministry of Development, in case of energy systems such as the GSHPs installation, the borehole drilling or the pit construction is only permitted within the boundaries of the private property where the air-conditioned space is situated. There is not a documented procedure for using municipal or neighbouring land area without getting acquired the legal right of use. In common spaces of buildings, the performance of works requires the full agreement (100 %) of the flat owners.

No special processing has been recorded regarding SGE applications in relation with any city zone as a result of non-large scale implementation of the technology in the Greek market so far. This technology is very juvenile in Greece and there are not enough examples or special cases of installations in special zones of protection.

Furthermore, due to not establishing of a complete master plan for the SGE and DH & C systems integration in the underground utility networks of the city, the implementation of any city's zone has no real sense. An additional delay factor might be the competitive technologies (e.g. natural gas, biomass burners, and energy fireplaces).

The compatibility of boreholes and other underground infrastructure is governed by the Decision No D9B,D/F166/OIK18508/5552/207 in which default distances from public infrastructures, utility grids and private properties are provided in detail. With regard to the underground infrastructure, garages are treated as part of the building. Metro and other pipelines have to comply with the regulations and the prescribed distances. In any case, no interference of boreholes has been recorded in garages, metro, or pipelines so far, mostly due to the small number of installed SGE systems.

The availability of the ground

The suitability of the geological settings in Greece is not argued. Most of the areas (north and south and in islands) present very good values of thermal conductivity.

The knowledge of building stock in Greece is the key factor for any potential technical intervention. Hellenic Statistical Authority (EL.STAT.) is the source for any information with regard to the building stock (www.statistics.gr).

The total of buildings in Greece mounted in 4,250,000. The 21 % of these are located in Macedonia while the 19 % in Attica. Regarding the type of buildings, 2.400.000 refers to family buildings and dwellings as well and the rest of about 1.150.000 buildings type concerns other uses (commercial, schools etc.). As of 1980, all the new buildings are well insulated. Regarding the year of construction, the 64 % of buildings in Greece were founded up to 1980, while the rest of 36 % of buildings between 1980 and 2006. As a result of this, the buildings constructed before 1940 (~15 % of the stock) should need extended refurbishment; while the ones built before 1980 (~50 % of the stock) should need maintenance. The newer buildings (i.e. ~35 % of the building stock) should be in good condition.

As regards, the available space, the Decision No D9B,D/F166/OIK18508/5552/207 provides a default distance from the boundaries of any infrastructure (public and/or private properties). Therefore the available space varies according to the property's area and the type and location of the adjacent infrastructures. For example for a property of 1.000 m^2 (= 20m x 50m), the available space for drilling is 736 m^2 (= 16m x 46m) or 73.6 %.

The table below presents the minimum default distances from the public infrastructures, the utility grids and the private properties as prescribed in the decision in effect.

Type of infrastructure	Distance
Property boundaries	2 m
Existing neighbouring buildings*	5 m
Expropriated zone of railway line	5 m
Main natural gas transmission pipeline	10 m
Central underground network (water supply, irrigation, drainage pipelines etc.)	5 m
HV power transmission lines	10 m
(unless the borehole is situated between the HV lines and the building)	
MV power distribution lines	5 m
(unless the borehole is situated between the MV lines and the building)	

**Note: refers to buildings of neighbouring property*

The energy demands are depending on the size and the age of the building. A general rule of thumb is the following:

"*The larger size and younger age the building has the lower energy intensity (demands per unit area) occurs*".

The usual values for the building energy demands vary from 60 – 100 W/m^2 (6 – 10 kW/m^2) for annual operation from 1.000 – 2.000 hours depending on the climatic zone. The systems typology concerns mostly ATES (open loop systems). The energy balance is applicable since the 80 % of buildings are operating in both modes (heating and cooling).

The BTES systems (closed loop systems) are mostly used in larger borehole fields (above 10 – 15 BHE) and in combination with Solar Combi systems.

As regards the particular zones, the following technical characteristics can meet.

- *Zone A*
  - Typology: ATES and rarely BTES,
  - Energy Balance: Yes
  - Energy Demand: 90-120 W/m^2
- *Zone B*
  - Typology: ATES
  - Energy Balance: Yes
  - Energy Demand: 90-120 W/m^2
- *Zone C*
  - Typology: ATES and BTES,
  - Energy Balance: Yes in larger applications
  - Energy Demand: 75-110 W/m^2
- *Zone D*
  - Typology: ATES and BTES,
  - Energy Balance: Yes
  - Energy Demand: 70-100 W/m^2
- *Zones E, F & G*
  - ATES and BTES,
  - Energy Balance: Yes, fully balanced in larger applications
  - Energy Demand: 60-100 W/m^2

Alternative heat sources

In the last years the most significant barriers in GSHP penetration in the heating and cooling market is the intense competition from market leading technologies and alternative energy sources the most important of which are:

- the air source heat pumps (air to air, air to water)
- the natural gas
- the biomass boilers (wood, pellets) and
- the infrared heating panels,

Air-source, natural gas and biomass boilers are characterized by low pricing and extensive distribution channels covering the entire market.

Other competitive technologies to SGE systems are the energy fireplaces (wood, pellets, and bioethanol), the open fireplaces and the masonry heaters.

Part 2 – Overview from participating countries

Appendix 6: Denmark – Analysis of SGE in cities

Land area classification

No cities or municipalities in Denmark have reserved specific areas for SGE. The examples from Denmark have been collected from interviews with experienced administrative staff from municipalities and experts from consulting companies.

Analysis of the potential for SGE in the zones

Ground Source Heating and Cooling is regulated pursuant to the Danish environmental protection act and permissions are issued by the Municipalities. To protect groundwater interest the act includes required safety distances to water extraction well. Protection of the groundwater is normally not a limitation for horizontal collectors, but for borehole heat exchangers the regulation provides the municipalities with a possibility to increase the required safety distance to water wells and to stipulate special conditions in the permit regarding e.g. the construction of the installation, in order to protect a water catchment against contamination. Some municipalities reject applications for borehole heat exchangers if there is uncertainty regarding a possible content of anti-corrosives in the brine. Others are generally very reluctant to issue permits for borehole heat exchangers because of general considerations regarding the groundwater protection and drinking water quality.

The regulation of groundwater based open loop systems is rather strict and specifies investigations and documentation regarding the geology and hydrogeology of the aquifer as well as the hydraulic and hydrothermal properties and the chemical and microbiological conditions. Furthermore, numerical modelling is required in order to document that the temperature of the groundwater in existing catchments will not increase more than 0.5 degree Celsius. For water protection areas it is required, that the groundwater resource must be exploitable again 10 years after the closing of the installation, which should also be documented by numerical modelling. These requirements are rather costly and imply that only larger installations are economically feasible.

Apart from the ones mentioned above there are no general restrictions for the SGE systems in Denmark, but the act require a specific assessment of areal interests in each case. Conflicts could be with existing installations, different levels of groundwater protection etc. In each case the municipality can set specific restrictions if special interests related to other legislation should be protected.

Copenhagen Municipality has designated areas where older buildings are vulnerable to variations in the water table from pumping in boreholes e.g. Applications for ATES in these areas require documentation of how oscillations in the water table is minimised. Closed system, both BTES and horizontal systems, are not seen problematic.

The availability of the ground

Most of the subsurface in Denmark is suitable for SGE systems, but there can be a difference in energy uptake / efficiency depending on the local geology. The limitation could also relate to lack of space due to other SGE nearby or due to nearby water wells. For all zones the situation is first come first served.

Alternative heat sources

In Denmark district heating is a competing heat source to SGE. Pursuant to the energy legislation it is possible by political decision to require house owners to connect and stay connected to district heating plants, though, dispensation to use other sustainable energy sources is possible. This legislation aims at securing central heating and the requirements to join a district heating company may be due to economic interest in reducing costs for user of district heating.

Other sustainable energy systems, based on wind or the sun, are getting more and more common in Denmark. Wind power has been used for decades and windmills, both on land and off shore, are contributing with more than 30 % of the Danish electricity consumption. Numerous of solar cells have been installed during the last few years supported by varying subsidies.

Appendix 7: Belgium - Analysis of SGE in cities

Belgium presents the highest population density of Europe. About 4,3 million house were registered in 2008 and this figure rise by about 9 % each year. To date, about 42 % of the global heating demand arises from buildings (60 % for households and 40 % for tertiary buildings). In Southern Belgium (Wallonia) single buildings built before 1945 are dominant. In Northern Belgium (Flanders) buildings are generally more recent and diverse (60 % of housing were built before 1970).

Land area classification

In Wallonia, about 8 % of the registered land area is built. The remaining 92 % is made of agricultural land, pastures and woods see Figure 1. Figure 3 shows a slow evolution of such distribution in the last decades.

About 260 000 ha are for urban purposes, against 1 400 000 ha which are for non-urban purposes. Residential areas cover slightly more than 180 000 ha, less than 10 % of Walloon territory. Those are mainly surrounding old urban cores of cities and villages.

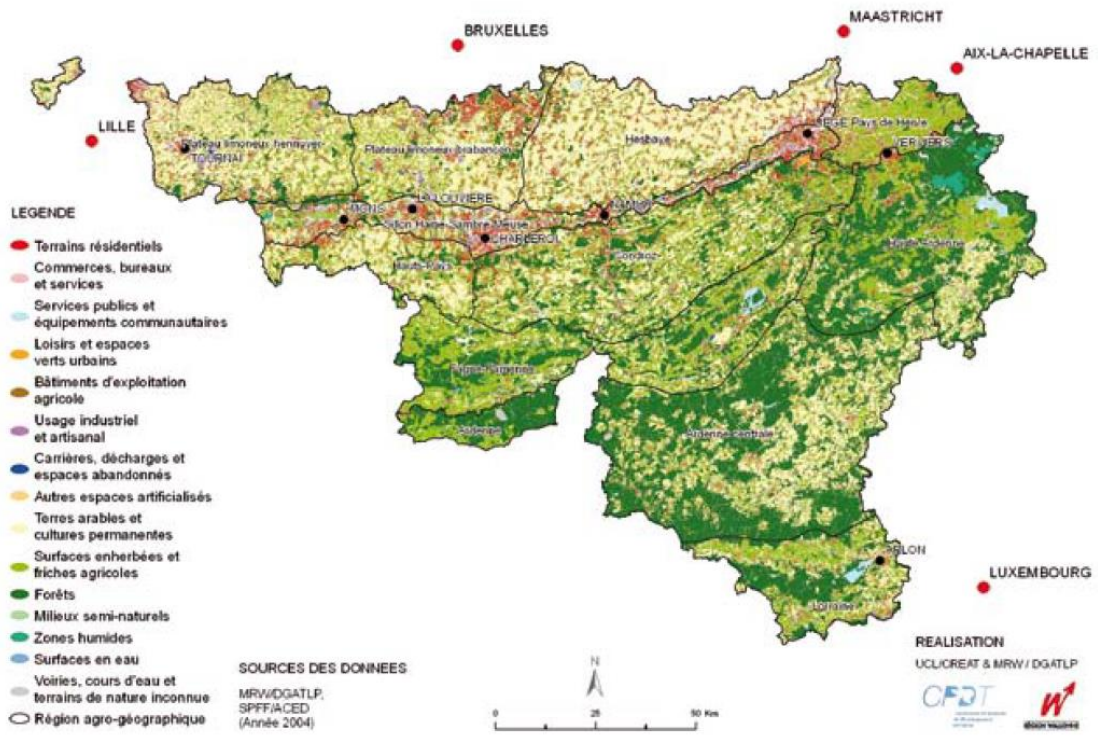


Figure 2: land use occupation in Wallonia

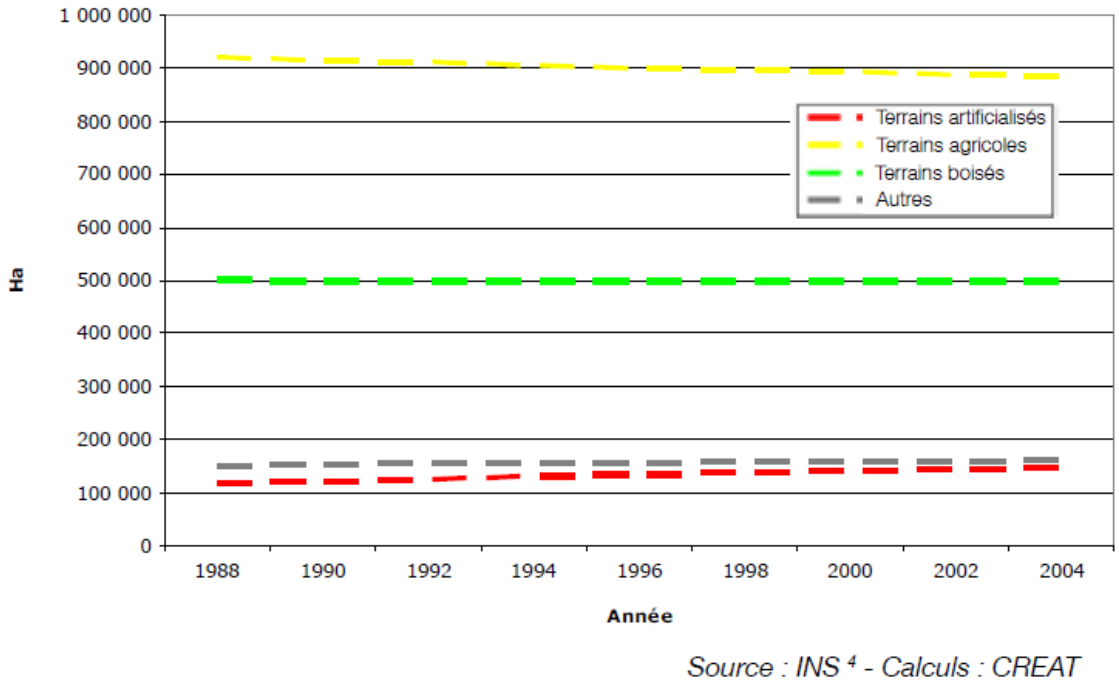


Figure 3: Evolution of ground occupation in Wallonia.

Zone	Name
A	Older settlements
B	Areas with special attention to preservation.
C	Dense urban settlements
D	Sparse urban settlements
E	Urban development areas
F	Commercial operation areas
G	Industrial area
H	Areas for the technical sustainment of the city
I	Park areas
J	Water areas with waterways
K	Main roads and railroad tracks

Outside the cities, underground occupation related to human activities not really an issue.

In cities, older settlements (A) and areas, with special attention to preservation (B) (e.g. protected non movable heritage) are usually subject to special schemes regarding building retrofit and drilling.

While in urban settlements (C, D), the single permit procedure[3] is taking any potential impact of an SGE installation into account.

In urban development areas (E) SGE installation can be taken into consideration at an earlier stage of building works, improving the feasibility of such project.

The very small amount of GSHP installed and running in Walloon cities makes that the proximity effect of geothermal boreholes is actually not an issue for the time being.

It should be underlined that:

- Walloon territory is structured in 'poles', as shown in Figure 4
- Each type of municipality has its own land occupation rate, as shown in table 6
- About 50 % of Belgian households burn natural gas to heat their homes (most of them in Flanders), while more than 75 % of Walloon households are still using fuel oil as main heating source (mainly due to the absence of gas connection in sparse urban settlement).
- Nearly none of the Walloon cities have underground metro/railway facilities

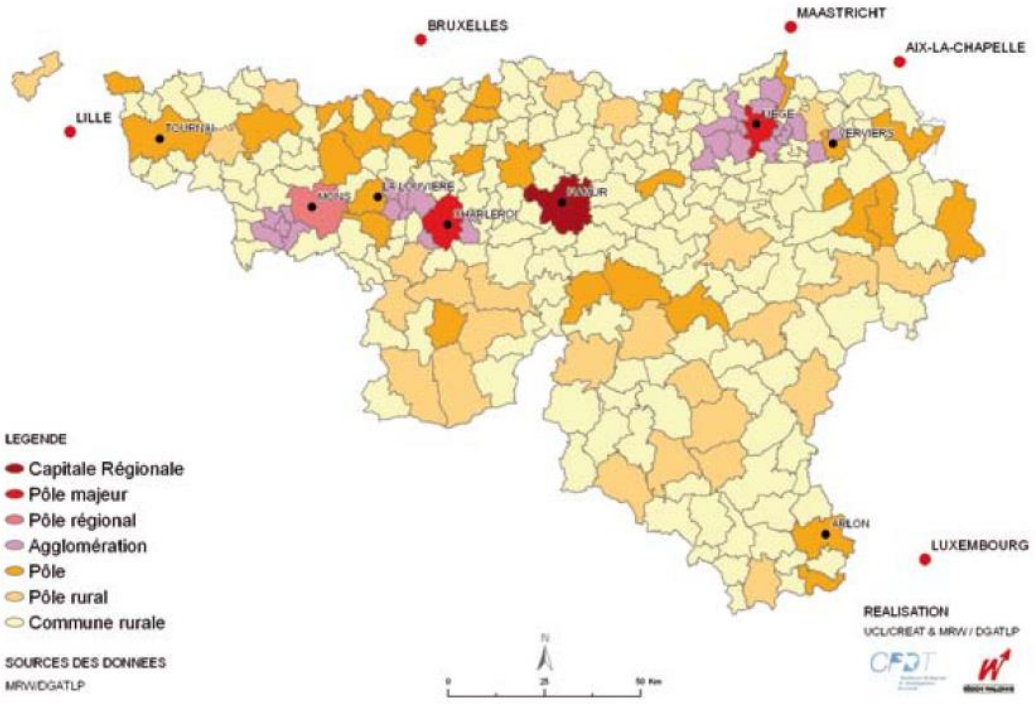


Figure 4 Structuration du territoire en pôle selon le SDER[4]

[3] Urban permit + environmental permit
[4] Schéma de Développement de l'Espace Régional

Tableau 1: Répartition de l'occupation du sol (2004) par type de commune (hiérarchie du SDER)

	Principales catégories d'occupation du sol	Capitale régionale	Pôle majeur	Pôle régional	Agglo-mération	Pôle	Pôle rural	Commune rurale	Région Wallonne
Terrains artificialisés	Terrains résidentiels	16,17%	26,85%	13,38%	18,03%	7,89%	2,89%	4,59%	5,62%
	Terrains occupés par des commerces, bureaux et services	0,79%	2,45%	0,88%	1,02%	0,48%	0,14%	0,14%	0,26%
	Terrains occupés par des services publics et équipe-ments communautaires	2,41%	5,58%	2,66%	2,32%	1,82%	0,50%	0,76%	0,99%
	Terrains à usage de loisirs et espaces verts urbains	1,09%	3,99%	1,51%	0,78%	0,77%	0,48%	0,47%	0,58%
	Terrains occupés par des bâtiments agricoles	0,40%	0,16%	0,37%	0,49%	0,64%	0,50%	0,54%	0,54%
	Terrains à usage industriel et artisanal	1,64%	7,99%	4,30%	3,97%	1,58%	0,47%	0,57%	0,93%
	Carrières, décharges et espaces abandonnés	0,46%	0,73%	1,12%	0,34%	0,18%	0,11%	0,14%	0,16%
	Infrastructures de transport	1,12%	1,95%	0,84%	1,03%	0,48%	0,26%	0,24%	0,34%
	Autres espaces artificialisés	0,08%	0,26%	0,09%	0,03%	0,02%	0,01%	0,01%	0,01%
	Sous-total	*24,15%*	*49,95%*	*25,14%*	*28,00%*	*13,86%*	*5,36%*	*7,46%*	*9,43%*

Table 5: Land use repartition (2004) by type of municipality according to SDER

Commercial areas (F) are either located in city centres (mainly local shops) or close to dense urban settlements. The very location of the latter and the heating and cooling balance as well as the energy needs of shopping malls turn SGE into a pretty interesting option in such areas.

It should be noted that two deep geothermal wells are exploited in the neighbourhood of the city of Mons, providing thermal energy to 2 hospitals, 3 schools, a swimming pool, 355 housings and a train station. Such site is thus offering a significant potential for geothermal electricity production through deep (>5000m) hot water aquifers about to be exploited by 2020.

Former industrial areas (G) are gradually disappearing and/or turned into services and other tertiary activities areas (offices...). In those areas also, the balance between heating and cooling needs makes SGE an interesting option, competing with gas distribution networks and potential (biomass) heat networks.

Areas for the technical sustainment of the city (H) and Park areas (I) are not very relevant categories/zones with respect to SGE in Wallonia.

Water areas and waterways (J) on the contrary are very common, as shown in Figure 5 below. The potential to use water from those channels as a heat source for surrounding buildings and industrial zones might be considerable.

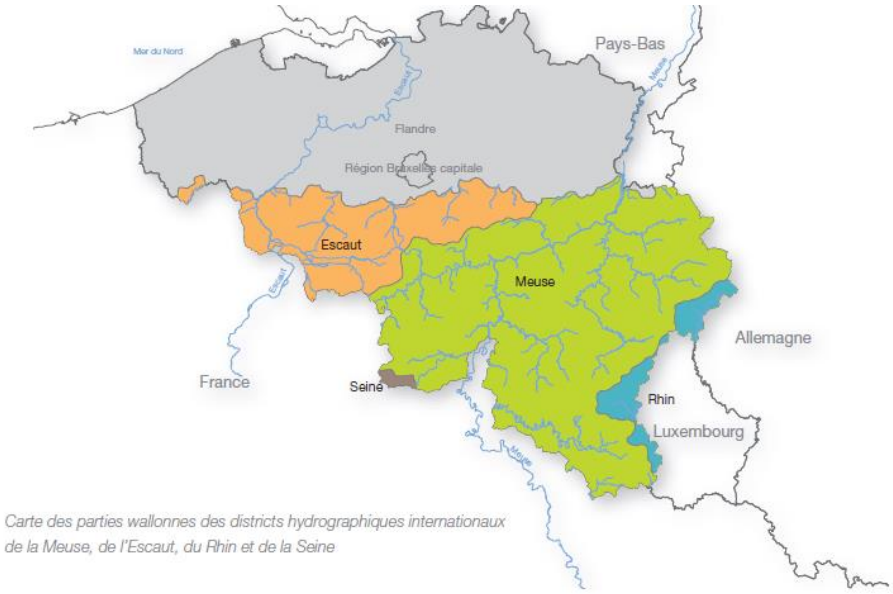


Figure 5: map of Walloon sections of international waterways

Aquifers are well protected against any risk of pollution (incl. thermal changes). In drinking water protection areas, (geothermal) drilling activities are virtually forbidden. Overall, any artificial groundwater recharge is subject to an Environmental Impact Assessment, which makes (even small) ATES project pretty hard to realize.

Final energy use in housing (35 200 GWh) and Service (13 800 GWh) amounted to a total of nearly 50 000 GWh a year in 2008, concentrated on less than 10 % of the whole territory.

On the other hand, geothermal energy production rose to 18 GWh only that same year, while heat pumps production counted for an additional 37 GWh. The most prominent heating RES used by regional and local authorities being Biomass (fire wood), producing no less than 1 430 GWh heat.

There are about 40 (small) heat networks in operation in Wallonia (Figure 6) and 30 projects under preparation).

70 % of heat networks use biomass, the average size of those networks is about 400 kWth and 63 % of those networks count less than 1 km length.

A couple of big projects under preparation (>5 MW) rely on (deep) geothermal energy.

Hence, we can conclude that biomass energy is the most competing RES for heat production with respect to SGE in Wallonia.

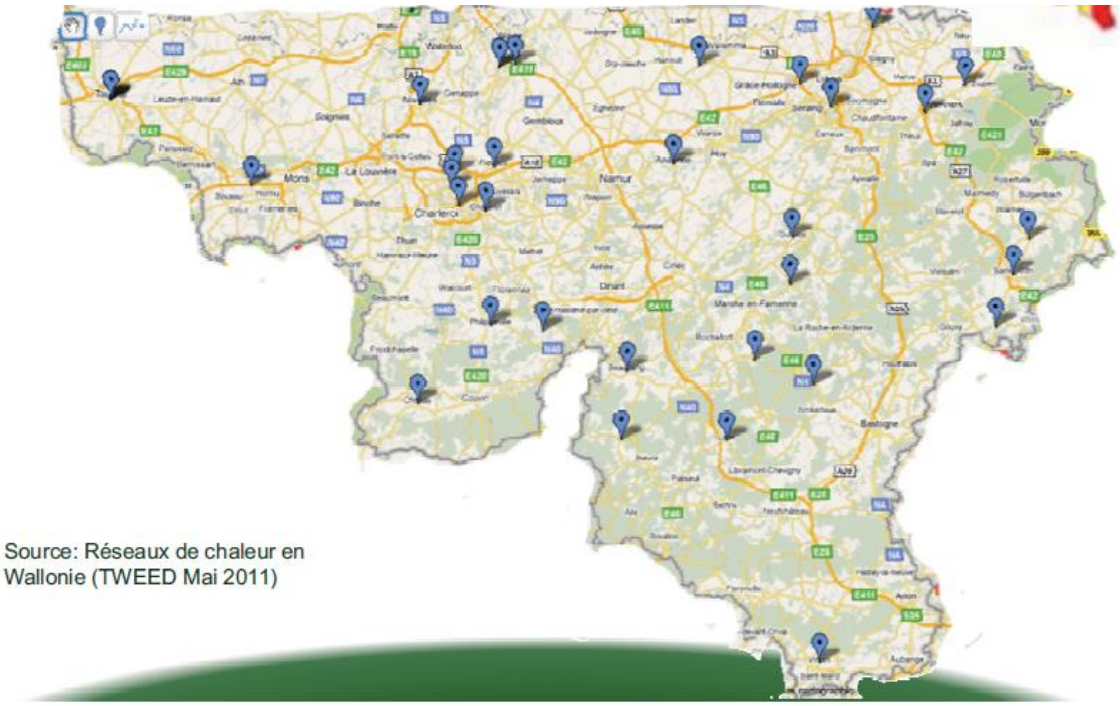


Figure 6: map of heat networks in Wallonia

The existing SGE systems in operation are not well documented in Wallonia. There is for example no central database to register SGE project and/or operating installation. Each municipality[5] keeps a copy of the authorization given to drilling requests for its own (paper) archive. On the contrary the 10.000 groundwater abstractions under Walloon ground are subject to georeferencing (thus centralized and easily available).

Analysis of the potential for SGE in the zones

The most prominent non-technical barrier preventing SGE systems to develop in urban settlements is undoubtedly the permitting procedure, which takes at least 3 months and is not always in line with the building permit procedure and rules.

For open loop systems (ATES), any artificial groundwater recharge is subject to an EIA, irrespective of the water flow or the injection temperature

In general there are no restrictions/barriers for SGE systems in a specific or typical for zone A-K. The single permit procedure is applied everywhere with different constraints according to the activity class of drills and wells.
In drinking water protection areas (geothermal) drilling activities are virtually forbidden.

[5] There are 262 Walloon municipalities

Drilling geothermal boreholes is always subordinate to the demonstration that no existing underground water/gas or electricity network is put at risk by such activity.

The availability of the ground (see upper part)

From a geological point of view the underground is suitable for GSHP in (vertical) closed loop systems in most parts of Wallonia.

Alternative heat sources

As renewable source, Biomass (wood) is definitely competing with SGE in rural / sparse urban settlements, mainly biomass boilers, connected or not to heat networks.

As non-renewable sources, mainly in (dense) urban settlements, natural gas is competing with SGE, as and when buildings are connected to municipal gas networks.

Appendix 8: France - Analysis of SGE in Région Centre

The "*Région Centre" (committed Region)* is one of French regions with largest commitment for the development of the geothermal energy on its territory, with precise ambitious objectives.

The "*Région Centre"* initiated a lot of dispositions to support the development of geothermal energy and to reach its objectives, in addition to the national supports (Cf. national report).

Table 6 : Supporting tools for SGE in Région Centre

Technical supporting tool	Atlas of shallow groundwater geothermal potential (GIS on shallow ground water resources http://www.geothermie-perspectives.fr/espace-regional/centre)
Structuring of the sector	Quality Charter **géoqual** (ground water and)
Financial supports	Isolaris Loan (individuals)
Training	**Dedicated course at the University IUT GTE** Workshop /training (Designer & Drillers)
Research	**Experimental platform for GSHP**

In addition a study was realized in 2011 for the EVALUATION OF THE POTENTIAL DEVELOPMENT OF GEOTHERMAL ENERGY IN REGION CENTRE

This study considered all the technologies susceptible to be exploited:

The SGE, shallow aquifers and vertical heat exchangers

The use of deep aquifers

This development potential for SGE is defined by crossing the data localized in a square stitch of 250 m on 250m, of geothermal resources (productivity of the concerned superficial aquifers) and the needs for surface users (mainly heating and domestic hot water). The work of adequacy between geothermal resources and energy consumption required the use of a Geographical Information System-GIS.

The Energy consumptions were determined from the constructed surfaces.

The principle of the developed methodology is to compare the geothermal resources (one or two aquifers) at the thermal need, on the scale of the stitch, while taking into account the various technical, statutory and economic constraints which can limit the implementation of an operation. The objective so is to determine which part of the thermal needs can be satisfied by one of the superficial aquifers, what allows to deduct a value from it of potential.

Mapping of the thermal needs

Needs before 2020 are two different natures, what requires two approaches:

The consumption in the existing buildings, with stabes and uncertainties on the level of renovation.

The consumption of the new constructions, which takes into account the new thermal regulation – RT2012.

To localize the existing consumers, it was decided to work with the data base BD TOPO® (©IGN2011). This database allows to map the surface of buildings and to specify some of their characteristics (in particular, the indication of the height); residential buildings and tertiary are represented.

The objective is to determine on the scale of the working stitch the energy consumption. For this purpose, the hypothesis was mad that the thermal need is proportional on the surface of the building.

Calculation of a surface warmed by building:

The surface of the building is multiplied by the number of floors (total height divided by an average value of height under ceiling). To determine a living space (and thus warmed), was considered only 85 % of total surface.

Allocation of a surface warmed by building on the scale of the working stitch.

The total surface to be warmed (m2) by stitch is the sum of surfaces of the wall surfaces of the buildings located in the stitch.

It is then a question of multiplying the surface warmed by a ratio of consumption kWh/m^2 (or kW/m^2).

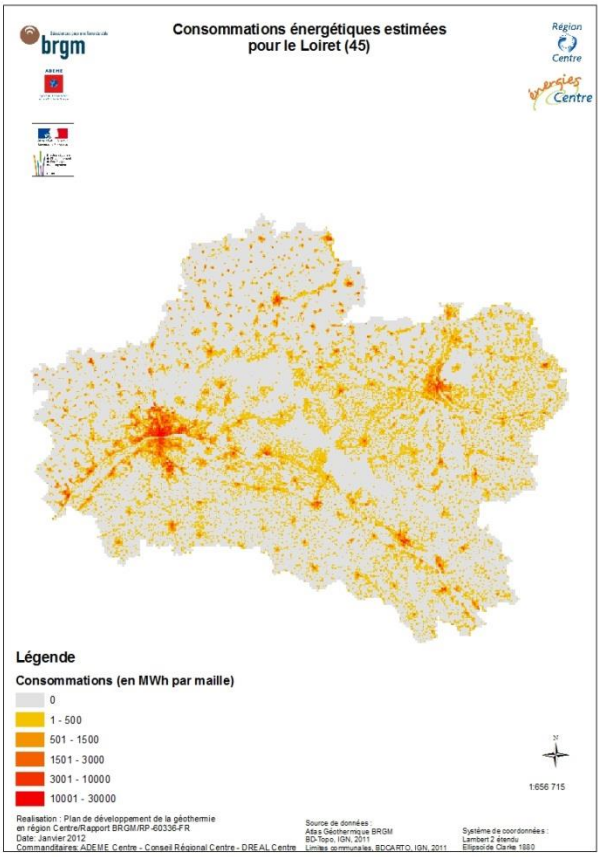
For this study, two zones of consumption were studied:

Zone “high” aiming to be representative of the current average consumption, for the residential and Tertiary: 200kWh/m^2

Zone “low” aiming to be representative of the consumption aimed at the horizon 2020: 50 kWh/m^2.

We so obtain a mapping of the thermal needs for the users on the scale of the stitch

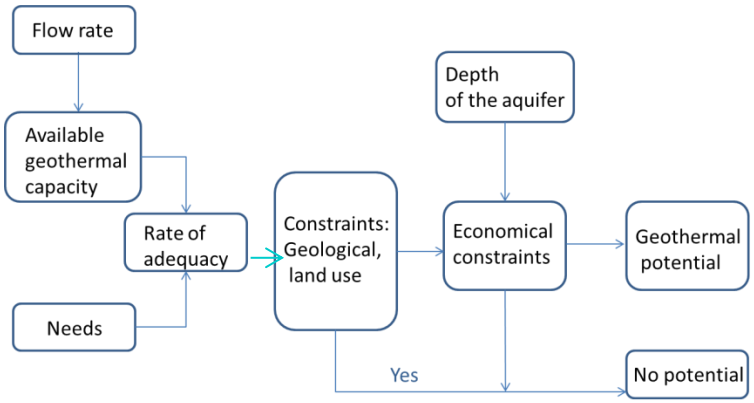
Remark: this exercise has its limits because it is clear that the energy consumptions are not directly proportional on the warmed surface. Other parameters, as the age of the building are important in the evaluation of the energy consumptions. However, it allows to give a good order of magnitude of the density of consumption.



Example of mapping the consumption of existing buildings in the department of Loiret

Geothermal potential from shallow ground water (lees than 100m deep)

General methodology to define shallow geothermal ground water potential



Technical and economic constraints

Technical constraints are:

Existing geothermal operations (drillings declared in the National ground data base http://infoterre.brgm.fr/dossiers-sur-le-sous-sol-bss)

Protected perimeters for drinkable ground water (ARS national data base)

Existing cavity (http://www.bdcavite.net/)

The economic indicator is the time of return updated by the overinvestment compared with a fossil energy. When it is upper to 30 years it is not acceptable.

Once fixed the rate of updating and the energy prices, this time of return depends of two parameters:

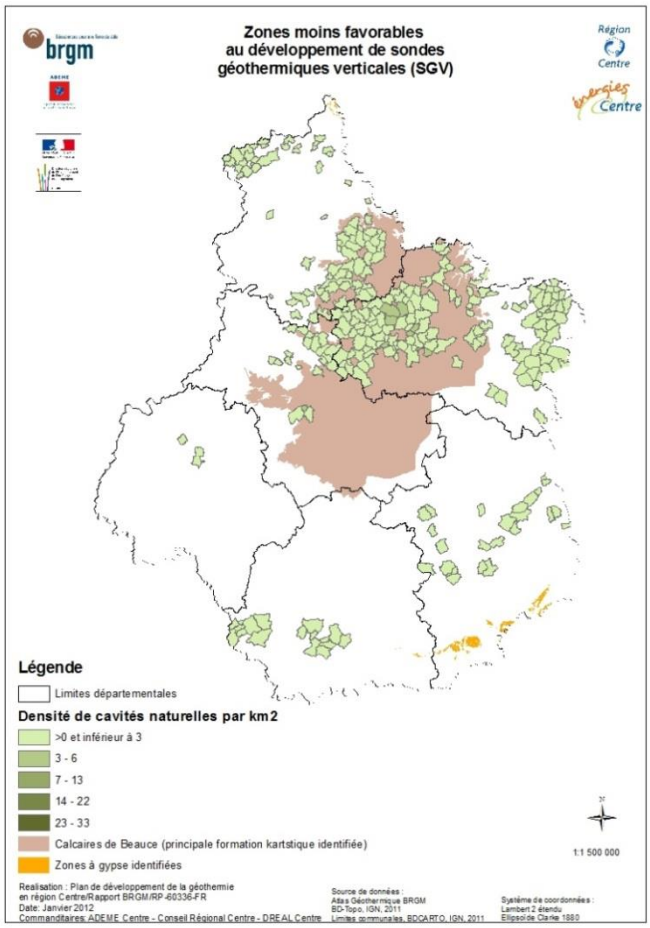
The depth of drilling,

The energy consumption of the building

Vertical heat exchangers

The potential of the vertical heat exchangers is deducts of the potential of the surface aquifers, for the warmed surfaces lower than 5 000m^2, for the stitches on which there is no potential on superficial aquifers (no shallow aquifers to satisfy at least 50 % of needs; or because the surface to warm is lower than 100 m^2), for the stitches on which there are no technical or statutory constraints.

The potential of the vertical heat exchangers, on the basis of other hypotheses, be much more important because in a number of geographical ares, both forms of SGE (ground water and vertical heat exchanger) are possible.



Restrictions for SGE systems

-Zones of geological constraints for the setting-up vertical heat exchangers have been identified there are: karst areas, gypsum formation,

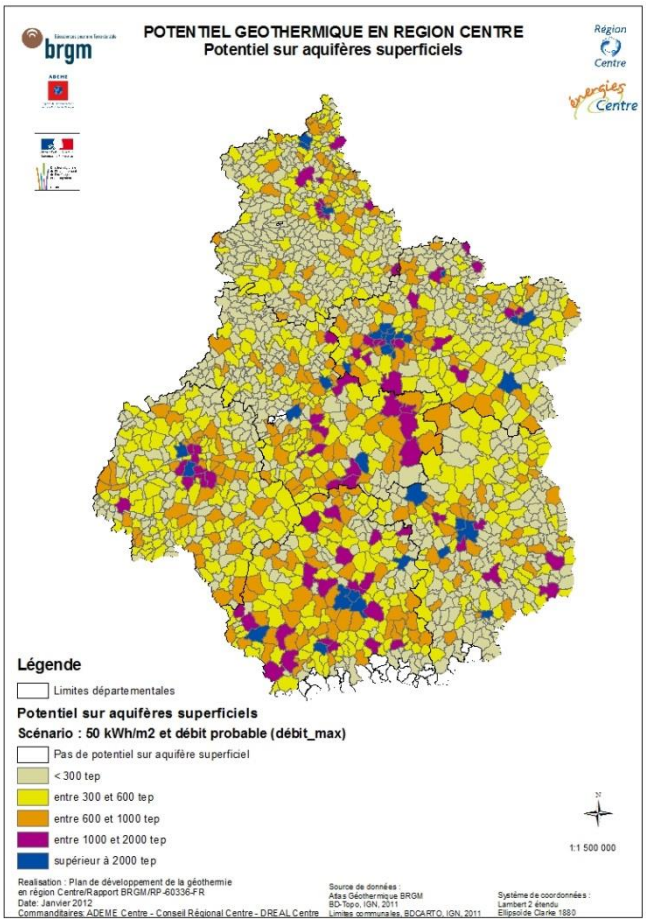
- Zones with regulation constraints or too small land space available have also been identified (only protected areas for drinkable water are regulatory constraints for vertical heat exchangers).

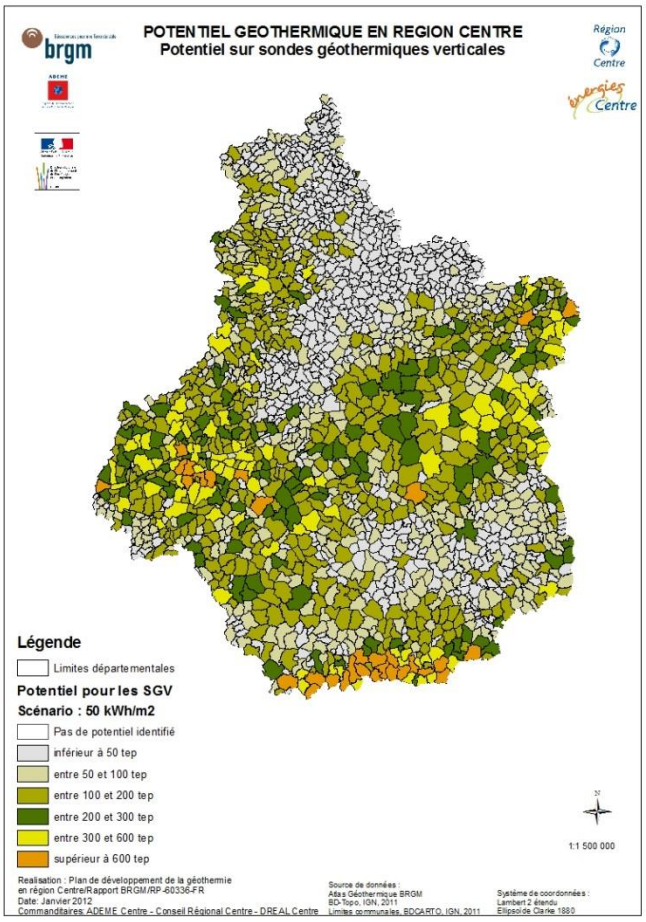
Example of results

The table below presents the SGE potential, using the most extreme both zones (taken 50 kWh / m2 and “low rate” and of the zone 200 kWh / m2 and “high rate”).

		Nombre	tep	Gained in primary energy (MWh_{ep})	Tons of CO2 avoided annually
Low zone					
	Ground water		447 937	1 947 840	815 910
	Vertical heat exchangers		205 741	894 658	374 754
High zone					
	Ground water		2 823 123	12 276 262	5 142 274
	Vertical heat exchangers		753 852	3 278 099	1 373 128

The following maps present the results, on the scale of the municipality:





SGE potential, ground water **SGE potential, vertical heat exchangers**

An additional analysis was made for the high schools buildings of the region (ground water SGE)

Links between urban planning and renewable energy plans

Main urban planning documents, PLU (*Plans Locaux d'Urbanisme* - the local urban planning documents) and SCOT (*Schéma de Cohérence Territorial - Scheme of territorial Coherence*), have to take into account local energy actions plans (SRCAE and PCET) and can compel development of renewable energies in some places.

The illustration below shows the links existing between space planning documents and local energy plans (SRCAE and PCET).

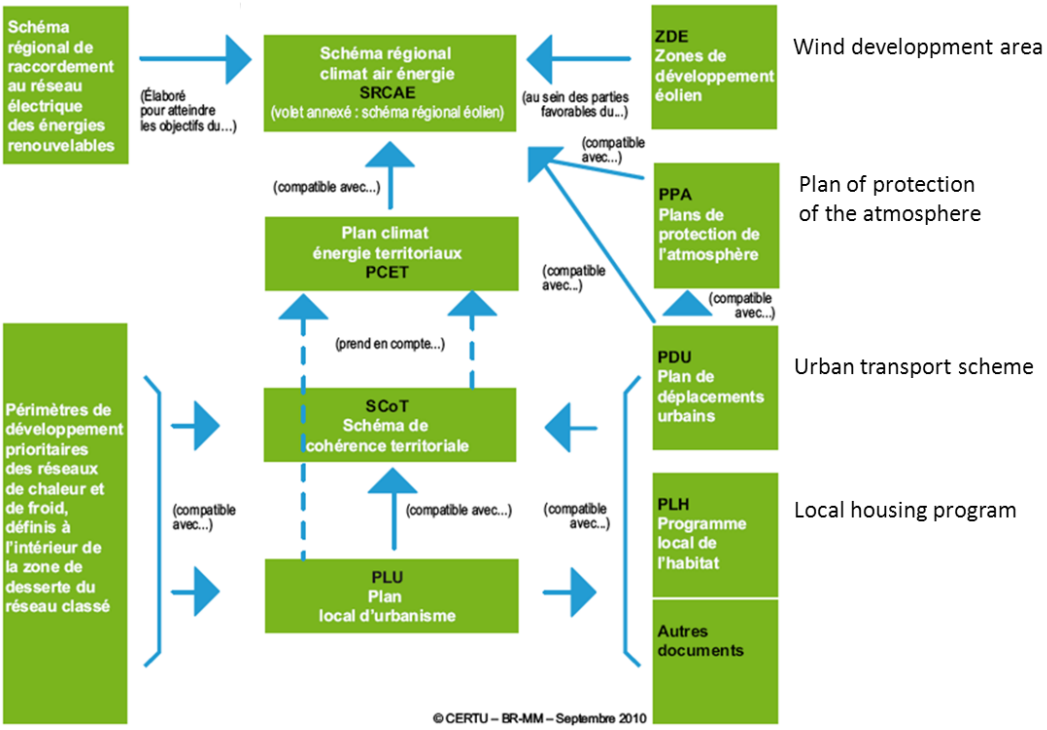


Figure 7 : Coordination of the regional initiatives

SRCAE: Schema régional climat air énergie Regional scheme Air-Climate-Energy

PCET: Plans Climat-Energie Territoriaux Territorial Energy and Climate Plans

SCoT: Schema de coherence terriitoriale Scheme of territorial Coherence

PLU: plan local d'urbanisme local urban planning documents

Alternative heat sources

For single family houses, air source heat pumps are more popular (due to investment rate).

In France, the Investment and operating cost are often compared with those of gas boilers

Geothermal District heating (deep aquifers) are popular in the Paris area (end also in Aquitaine –SW). In other regions, biomass district heating are popular (depending of the geographical situation) and they can be in competition with geothermal energy.

Appendix 9: Germany – Analysis of SGE in cities

Land area classification

Analysis of the potential for SGE in the zones

In Germany, drilling for SGE is not regulated by local/municipal planning authorities. These authorities are controlling construction (including underground construction like power and water supply, sewage, etc.), but not the thermal use of the underground. Drilling permits are either issued by water authorities (for most SGE) or by mining authorities (in case of larger systems or drilling depth >100m, see below). Water authorities have been separate offices in the past, but today are commonly merged into environmental offices ("Umweltamt"), on the level of districts ("Kreis") or of larger cities (in Germany, certain larger cities are "kreisfrei", i.e. not belonging to a district, and performing the responsibilities of districts themselves). The situation in the three cities constituting an own state (city state: Berlin, Bremen, Hamburg) is different again; here the responsibilities of large cities and those of states are cumulated in one authority. There is another intermediate level within the larger states that need to be mentioned here, because mining authorities are typically organised on that level: the "Regierungsbezirke" (government districts). Each "Regierungsbezirk" comprises a number of "Kreise", and

The following general rules can be set up, and the different levels elucidated, in form of a matrix:

Type of task	State (Land)	Governm. District *	District (Kreis)	City/ Municip.	City State	Large City (kreisfrei)
	normal				exception	
Basic legislation	X				X	
Mining authority		X			X	
Water authority **			X		X	X
Regional planning		X			X	
Urban planning				X	X	X

* Where existing, otherwise these responsibilities are on the state level.

** Mainly inside environmental offices is provided by states

Mining legislation (incl. large/deeper SGE)

The following information analyses the impact urban and regional planning may have on SGE installation in Germany, and explains the actual permitting process for SGE with water are mining authorities.

In Germany, urban and regional planning is following a structured approach, regulated in state legislation. This results in 16 different legal backgrounds and differences in details; however, it is possible to extract some common approach.

Local plans are prepared by cities and communities (municipalities). They delineate areas for residential buildings, industry, parks, etc., similar to the zoning as proposed in Regeocities. None of this zoning has a direct implication on SGE, with the exception of areas for underground workings like mines are road/rail tunnels.

The main impact on SGE from public planning is the existence of water protection areas (Wasserschutzgebiete, WSG). Also here, large differences can be seen among the different states. While the basic principles of delineation of WSG are laid down in a guideline from the German Association for Gas and Water (DVGW), the practical approach in the different states varies. This WSG are divided in different zones (I is the direct surrounding of the well, II the nearer zone with certain restrictions for digging and building, and III the outer zone, which can be divided again into IIIa and IIIb, the latter comprising the whole catchment area).

As an example, what is considered WSG IIIb in Hessen, may not be considered as WSG at all in Bavaria.

Data exist for 2007; of the total area of Germany, 11.6 % were WSG of some kind. The difference among the states is substantial: Hessen and Baden-Württemberg lead the list with 28.9 % and 25.4 %, respectively, while Bavaria and Schleswig-Holstein bring up the rear with only 4.5 % and 3.2 %, respectively (the three “city-states” Berlin, Bremen and Hamburg are neglected here).

The ownership of the surface also has an impact on the possible use of SGE. As long as the use can be limited to the area beneath the surface § 4 BBergG

NB: Also the ground under an area in public ownership cannot be used without a permit. As it is a different owner than the owner of the lot with the SGE surface use, the exception as to § 4 BBergG does not apply.

Of course, planning on the surface can limit the area available for drilling operation.

There are basically no differences in the permitting for drilling among urban and rural areas.

Appendix 10: Italy - Analysis of SGE in cities

This section describes the challenges for SGE in very small towns and villages located in geothermal area in Tuscany Region (Arcidosso, Casole d'Elsa, Castel del Piano, Castelnuovo Val di Cecina, Chiusdino, Montecatini Val di Cecina, Monterotondo Marittimo, Monteverdi Marittimo, Montieri, Piancastagnaio, Pomarance, Radicondoli, Roccalbegna, Santa Fiora).

Figure 7.1 shows the location of municipalities in geothermal area in Tuscany Region.

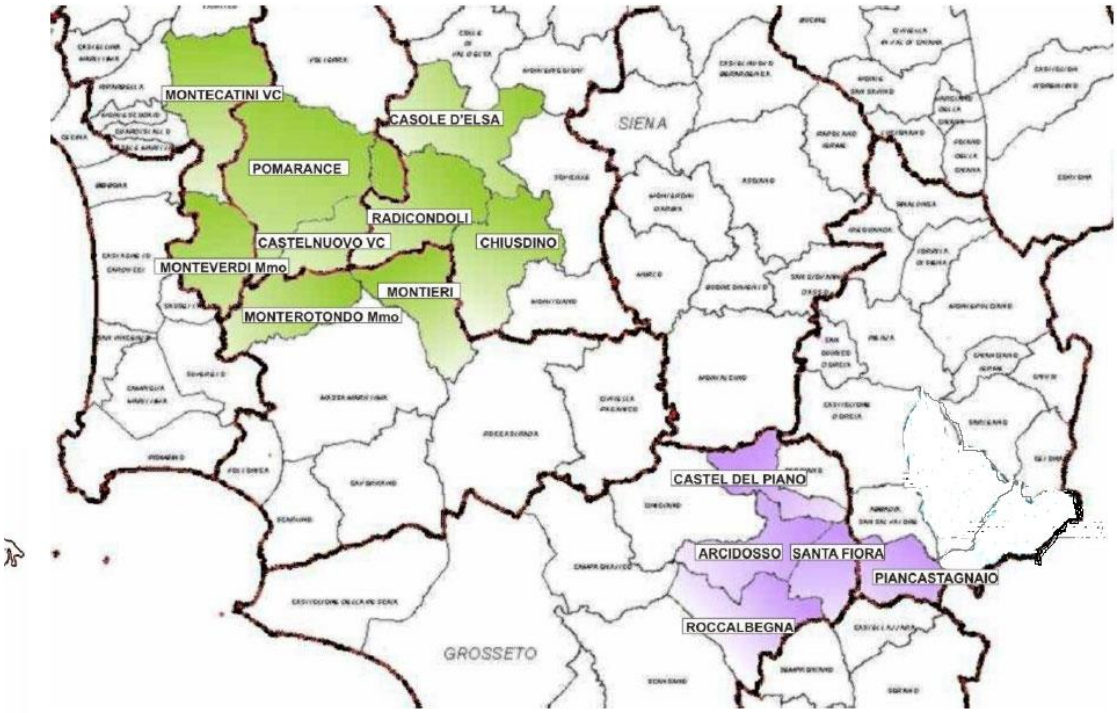


Figure 7.1 Location of 14 municipalities in geothermal area in Tuscany Region.

Land area classification

The REGEOCITIES zones are applicable to 14 very small cities in Tuscany (listed above) (ca 30 000 inhabitants).

Analysis of the potential for SGE in the zones

This section describes how the situation is in general in Italy.

Outside the cities, underground occupation related to human activities is not considered really an issue.

In general, there are restrictions/barriers for SGE systems in a specific or typical for zone A-K. Older settlements (A) and areas, with special attention to preservation (B) (e.g. protected non movable heritage) are usually subject to special schemes regarding building retrofit and drilling.

In urban settlements (C, D) the single permit procedure assesses any potential impact related an SGE installation.

In urban development areas (E) SGE installation can be taken into consideration at an earlier stage of building works, increasing the likely of realizing SGE systems.

In commercial areas (F) SGE systems are an interesting option in order to satisfy heating and cooling demand in shopping malls.

Industrial areas (G) are suitable to use SGE installations for heating and cooling needs, competing with gas distribution networks and potential (biomass) heat networks.

Areas for the technical sustainment of the city (H) and Park areas (I) can be possible categories/zones for the adoption of SGE systems.

Water areas and waterways (J) can potentially provide water for open loop SGE systems as heat source for surrounding buildings and industrial zones, but groundwater abstraction boreholes cannot be realised within drinking water protection zones, according to national regulation.

In general, there are restrictions for drilling in water protection areas, which include built environment, also in central parts (all type of zone zones).

It is not possible to drill on ground not owned by the SGE owner, including municipal owned ground like streets and parks, if SGE owner does not ask for a utility easement. The law admits that underground drilling geometry exceeds the vertical projection of the land owned by the SGE owner, if the top of the well on his/her ground and there are not interferences with underground services of public utility. In general, the SGE owner has to demonstrate the absence of interferences also between the installation/drilling and the aquifer. The SGE owner have to provide the provincial water management authority with a technical report signed by a registered geologist. This report should demonstrate the absence of relevant quantitative and qualitative interactions between the SGE installation and surface/underground aquifer (e.g. thermal disturbance). After a preliminary investigation, provincial officers provide SGE owner with a concession that may include some technical prescriptions and recommendations (e.g. wall treatment and waterproofing of wells).

There are not differences in the regulative framework for the different zones because very often the installation of SGE is not contemplated in the urban planning regulation. Nevertheless, those rules indicate that the drilling operations require licenses and permissions. For this reason, it is necessary to present a project contemplating the drilling plan. This project is analysed by the municipal technicians to provide the permission in case that the drilling operations are not in direct conflict with other infrastructures, issues or administration.

In general, it is not possible to drill on ground not owned by the SGE owner, including municipal owned ground like streets and parks, if SGE owner does not ask for a utility easement. The law admits that underground drilling geometry exceeds the vertical projection of the land owned by the SGE owner, if the top of the well is on his/her ground and there are not interferences with underground services of public utility.

Generally, there are no special permissions required for SGE system installations other than the ones that include compliance with the building regulations, planning permission regulations, EIA requirements for large systems and water management regulations for open loop system.

The SGE owner has to demonstrate the absence of interferences also between the installation/drilling and the aquifer. The SGE owner has to provide the provincial water management authority with a technical report signed by a registered geologist. This report should demonstrate the absence of relevant quantitative and qualitative interactions between the SGE installation and surface/underground aquifer (e.g. thermal disturbance). After a preliminary investigation, provincial officers provide SGE owner with a concession that may include some technical prescriptions and recommendations (e.g. wall treatment and waterproofing of wells).

The availability of the ground

Generally, in most parts of Italy, the underground is suitable for GSHP from a geological point of view, but there are some Italian areas such as Rome where any drilling activity is forbidden in order to preserve underground aquifers. In case of contaminated soil, drilling activities are allowed only if the soil is reclaimed.

In the geothermal area in Tuscany[6], SGE owners have to demonstrate the absence of interferences with geothermal power stations which exploit geothermal high enthalpy resources. Generally, it is easy to demonstrate the absence of interferences because SGE systems need different depth and temperature compared with systems for geothermal high enthalpy.

Besides the geological conditions, lack of space between boreholes can become a limiting factor as well as lack of thermal underground volume. For zone C (dense urban settlements), such as areas with multifamily buildings the distance between boreholes can become the limiting technical factor. In Italy there is not a recommended distance between boreholes. For zone C, SGE owner has to check overall environmental impacts and interferences on the aquifer caused by new SGE installation and previous ones according to general environmental law.

The geothermal area in Tuscany is characterized by old buildings which are not retrofitted. These buildings have radiators that operate with very hot water (65-75°C). Therefore, this solution is not efficient for SGE systems.

[6] The geothermal area in Tuscany consists of two sub-areas: Nord (Montecatini Val di Cecina, Castelnuovo di Val di Cecina, Pomarance, Radicondoli, Monteverdi Marittimo, Chiusdino, Monterotondo Marittimo and Montieri) and Sud (Castel del Piano, Radicofani, Abbadia San Salvatore,San Casciano ai Bagni, Piancastagnaio, Santa Fiora, Arcidosso and Roccalbegna).

Alternative heat sources

These areas are characterized by geothermal high enthalpy resources traditionally used to generate electricity, but there is also a great potential for the exploitation of heat from geothermal energy. Therefore, the main competing heat generator of SGE systems is district heating from geothermal energy. Pomarance, Castelnuovo Val di Cecina, Monterotondo Marittimo and Santa Fiora have district heating from geothermal source.

Generally, other competitors of SGE systems are biomass installations, solar thermal plants and air source heat pumps. Biomass installations (i.e. pellet stoves) have competed with SGE systems because biomass installations have lower investment cost, but now the diffusion of biomass installations is hindered by environmental thresholds for PM10. Solar thermal plants are strong competitors for SGE systems because of high solar potential in Italy and lower investment cost. For single family houses are air source heat pumps the most popular choice, especially for newer houses with higher energy efficiency and a relative low heat energy demand. Air source heat pumps are an alternative that have a lower investment cost than GSHP and almost the same operation cost.

Appendix 11: Romania - Analysis of SGE in Bucharest

In this section the challenges for SGE in the city of Bucharest are analysed including existing regulatory examples.

Land area classification

The REGEOCITIES zones are applicable to the city of Bucharest (over 2.000.000 inhabitants).

A. Older settlements
B. Areas with special attention to preservation
C. Dense urban settlements
D. Sparse urban settlements
E. Urban development areas
F. Commercial operation areas
G. Logistic zones and manufacturing
H. Areas for the technical sustainment of the city
I. Park areas
J. Water areas with waterways
K. Main roads and railroad tracks

Analysis of the potential for SGE in the zones

In general there are no explicit restrictions for SGE systems in a specific or typical for zone A-K. The reason is that the current legislation does not include at all this possibility (neither to stimulate nor to prohibit it). The barriers exist but they are mainly economical and generated by the lack of legislation.

Existing "open" technology applications encounter difficulties generated also by the lack of rules that allow abusive interpretations. For example, the owners are requested to throw restitution water in open waters (rivers or lakes) or at sewerage network instead of using restitution wells (as it is compulsory in Europe in order to preserve the quantity and the pressure of the aquifer). The reason invoked by the Romanian water authorities is the need of preservation of water quality considering that ATES applications can threaten it. The applications owners tracked all the water quality analyses that demonstrate the contrary reality.

A simple open installation does not need a special approval procedure, the wells being considered as any other water supply solutions.

The same situation is for closed systems where drillings < 100 meters depth must not be specially approved as a solution accessing Earth energy, but as a solution accessing underground waters. The approval is in this case included in the “Environment Authorization” and is issued by the National Waters Authority. When the drilling are > 100 meters deep the approval must be issued by the National Authority for Mineral Resources (ANRM). Because ANRM does not issue a drilling procedure for GSHP applications purposes, all closed systems in Romania are <100 meters.

As a conclusion, in Romania there are not specific norms for water supply wells / drillings and water wells / drillings for energy purposes.

The Romanian municipalities do not record the functional applications ("open" or "close" technology), their impact on the RES energy production or on the local environment. This is why a Guide regarding the Data base for functional applications allow them to understand not only the advantages of the technology, but also the obligations of the local authorities. On the other hand this "bottom-up" approach without a national legislative coherent clarification will determine very heterogeneous tracking systems at local levels.