REGEOCITIES

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Report on the activities undertaken and on the methodology followed and on the results obtained as part of the task on promoting the inclusion of SGE in SEAPs of representative cities

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Contents

1. Activities undertaken

In the third year of the REGEOCITIES project, two of the partners, Scuola Superiore Sant'Anna - Italy and Romanian Geoexchange Society - Romania focused on an important aspect of the heating and cooling systems with geothermal heat pumps (GSHP). This subject is the Life Cycle Cost (LCC) and the action was planned because its conclusions could positively influence the inclusion of this technology in the Sustainable Energy Action Plans (SEAPs) of the municipalities which have signed the Covenant of Mayors (CoM). To this end, two separated studies have been carried out:

(a) Life Cycle Cost Analysis

(b) Sustainable Action Plans Analysis

The two studies, includingtheir results and conclusions, are included in this document (subchapter 5.1 and 5.2).

2. METHODOLOGY FOLLOWED

This activity aimed to achieve the REGEOCITIES objectives especially by demonstrating the need of introducing LCC analysis in SEAPs. The method included:

(a) The consultation of the REGEOCITIES partners in order to collect their experience and knowledge in their countries;

(b) The consultation of previously finalized REGEOCITIES project results and their sources;

(c) The consultation of the scientific, technical and economical literature internationally published on LCC issue in GSHP applications;

(d) The screening of the SEAPs and evaluation as part of a methodical survey of 47 SEAPs which are publicly available on the website of the Covenant of Mayors.

3. RESULTS OBTAINED

The LCC Analysis reviewed the studies about LCC of GSHP systems in Europe especially and the presence of GSHP technology and applications in SEAPs. It also focused on the impact of permitting costs caused by standards and regulations. The results and findings are largely presented in the two analyses. Some important conclusions are the following:

- The major costs of GSHP system are upfronnt investment costs that are mainly influenced by the drilling and in general by installation costs.
- The analysis of regulations and legal permit costs in some European countries showed the difficulty of estimate exact costs due to the fact that administrative fees vary at local level.
- These high initial costs are balanced by lower maintenance and operating costs.
- The investments without a LCC approach in the selection of the cost-effective technological solution for heating and cooling disadvantages GSHP systems.
- An effective set of regulations, guidelines and standards for the promotion of SGE systems and in particular GSHP systems should consider these factors;
- The LCC approach gives investors and policy makers the opportunity to better understand the characteristics of the compared heating and cooling systems / solutions / alternatives and the base to choose GSHP over other H&C technologies, including in the local SEAPs.

The SEAPs Analysis studied the SEAPs that have adopted specific actions for the development of SGE systems for thermal purposes and it was carried out in order to identify peculiarities, influencing factors and the type of actions planned and implemented for the development of SGE systems.

The main conclusions are the following:

- The SEAPs were based on the collaborations between public authorities, research centres, universities, associations, companies and other municipalities;
- There is a significant development potential in the future, because the majority of CoM's signatories have not yet implemented these plans;
- The analysis highlights the need for an integrated strategy where the general planning of measures for energy efficiency and renewable energy sources, and the implementation of pilot projects and installations for renewable energy sources are both present. This integrated approach can promote the adoption of a cost-effective set of actions, which will in turn be beneficial for the development of SGE systems;

- In the SEAPs analysed, the most commonly adopted actions are training activities and information campaigns for the deployment of energy efficiency and renewable energy sources followed by pilot projects and installations for the development of SGE systems at local level.
- Some SEAPs integrate more than one action that foster the development of SGE in order to strengthen the effort to overcome technical and non-technical barriers to the development of this renewable energy source;
- The analysis shows that integration of actions for the promotion and development of SGE systems in the SEAP is a step-by-step process that involves the municipality and its organization, all local economic actors but also citizens;
- The first efforts of local authorities should solve the lack of information about benefits, possible risks, potential and operation of SGE systems and overcome related scepticism and opposition, because shallow geothermal energy is still little known by civil servants and citizens;
- The assessment of the local geothermal resource potential can be a crucial step in the development of SGE systems because it can foster public and private investors;
- Policymakers should assume a crucial role in setting off and spreading the knowledge and skills related to the promotion of shallow geothermal energy systems.

4. PROPOSALS FOR THE COVENANT OF MAYORS based on SGE potential and advantages and on the potential effects induced by SGE presence in SEAPs

Based on the conclusions outlined above, the REGEOCITIES consortium brings forward the following key recommendations to the Covenant of Mayors in view of of the next revision of CoM Guidebook "How to develop a SEAP" - Chapter **3. Heating /cooling and electricity production** (page 101):

a) **There should be a clear separation between airsource and geothermal heat pumps.** Air source and geothermal heat pump systems are different. Geothermal systems making use of heat pumps require different professional figures involved, different training activities, system design, planning requirements and lisencing. There may be synergies and/or overlaps between geothermal heat pump systems and underground urban planning, including for parkings and underground public transportation. Therefore, the deployment of geothermal systems making use of heat pumps require a differenciated approach in terms of planning and policies; signatories should be made aware of this.

b) **The section on geothermal heat pump technology should be complemented with additional information,** including on underground thermal energy storage.

c) An additional section comparing all H&C technologies (renewable and fossil) should be added, including each technology limits, advantages and disadvantages.

To sum up, the section on airsource/geothermal heat pumps should be as follows:

The current content of the Guidebook	Proposals for a revised version of the Guidebook
3.4 Heat pumps and geothermal heat pumps The use of heat pumps for heating and cooling is very well known. This way of producing heat or cold is particularly efficient. Heat pumps are composed by two heat exchangers. In winter the heat exchanger located outdoors will absorb heat from the environmental air. The heat is transferred to the indoor exchanger to heat the building. In summer the role of each part is inverted. As the outdoor unit must transfer heat in summer and absorb it in winter, the performance of the heat pump is highly influenced by the outdoor temperature. In winter/ summer, the lower/higher this temperature is the more the heat pump’s performance will decrease. As the performance of heat pumps depends on both the indoor and the outdoor temperatures, it is convenient to reduce the difference between them as much as possible to increase the performance. Accordingly, in winter season an increase of temperature in the heat pump’s cold side (outside) will improve the performance of the cycle. The same reasoning can easily be applied to the hot (outside) part in summer. A possible solution to increase typical performance value is to use the ground or ground water as a source of heat in winter and of cold in summer. This can be done due to the fact that, at a certain depth, the ground temperature doesn’t suffer significant fluctuations throughout the year. Generally speaking COP or EER values can be improved by 50 %. Seasonal Performance Indicators (SPF) can be improved by 25 % with respect to an air-water cycle. This leads to the conclusion that the electricity consumption in this case could be 25 % lower than the case of an air-	3.4 a) **Airsource** heat pumps The use of heat pumps for heating and cooling is very well known. This way of producing heat or cold is particularly efficient. Heat pumps are composed by two heat exchangers. In winter the heat exchanger located outdoors will absorb heat from the ~~environmental~~ ambient air. The heat is transferred to the indoor exchanger to heat the building. In summer the role of each part is inverted. As the outdoor unit must transfer heat in summer and absorb it in winter, the performance of the heat pump is highly influenced by the outdoor temperature. In winter/ summer, the lower/higher this temperature is the more the heat pump’s performance will decrease. As the performance of heat pumps depends on both the indoor and the outdoor

water conventional heat pump. This reduction is higher than the case of an air-air cycle for which general data is not available. The heat transfer process between the Ground Heat Exchanger (GHE) and surrounding soil is dependent on local conditions such as the local climatic and hydrogeological conditions, the thermal properties of soil, soil temperature distribution, GHE features, depth, diameter and spacing of borehole, shank spacing, materials and diameter of the pipe, fluid type, temperature, velocity inside the pipe, thermal conductivity of backfill and finally the operation conditions such as the cooling and heating load and heat pump system control strategy. Geothermal energy systems can be used with forced-air and hydronic heating systems. They can also be designed and installed to provide 'passive' heating and/or cooling. Passive heating and/or cooling systems provide cooling by pumping cool/hot water or antifreeze through the system without using the heat pump to assist the process. **Example:** Let us compare the primary energy saved with a conventional boiler, a condensing one, a heat pump and a Ground Heat Exchanger Heat Pump to produce 1 kWh of final energy.	temperatures, it is convenient to reduce the difference between them as much as possible to increase the performance. Accordingly, in winter season an increase of temperature in the heat pump's cold side (outside) will improve the performance of the cycle. The same reasoning can easily be applied to the hot (outside) part in summer. **3.4 b) Geothermal heat pumps and Underground Thermal Energy Storage** A possible solution to increase typical performance value is to use the ground or ground water as a source of heat in winter and of cold in summer. This can be done due to the fact that, at a certain depth, the ground temperature doesn't suffer ~~significant~~ fluctuations throughout the year. Generally speaking COP or EER values can be improved by 50 %. Seasonal Performance Indicators (SPF) can be improved by 25 % with respect to an air-water cycle. This leads to the conclusion that the electricity consumption in this case could be 25 % lower than the case of an air-water conventional heat pump. This reduction is higher than the case of an air-air cycle for which general data is not available. The heat transfer process between the Ground Heat Exchanger (GHE) and surrounding soil is dependent on local conditions such as the local

	climatic and hydrogeological conditions, the thermal properties of soil, soil temperature distribution, GHE features, depth, diameter and spacing of borehole, shank spacing, materials and diameter of the pipe, fluid type, temperature, velocity inside the pipe, thermal conductivity of backfill and finally the operation conditions such as the cooling and heating load and heat pump system control strategy. Geothermal energy systems can be used with forced-air and hydronic heating systems. They can also be designed and installed to provide 'passive' heating and/or cooling. Passive heating and/or cooling systems provide cooling by pumping cool/hot water or antifreeze through the system without using the heat pump to assist the process. ***Geothermal systems intended to change the underground temperature periodically (e.g. seasonally) fall under the term Underground Thermal Energy Storage (UTES). The delineation between geothermal heat pumps and UTES is not sharp, and among the larger installations, only a minority is "pure UTES". Large geothermal heat pump installations with ground heat exchanger fields or aquifer systems also qualify for the term 'storage'; In all these large installations it is crucial to pursue a long-term balance of heat***

	extracted from and injected into the ground. Example: Let us compare the primary energy saved with a conventional boiler, a condensing one, a heat pump and a Ground Heat Exchanger Heat Pump to produce 1 kWh of final energy.

The final table included in the current version of the Guidebook is the following:

TECHNOLOGY	FINAL ENERGY KWH	PERFORMANCE RATIO ([24])	COP ([25])	PRIMARY ENERGY FACTOR ([26])	PRIMARY ENERGY (kWh)	PRIMARY ENERGY SAVED (%) ([27])
Conventional Boiler (natural gas)	1	92 %	-	1	1.08	-
Condensing Boiler (natural gas)	1	108 %	-	1	0.92	**-14.8 %**
Heat Pump (electricity)	1	-	3	0.25 – 0.5	1.32 – 0.66	**+22 % to -38.8 %**
Ground Heat Exchanger Heat Pump (electricity)	1	-	5	0.25 – 0.5	0.8 – 0.4	**-25.9 % to -62.9 %**

The table above should be complemented with a methodology to estimate primary energy savings and CO_2 emissions savings taking into account the electricity mix of the region/country.

5. STUDIES

The full version of the two studies are presented below.

5.1 LIFE CYCLE COST ANALYSIS

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SUMMARY

CHAPTER 1 – LIFE CYCLE COST BASICS

1.1 What is Life Cycle Cost?

The life cycle cost of a system may be simply defined as the sum of all costs incurred during its life span (i.e., the total of acquisition and ownership costs).

> ***First LCC steps***
>
> *The term life cycle costing was used for the first time in **1965** in a report entitled "Life Cycle Costing in Equipment Procurement" prepared by the Logistics Management Institute, Washington, D.C., for the assistant secretary of defense for installations and logistics, U.S. Department of Defense, Washington, D.C. As a result of this document, the Department of Defense published a series of three guidelines for life cycle costing procurement, entitled "Life Cycle Costing Procurement Guide (Interim)," "Life Cycle Costing in Equipment Procurement—Casebook," and "Life Cycle Costing Guide for System Acquisitions (Interim)".*
>
> *In **1971**, the Department of Defense issued Directive 5000.1, entitled "Acquisition of Major Defense Systems," concerning the requirement for life cycle costing procurement for major systems acquisitions.*
>
> *In **1974**, the concept of life cycle costing was formally adopted by the state of Florida and, in **1975**, a project entitled "Life Cycle Budgeting and Costing as an Aid in Decision Making" was initiated by the United States Department of Health, Education, and Welfare.*
>
> *In **1978**, the U.S. Congress passed the National Energy Conservation Policy Act, which made it **mandatory for every new federal building to be life cycle cost effective**.*

The approach used for estimating the total life cycle cost of equipment procurement is known as *life cycle costing*.

It simply means that, in equipment and services acquisition analysis, is necessary, but not sufficient to consider the procurement cost (Figure 1.1). The lifetime cost is essential. Otherwise, procurement decisions based totally on the acquisition cost may not be the best decision in the long-term.

According **ISO 15686-5 standard,** Life Cycle Cost is

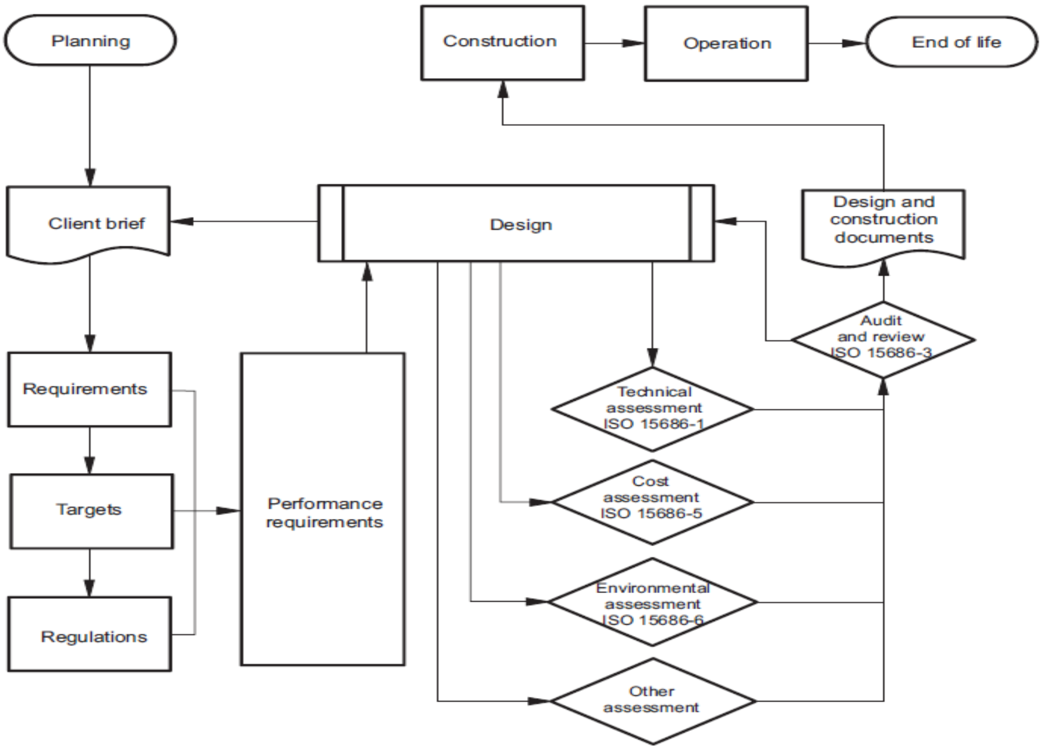
"Cost of an asset or its parts throughout its life cycle, while fulfilling the performance requirements".

The Life Cycle Cost of an asset is defined as:

*"The **total cost** throughout its life including planning, design, acquisition and support costs and any other costs directly attributable to owning or using the asset".*

Life Cycle Costing enables decisions on acquisition, maintenance, refurbishment or disposal to be made in the light of full cost implications.

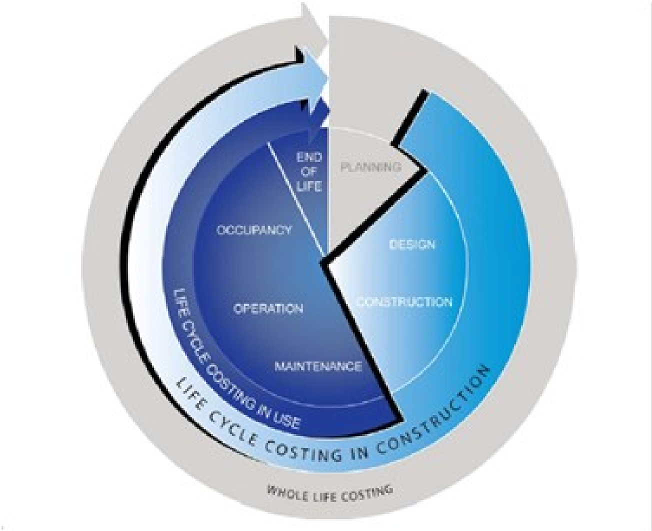
Figure 1.1 – Diagram of process for the procurement of services and/or equipment



Despite an increasing enthusiasm, the application of LCC in the building and Heating, Ventilating and Air Conditioning (HVAC) sector remain rather limited because of the numerous data that have to be considered.

It is most effective to implement LCC during design stage of a project where there is opportunity to explore and compare different options against each other.

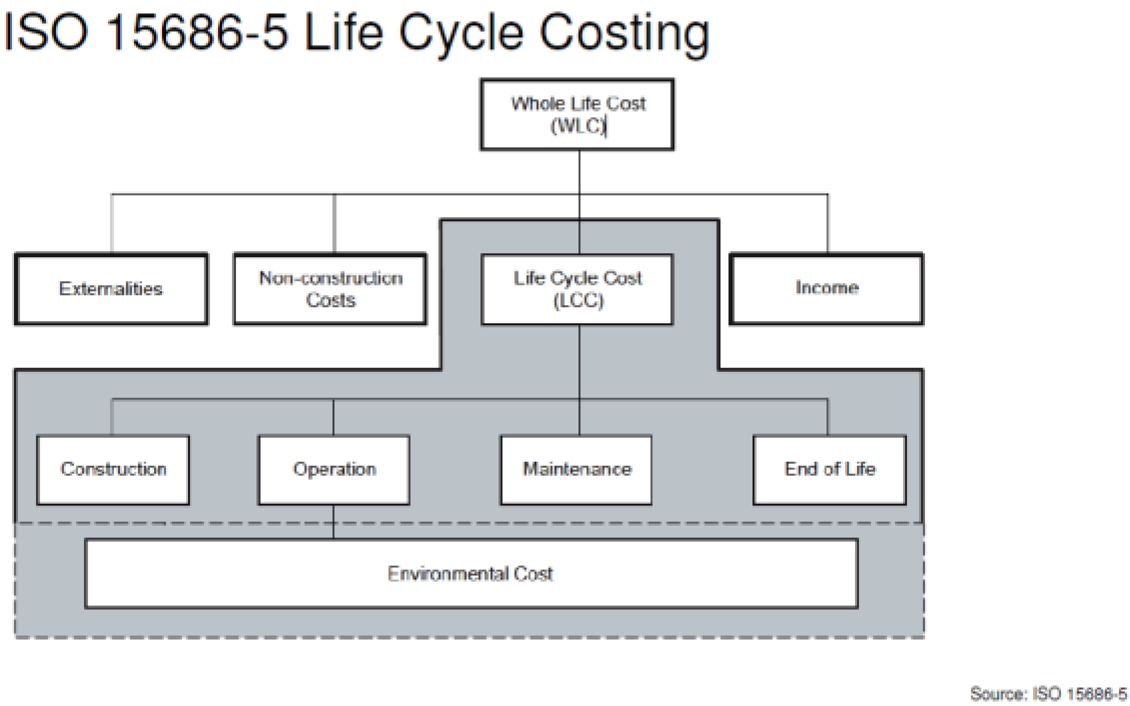
Figure 1.2 – Life Cycle Costing approach in the building and HVAC sector



LCC can establish an interrelationship between planning and design decision where all assumptions are explicitly stated. During design stages, proper consideration of the cost-in-use aspects of a project is likely to benefit in terms of the formulation of optimal design solutions, materials selection, budgetary planning, long-term cost control and a framework for functional performance measurement (Figure 1.2).

Formally, the costs involved in a LCC analysis are the following (Figure 1.3):

Figure 1.3 – Components of ISO 15686-5 standard



The detailed costs in a general approach are the following:

CONSTRUCTION	***OPERATION***	***MAINTENANCE***	***END OF LIFE***
Professional fees	*Rent*	*Maintenance management*	*Disposal*

			inspections
Temporary works	*Insurance*	*Adaptation and refurbishment of the asset in use*	*Disposal and demolition*
Construction of asset	*Cyclical Regulatory Costs*	*Repairs and replacement of minor components / small areas*	*Reinstatement to meet contractual requirements*
Initial adaptation of refurbishment of asset	*Utilities*	*Cleaning*	
		Grounds maintenance	
		Redecoration	
Taxes	*Taxes*	*Taxes*	*Taxes*
Other	*Other*	*Other*	*Other*

Correctly implemented, LCC is a solution toward the sustainable development concept applied to buildings that minimize adverse impact and enhance economic and socio-cultural aspects.

It provides required functionality and performance of the system through a holistic life cycle approach:

- Design,
- Construction,
- Operation,
- Deconstruction.

Embedded in decision-making, LCC offers reasonable ways to the identification of improvement potentials, of win-win situations, of balanced solutions using not single-criteria priorities.

LCC as an economic evaluation method takes account of all relevant costs over the defined time horizon (period of study), including the adjustment for the time value of money (i.e. net present value, or internal rate of return, or payback period, if required).

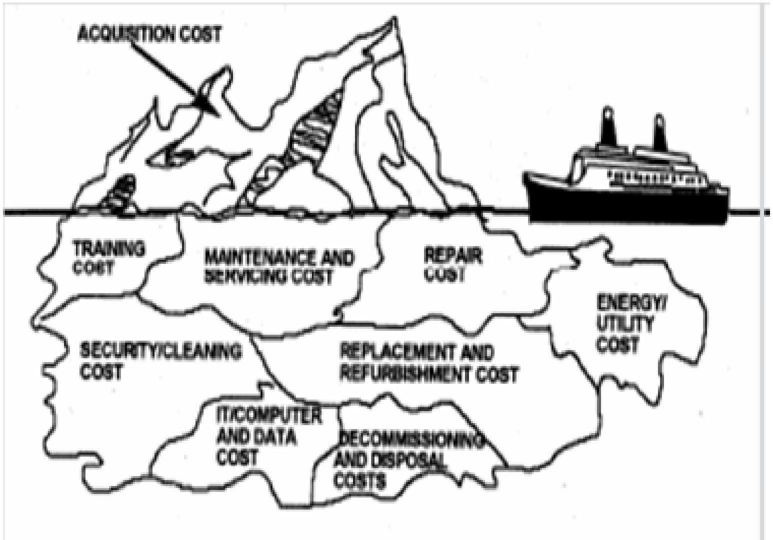
The LCC analysis is based on the calculation of the overall costs of project alternatives and selection of the design / solution / alternative that ensures the lowest overall cost consistent with the quality and function.

1.2 Why using Life Cycle Costing?

In the past, comparisons of asset alternatives, whether at the concept or detailed design level, have been based mainly on initial capital costs / acquisition costs.

Growing pressure to achieve better outcomes from assets means that ongoing operating and maintenance costs must be considered as they consume more resources over the asset's service life.

Figure 1.4 – All costs associated to the Life Cycle Cost approach



For example, the operating costs of a hospital consume an equivalent of the capital cost every two to three years and can continue to do so for forty years or more.

The operating costs of a school can consume the equivalent of its capital cost every four to five years and remain in service for a century.

Both the capital and the ongoing operating and maintenance costs must be considered wherever asset management decisions involving costs are made. This is the Life Cycle Cost approach.

Thus, Life Cycle Costing is a process to determine the sum of all the costs associated with an asset or part thereof, including acquisition, installation, operation, maintenance, refurbishment and disposal costs.

1.3 Life Cycle Costing Advantages and Disadvantages

The main benefit of life cycle costing is that, by forcing consideration of all costs, it could lead to wiser decisions. Cost of operations and maintenance outweigh acquisition / construction costs that are very often prevalent as a factor of selection among competing systems.

According to the UK Royal Academy of Engineering, in the building industry the **ratio 1:5:200** or even **1:10:200** is a "rule of thumb" (useful principle having wide application but not intended to be strictly accurate or reliable in every situation) that states that: if the initial construction costs of a building is 1, then its maintenance and operating costs over the life time years is 5 or even 10, and the business operating costs (salary of people working in that building) is 200.

Focussing the attention of the deciders on costs of different stages, LCC might lead to recognition of the need for new designs, new methods of operations or new maintenance policies.

LCC is useful in:

- Reducing the total cost;
- Making decisions associated with equipment replacement, planning and budgeting;
- Comparing the costs of competing project / solutions / alternatives;
- Making a selection among competing contractors and manufacturers;
- Controlling programs.

In contrast, some of the main disadvantages of life cycle costing include that it

- Is time consuming;
- Is costly;
- Uses data that may be uncertainly forecast;
- Is a trying task when attempting to obtain data for analysis.

1.4 Uncertainty and risks associated with LCC management

The parameters of the LCC analysis depend on the purpose and use of the intended results. LCC analysis should explicitly define the scope, level (multi asset or portfolio / estate level, single asset or whole building level, cluster level (multi element), elemental level, system level, component or more detail level) and period of analysis together with an anticipated level of uncertainty and risks relating to the LCC analysis.

In order to quantify uncertainty in the cost estimates, a sensitivity analysis must be conducted. The different costs are varied in a certain range (from -/+ X%) of the base case.

Life cycle costing deals with future costs that imply variability from predicted values or assumptions in:

- Capital costs (actual v predicted);
- Operational costs (annual expenditure provision v actual life cycle replacement plans);
- Interests, inflation, discounts, discount factors, prices escalation;
- Long term energy price escalation based on assumptions, strategies and global political decisions on fossil fuels;
- Costs of refurbishment / upgrades;
- Technology obsolescence;
- Environmental targets (e.g. new environmental legislation);
- Evolution of labour wages;
- Service lives predictions;

- Availability and robustness of cost and equipment performance data.

Finally, the risk of LCC analysis could be evaluated through the following assumptions:

- Who holds the life-cycle risk - prime vendor or contractor level;
- Hand-back requirements;
- Minimum elemental service lives;
- Clearing assumptions on LCC period;
- Level of financial fees and taxes that were included in LCC or not;
- IT was included in LCC or not;
- Redecoration cycles were included in LCC or not;
- Existing estate risks.

1.5 Applicable Directives, Standards, Rules

Directives

There is no a special EU Directive on LCC, but the **Directive 2014/24/EU**[1] on public procurement that repeals Directive 2004/18/EC extensively covers LCC of public procured equipment and services, including for shallow geothermal applications.

Standards

ISO 15686-5: 2008 Buildings and constructed assets – Service Life Planning – Part 5: Life-cycle costing[2]

The extended format of ISO/DIS 15686-5:2014 covers all the LCC aspects and is presented in Annex 2.

ASTM E917 Standard practice for measuring life-cycle costs of buildings and building systems

EN 15459 Energy performance of buildings – economic evaluation procedure for energy systems in buildings

EN 15643-4 Sustainability of construction works. Assessment of buildings. Framework for the assessment of economic performance;

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[1] A selection of LCC provisions from Directive 2014/24/EU is included in Annex I.
[2] The 2014 revision of this standard is up today (March 1st, 2015) only in draft format.

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CHAPTER 2 - LCC ANALYSIS IN THE EUROPEAN GSHP MARKET

2.1 Introduction

This section reviewed the LCC analyses of the ground source heat pump (GSHP) systems across the European market. In order to obtain a clear overview about the life cycle costs of the GHSP systems, the study considers only the part of a single system that cover: borehole heat exchanger, water source heat pump, installation, electrical and hydraulic works.

This analysis aims to investigate the impact of single costs, and in particular pinpoint costs caused by standards and regulations, related to the GHSP systems in family houses, office and public buildings by using several sources of information, such as scientific papers, project reports and databases on case studies about GHSP systems in Europe.

2.2 Economic aspects in the GSHP systems

The GSHP systems, also known as shallow geothermal or vertical close loop systems, exploit shallow (low enthalpy) geothermal energy for heating and cooling. These systems do not use directly the geothermal energy but employ a heat pump in order to reach the correct temperatures for heating and cooling, and to ensure a basic thermal comfort. Therefore, a GSHP system consists of:

- the heat source (vertical borehole heat exchanger);
- the heat generation;
- the heat distribution system;
- the domestic hot water system.

In some cases, there are other components that help the operation of system (traditional boiler, PV system, etc.) which works together in order to minimize the costs.

Before starting the analysis, the subsection below summarizes items costs associated with a GSHP system.

2.2.1 Relevant item costs for GSHP installation

The relevant costs related for GSHP installations can be classified into four categories:

1. ***Investment or capital cost***
   - 1.1. Purchase of underground material (i.e. collector etc.)
   - 1.2. Purchase of Heat Pump
   - 1.3. Purchase of other over ground/in house material (not Heat Pump)
   - 1.4. Ground work and drilling
   - 1.5. Building system installation of Heat Pump
   - 1.6. Other retrofitting, refurbishment of HVAC
   - 1.7. Technical Design, calculations/simulations
   - 1.8. Permit process (incl. basis and other doc.)
   - 1.9. Subsidies if not included in above costs
2. ***Annual and other periodic costs***
   - 2.1. Energy costs (electricity) or operating costs
   - 2.2. Energy Subsidies and energy taxed if not included above
   - 2.3. Heat pump maintenance and service (incl. legal required service such as yearly leakage detection or refrigerant tax)
   - 2.4. Other maintenance and service, rinsing of wells.
   - 2.5. Annual Legal permit costs: Environmental audit, environmental measurements, etc.
   - 2.6. Labour cost of normal system supervision.
   - 2.7. Other costs not included above.
   - 2.8. Cost for land use, groundwater water use.
3. ***Decommissioning and disposal costs***
   - 3.1. Scrapping of Heat Pump, incl. cost for destruction of refrigerant
   - 3.2. Dismantling of heat pump system
   - 3.3. Restoration of land

3.4. Other cost at end of use

4. ***Financial costs***

4.1. Loan cost (interest rate), same as for investment in building or other interest rate if investing in heat pump

4.2. Subsidy for heat pump (i.e. green loan)

The analysis of study about LCC of GHSP systems attempted to identify the above-mentioned categories of costs.

2.3 LCCA theory and current approach to GSHP economics

Generally, the objectives of LCC analysis in GSHP systems are:

a. to estimate the life-cycle cost of a shallow geothermal application with ground source heat pumps (GSHP) in a building;

b. to compare the LCC of different shallow geothermal design options in order to choose the best GSHP solution;

c. to compare the life-cycle cost of a shallow geothermal application to the life-cycle costs of conventional heating, ventilating, and air-conditioning (HVAC) systems.

The competing alternatives for shallow geothermal in a building HVAC system (conventional or renewable) could be:

- Air source heat pumps;
- Fuel Oil boiler heating system;
- Natural gas furnaces;
- Other fossil fuel based conventional H&C systems;
- Solar Heating & Cooling;
- Biomass or biogas heating;
- District Heating & Cooling;
- Electric Heating & Cooling;
- Different hybrid solutions (e.g. fossil & solar).

As a conclusion, the analysis allow to:

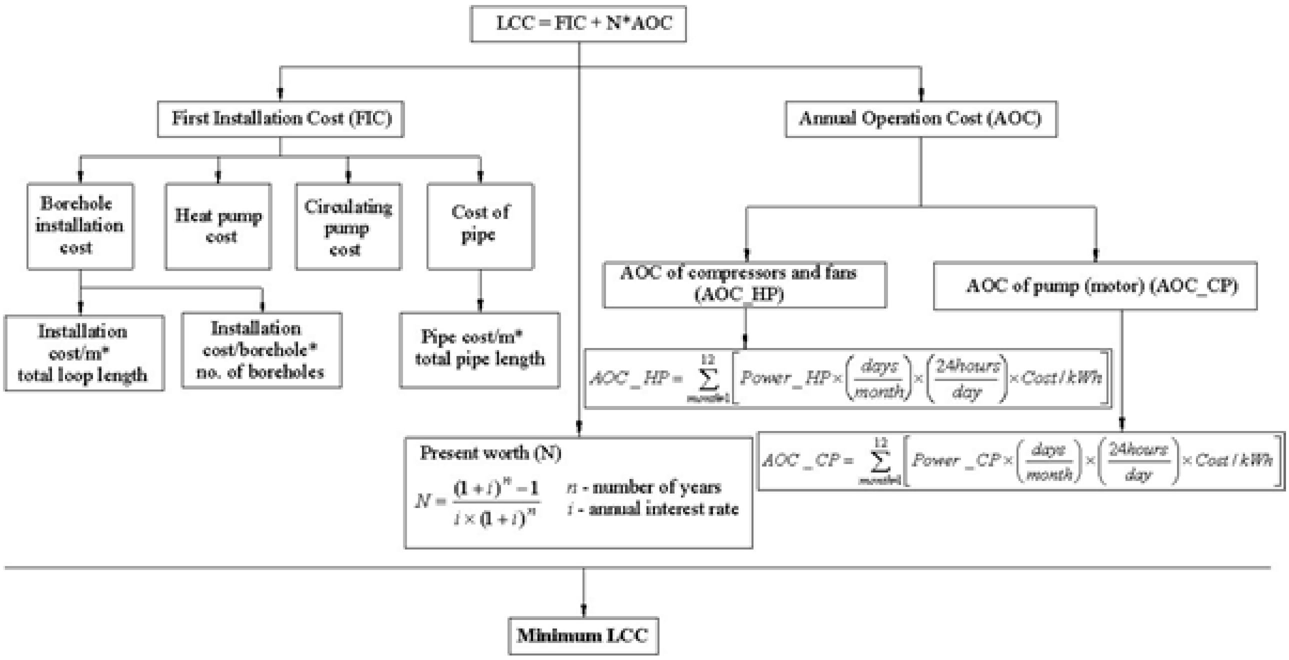
- Choose among (minimum) two mutually exclusive alternatives on the basis of lowest LCC;
- All alternatives must meet established minimum performance requirements;
- All alternatives must be evaluated using the same database, service date, study period and discount rate;
- Positive cash flows (if any) must be subtracted from costs;

- Effects not measured in quantified money must be either insignificant, uniform across alternatives or accounted for in some other way;
- Ranking of solutions depending on the emission of greenhouse gases is compulsory.

Bao Vu et al. (2013) propose a specific and advanced model of LCC to optimize the LCC of GSHP systems by taking into consideration the effect of pipe sizes and capacity of the heat pump for not only single U-type heat exchanger but also for double, triple U-type, and coil-type heat exchangers. This model is the evolution of previously publications in order to support the design of GSHP systems but also to simulate operation costs.

The figure 2.1 describes the components of the LCC equation and their relation, and covers the aspects related to a GSHP system. The equation consists of two main costs (first installation cost and annual operation cost), but overlooks the costs associated with standards and regulations.

Figure 2.1 - Components of life cycle cost analysis of a GSHP system (Asociación de productores de energías renovables, Análisis sectorial - Sector Geotérmico de Baja Entalpía, 2010)



Moreover, the studies on economic analysis of GSHP systems and LCC analysis have difficulty including and evaluating the risk of system underperformance and/or failure due to the uncertainty in actual demand loads (Garber et al., 2013).

Another aspect that it is crucial in the timeframe considered in the LCC analysis. According to the Directive 2010/31/EU, the LCC analysis should be performed for a 30-year calculation period. Longer calculation periods are not recommended, as beyond a 30-year timeframe, assumptions on interest rates and forecasts for energy prices become very uncertain. It is worthwhile to mention that no disposal costs are taken into consideration for components with lifetimes longer than the calculation period.

2.4 Review of the costs available

Since the LCC analysis considers the total "lifetime" cost to purchase, install, operate, maintain, and dispose of that equipment, the availability of economic data for each item cost is crucial. For this reason, it is interesting to verify the presence of economic data for each item cost associated with GSHP installations. GROUND-MED database allows the selection of six cases that contain information about costs.

The cases analysed differ in climate zone, type of building, year of construction and installation, but all of them use the same technology for HVAC (with different purposes: heating, cooling and/or domestic hot water). Table 2.1 shows the ratio of the costs associated with six GSHP installations. The analysis reveals that are easily available data about "investment cost" category.

In particular, the heat source (i.e. borehole, drilling, etc.) is the main cost of a GSHP system followed by heat pump and heat distribution. The data about domestic hot water system are not available in all six cases.

Unfortunately, there are not enough information to calculate lifetime costs that consist of investment cost, annual and other periodic costs, scrapping and recycling cost at the end of use, and financial costs.

Table 2.1 – Case studies from GROUND-MED database

Label and link	**Office building in Keratea**	**Two-family house in Pikermi**	**Metallurgic Research Centre**	**One-family house in Mölnlycke**	**Low energy house in Grafstal**
Country and year of installation	Greece, 2005	Greece, 2010	Spain, 2006	Sweden, 2004	Switzerland, 1998
Building type	Office building	family house	Office building	family house	family house
Purpose	Heating and cooling	Heating and hot water	Heating and cooling	Heating and cooling	Heating and hot water
Heat source [%]	29	35	61	41	25
Heat pump [%]	26	61	19	38	26
Heat distribution [%]	11	26	20	21	29
Domestic hot water [%]	34	9	n.a.	n.a.	7
Other costs [%]	n.a.	9	n.a.	n.a.	12
Pay-back time [years] (no subsidy)	n.a.	10	9,5	n.a.	n.a.

Another source of data related to only Spanish market is the analysis of the Asociación de productores de energías renovables that reports information about costs for (vertical or horizontal) GHSP system in a typical family house.

The data confirm the findings of cases collected in the GROUND-MED database, because drilling is the most important item cost associated with a GHSP installation (Table 2.2).

Table 2.2 – Analysis for a 150 m^2 Spanish family house in heating and hot water mode

Costs [€]	Vertical loop	Ratio	Horizontal loop	Ratio
Drilling	10000	50%	7000	41%
Heat pump	7500	38%	7500	44%
Hydraulics	2500	13%	2500	15%
Total cost	20000		17000	
Pay-back time [years]	5-15		5-15	
Lifetime [years]	20		20	

The next sections describe the studies about the assessment of costs associated with GSHP systems.

2.4.1 Capital or investment costs

Blum et al. (2011) analysed data from more than 1100 German residential GSHP systems and calculated that the average capital cost of a GSHP system is 23460 € with standard deviation of 6754 €. Another study reported capital costs for comparable GSHP systems, which range between 15300 € (Austria) and 23500 € (Switzerland).

Hence, the capital costs in Germany are similar to those in Switzerland but higher than other countries such as USA, Austria, Norway and Sweden (Rawlings and Sykulski, 1999). According to Rawlings and Sykulski (1999), USA, Canada and Sweden have low capital costs thanks to the economies of scale. Other factors that influence the capital cost are country-specific legal requirements and designs for the borehole heat exchanger such as backfilling (e.g. not required in Sweden).

Another study analysed a GSHP system in a new office building constructed in 2008 (Luo et al., 2013). The building, located in the city of Nuremberg in Southern Germany, has three floors and one basement with a total area of 1530 m^2. The borehole heat exchanger was constructed with eighteen boreholes that can be grouped into three blocks in accordance with borehole diameter: block I of 121 mm, block II of 165 mm and block III of 180 mm.

The capital costs of the borehole heat exchanger are appraised by the amount of money needed for accomplishing the project. The price of the main composites of the GSHP system, such as U-tube, heat pump and grouting material, are listed in accordance with the three borehole diameters (Block I-III) in Table 2.3. The main part of the capital costs for installation of the GSHP system is the drilling.

Table 2.3 - Main capital costs of the GSHP system in € (Luo et al., 2013)

Component	Block I	Block II	Block III
Drilling borehole	24000	24000	24000
Buried pipe	3131.4	3131.4	3131.4
Spacer	184.8	184.8	184.8
Grouting	1374.3	2555.52	3041.28
Heat pump	2666.67	2666.67	2666.67
Accessories[3]	666.67	666.67	666.67
Total	32023.84	33205.05	33690.81

De Carli et al. (2014) have considered the use of a GSHP for district heating and cooling in Italy. The study assessed energetic and economic aspects by including the density of population in the district where buildings are located. The energetic and economic analysis compared the traditional system with the innovative system. The traditional system consists of boilers, chimneys and split system air conditioners, while the innovative system is represented by four options:

- GSHP covering all heating, DHW and cooling loads (case HP);
- GSHP covering heating, cooling and DHW loads, coupled with thermal solar collectors (case HP - S);
- GSHP sized for cooling and used for the base load for heating, with additional boiler for meeting peak loads of heating and DHW (case HP - B);
- GSHP covering all heating, DHW and cooling loads, coupled with PV cells (case HP - PV).

The initial costs (i.e. capital costs and installation costs)[4] of innovative solutions are higher than traditional solutions (Table 2.4) confirming other studies, but required lower maintenance costs (see "annual costs" section).

These results are confirmed by another study that evaluates the benefits associated with the replacement of gas boilers with geothermal heat pumps in a single family house (180m²) in Kaunas, Lithuania (Zinevicius and Aleksandravicius, 2012). In particular, the study showed that investment costs of the GSHP amounted to 9372 €, compared to 1100 € for the gas boiler, whereas operating costs of the GSHP are lower than those of the gas boiler.

[3] Accessories contain water circulating pumps, connection pipes, air pressure tank and buffer storage tank.
[4] Our analysis includes installation costs in capital costs.

Table 2.4 - Initial costs in all cases considered (De Carli et al., 2014)

Cases study		Low district		Medium district	
		Initial costs		Initial costs	
		Innovative system [k€]	Standard system [k€]	Innovative system [k€]	Standard system [k€]
HP	Semi-detached house	35	21	–	–
	4 apartments building	35	32	–	–
	24 apartments building	–	–	251	118
	Sub-district A	624	364	1522	711
	Sub-district B	1262	728	2642	1421
	Entire district	1841	1092	3614	2132
HP + S	Semi-detached house	39	21	–	–
	4 apartments building	43	32	–	–
	24 apartments building	–	–	243	118
	Sub-district A	766	364	1587	711
	Sub-district B	1546	728	2844	1421
	Entire district	2267	1092	3897	2132
HP + B	Semi-detached house	34	21	–	–
	4 apartments building	44	32	–	–
	24 apartments building	–	–	198	118
	Sub-district A	554	364	1059	711
	Sub-district B	1052	728	1936	1421
	Entire district	1654	1092	2720	2132
HP + PV	Semi-detached house	52	21	–	–
	4 apartments building	52	32	–	–
	24 apartments building	–	–	326	118
	Sub-district A	865	364	1865	711
	Sub-district B	1609	728	3297	1421
	Entire district	2340	1092	4568	2132

Morrone et al. (2014) have been conducted a technical and economic feasibility study on residential buildings, heated and cooled by geothermal heat pumps (GHP) equipped with energy piles, considering 20 years of operation. The building considered for the evaluation of the GHP performance is a seven storey building, with a total heat transfer surface of 1609 m^2, a gross heated volume of 5991 m^3 and window surface of about 200 m^2.

The same building has been considered for two different climate zones: Naples, located in the South of Italy, with a number of Degree Days (DD) equal to 1034, and a winter external design temperature equal to 2.0°C, and Milan, North of Italy, with a number of Degree Days (DD) equal to 2404, external design temperature of -5.0°C.

The investment costs for GHP and traditional systems (i.e. boiler and air-to-air heat pumps) have been reported in Table 2.5. The investment cost of the GHP system is higher than traditional one.

Then, the study assesses the economic savings associated with GHP system and shows that the financial performance of the investment is strictly related to the geographical location. In particular, the economic profit of GSHP system is higher in cold climate such as Milan.

Table 2.5 - Investment costs (in euros) used for the economic evaluation of the systems (Morrone et al., 2014)

Investment costs	**Geothermal system [€]**	**Ratio [%]**	**Traditional system [€]**	**Ratio [%]**
Pipes	4000	15%	-	
Labour (installation costs)	3500	13%	-	
GHP machine	19000	72%	-	
Cooling machine	-		8500	55%
Boiler	-		7000	45%
Total	26500		15500	

Sarbu and Sebarchievici (2014) reviewed briefly the energy, economic and environmental performances of a closed-loop GSHP system and the advanced engineering applications of hybrid GSHP systems. The study reported the results of a LCC analysis about the application of fours design options for a building that has an area of 1486 m^2 and is located in a warm-climate region, Atlanta (cooling-dominated climate). This building is equipped with fifteen 10.5 kW extended range heat pumps. The four design options are:

- Case 1 uses low-efficiency heat pumps and a configuration borehole with a low thermal conductivity grout.
- Case 2 is similar to case 1 except that high-efficiency heat pumps are used.
- In Case 3, the borehole thermal resistance has been lowered by using a high thermal conductivity grout and spreading the pipes against the borehole wall.
- In Case 4, the ground heat exchanger length has been reduced and a closed-circuit fluid cooler is used in the fluid loop.

Table 2.6 shows numerical results. Case 4 (hybrid system) has the lowest investment cost followed by Case 3. The main difference between these two cases is related to the borehole costs. Even though Case 4 has the cost of fluid cooler (8080 €), Case 3 requires higher borehole costs than Case 4.

Table 2.6 - Comparative numerical results of analysed solutions (Sarbu and Sebarchievici, 2014)

Specifications	**Case 1**	**Case 2**	**Case 3**	**Case 4**
GHE details:				
Heat Pump efficiency	Low	High	High	High
Hybrid system	No	No	No	Yes
Borehole thermal resistance, R_b [(mK)/W]	0.2	0.2	0.09	0.09
Bore field configuration	5×5	5×5	5×4	5×4
Total GHE length, L[m]	3165	2980	2280	1500
Annual energy consumption, in kWh:				

Heating annual performance factor, SPF	4.03	5.65	5.65	5.8
Cooling annual performance factor, SPF	3,86	5,44	5,44	4,89
Heat pumps	47730	34440	34440	37580
Fluid cooler	–	–	–	420
Costs, in €:				
Boreholes	79855 (74%)	75213 (66%)	75213 (66%)	41630 (47%)
Heat pumps	27690 (26%)	38080 (34%)	38080 (34%)	38080 (43%)
Fluid cooler	–	–	–	8080 (9%)
Total investment cost	107545	113293	113293	87790
Operation energy cost (for 20 years)	39160	28252	28252	30830
Total costs	**146.705**	**141.545**	**129.814**	**118.620**

2.4.1.1 Installation and commissioning costs

Garber et al. (2013) highlighted that installation costs are the major component of capital costs of GSHP system. Therefore, it is important that the ground heat exchanger (GHE) is sized correctly in order to minimize costs and improve system efficiency. As illustrated by Blum et al. (2011) oversizing the GSHP systems increases the installation costs for minor savings in operating costs.

On the other hand, undersizing the system increases the electric needs to satisfy the heating requirements, as the vertical or horizontal ground loops run colder and face heat recovering problems.

Commissioning cost is another component of costs, but there is a lack of studies about it.

2.4.1.2 Regulations and legal permit costs

Since there is a lack of studies about costs associated with permit procedures, standards and regulations for GHSP systems. For this reason, this report uses the information collected by the Deliverable 2.4 "Evaluation of technical standards to improve the LCC of SGE systems" and by European practitioners.

France

In France, even if it is not designed specifically for it, a legal framework exists to manage shallow geothermal energy (SGE). This framework essentially consists of the mining code and the environment code. The realization of drillings is legally supervised by the mining code and, groundwater exploitation by the environment code.

When license is needed, it could be expensive and need time (Necessary feasibility studies).

Germany

Cost for permits can be divided into the following categories:

- basic administrative fees,
- mandatory cost (e.g. for geological information provided by authority, mandatory investigations, etc.),
- cost for preparation of application for permit,
- any further cost that might arise during individual evaluation by authorities (e.g. expert statements of geological survey) and additional investigations imposed.

There are also cost associated with the technical standards "sensu strictu", i.e. some increase in cost over systems not complying with the standards; however, this cost is deemed to be necessary to ensure a reliable product. The SGE sector has to ensure compliance with technical standards in order to build a long-term, stable industry with good reputation.

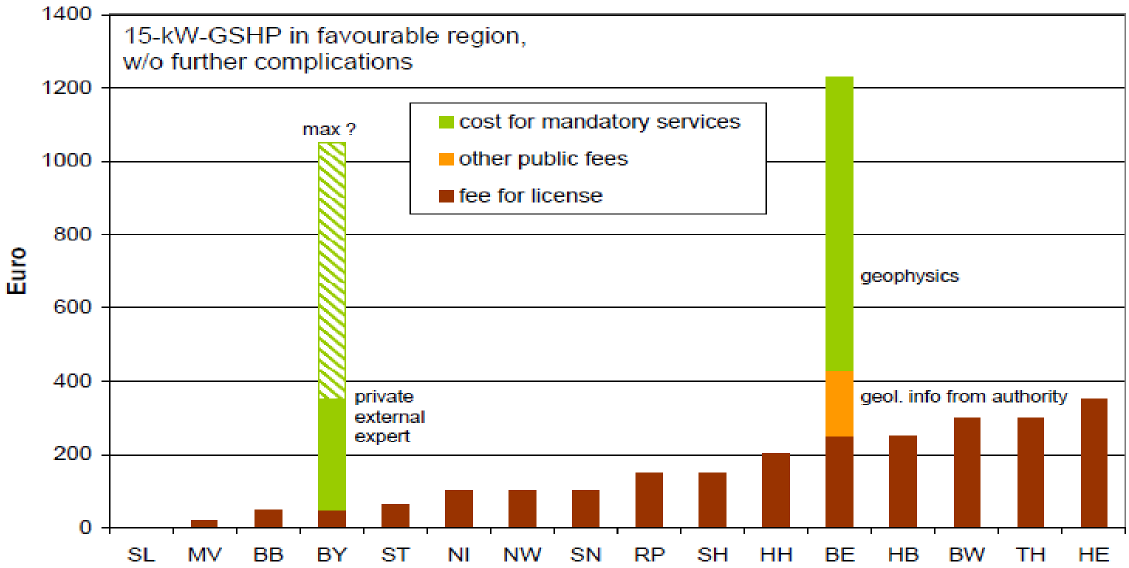
Questionable items are more found with state permitting guidelines and their practical use. Often they are not written explicitly in the documents, but can be experienced in the practical use of those guidelines by the administration. Changing standards does not seem to be of help here, as the administrative practice would have to be changed instead.

A comparison of fees and mandatory permitting cost is shown in Figure 2.2 (numbers do not include cost for preparation of the applications, and further cost as stated above)[5]. The analysis appraises fees and mandatory permitting costs for a GSHP of 15 kW heating output in German states. Hessen has the highest basic administrative fee (almost 400 €), whereas Berlin has the highest permitting costs including costs for licence fee, geophysics analysis and (mandatory) geological information from authorities.

Figure 2.2 - Germany - Permitting cost for a GSHP of ca 15 kW heating output in German states – basic administrative fee and additional mandatory cost (from Regeocities D2.1, Report on regulatory situation for Germany, Oct. 2012)[6]

[5] For more information about extra costs see Annex 3.

[6] The abbreviations for the states are given in the Table B of annex 3.



As an average, cost of about 400 € (250 € administrative fee and cost, 150 € for preparation of application) can be assumed for a single family house. For larger buildings the fees are increasing in most states, and preparation and investigation cost are raising substantially due the higher detail required. For use in theoretical comparison, a formula of y = 12 x + 280 might be applied, with y the cost in € and x the installed capacity in kW.

A considerable problem is the uncertainty of cost. While in the majority of cases it will be in the range stated above, there are notable exceptions with permitting cost exceeding 20% of the installation cost. Examples include a GSHP with 30 kW, where an additional monitoring well was required by the authority (also adding some 2000 € annually for monitoring and measurements in this well), or another installation in the same size range, where the required distance to the boundary of the lot could not be respected, and hence some 6000 € in mining fees were imposed.

The Netherlands

A permit application has to include a study of the effects that the system will have on the environment.

For a Borehole Thermal Energy Storage (BTES) system, the thermal influence of the system has to be provided in the registration or permit procedure. In some cases, the owner or installer will calculate these effects. In other cases, the help of a consultant will be asked. The average costs for ther calculation on these thermal influences are 500 tot 5.000 €, depending on the size of the system (residential to office building)

Municipalities are not allowed to ask for fees for the processing of registrations and permits.

For BTES systems, the monitoring costs are limited for residential systems, since the monitoring requirements are limited.

Sweden

For closed loop systems with heat pump, the Swedish code of law gives the municipalities right to decide if and where a permit from the municipality is required, if the installation is below 10 MW. Therefore, every municipality makes their own interpretation of necessary requirements to fulfil the law. Accordingly, the price for notification or permission varies among the municipalities likewise the waiting time to get a permit from a few days to a few months. For instance, grouting is sometimes required and sometimes not, also for identical underground conditions.

2.4.2 Annual costs

2.4.2.1 Energy costs or operating costs

The cost of energy constitutes an important component of annual costs associated with GSHP systems. The cost of energy is calculated as a function of the electric power installed and the energy consumed. According to De Carli et al. (2014), the presence of rates proportional to the energy consumption is an obstacle to the development of heat pumps. A possible solution could be the adoption of fixed rates for consumers who use heat pumps. De Carli et al. (2014) highlight the positive effect of lower energy costs on the payback time.

Sarbu et al. (2014) calculated the operation energy cost (lifetime 20 years) for the four cases reported in Table 6. Case 1 has a much higher present value of 20 years than the three other cases that use high-efficiency heat pumps, because this case uses low-efficiency heat pumps. Therefore, the choice of type of heat pump influences (the level of efficiency) strongly the energy costs related to the GSHP system.

Desideri et al. (2011) estimated operating costs of GSHP system with a power output for winter heating of 29 kW consistent with the winter heat demand of 26.5 kW by taking into account energy costs and winter operating costs (Table 2.7). The winter operating cost are 750 €, whereas to satisfy the same heat demand using natural gas boilers[7] the yearly operating cost is approximately 2100 €. Therefore, GSHP system is cheaper than natural gas boilers.

Zinevicius and Aleksandravicius (2012) evaluated the operating costs of the GSHP and those of the gas boiler. With a coefficient of performance

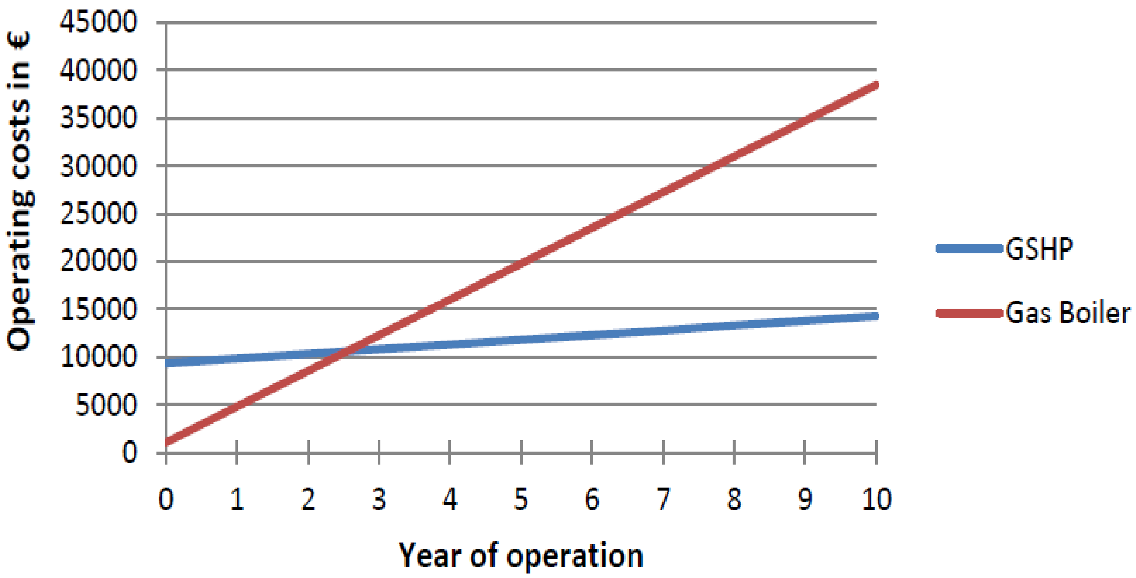
[7] The combustion efficiency is assumed close to 0.9 and is requires 3400 Nm^3 of natural gas. The annual maintenance costs are approximately 50 € and the natural gas cost is 0.61 €/Nm^3.

(COP) of 3.95, the GSHP had a heating capacity of 13 kW and of 24 kW for the gas boiler. Between the months of October and April, the average ambient temperature was as low as - 4.64°C. The operating costs of the GSHP (494 €/year) are lower than those of the gas boiler (3735 €/year). Figure 2.3 depicted that the gas boiler becomes more expensive than the GSHP after less than 3 years of operation.

Table 2.7 – Winter operating costs of the ground source heat pump (Desideri et al., 2011)

Electrical Energy Demand [kWh]	Electrical Energy Cost [€/kWh]	Winter Operating Costs [€]
4257	0.165	747

Figure 2.3 - Comparison of the operating costs of a ground source heat pump and of a gas boiler in a single-family house in Lithuania (Zinevicius and Aleksandravicius, 2012)



Therefore, the above-mentioned studies showed that operating costs of GSHP systems are lower than costs of conventional systems. This evidence is confirmed if energy prices for electricity are not too high. Recently, Germany has observed an increase of energy prices for electricity. This situation has virtually eliminated annual savings in GSHP installations in single-family houses. In Germany, this type of houses rarely has cooling demand, so just heating and DHW are provided. A comparison of the annual energy cost for a house with 15 kW maximum heat demand and annual heat demand of 22.5 MWh elucidates this problem. In Figure 2.4, the annual cost are shown for a condensing gas boiler, a fuel oil boiler, and GSHP installations with different efficiency (expresses as seasonal performance factor, SPF).

The prices used in the comparison are assessed through several web-based price-finding tools, and show the range of prices as to different suppliers and tariffs. The cost shown do include all legal levies and taxes.

The liberalisation in the power and gas market allows for selecting the cheapest supplier, and in particular with natural gas, the variation is considerable. In the fuel oil market, the actual range for the day was not so big, however, the price is very volatile over time and thus the fuel oil cost shown may not be valid in a few weeks time. Consumers with oil boilers tend to observe the development and to order a fill of their oil tank when they deem the price at a low.

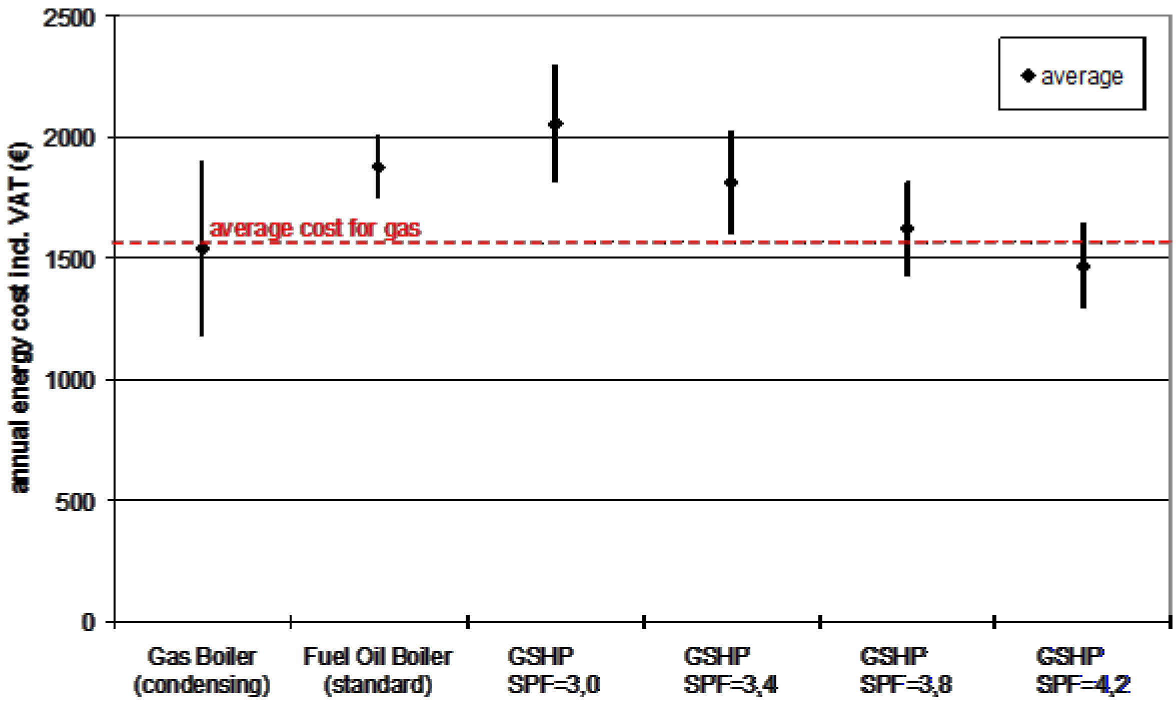
In May 2015, the average electric power price was so high (or, in a different view, the natural gas price was so low), that only very efficient GSHP had lower annual energy cost than a condensing gas boiler (Figure 2.4).

Under the circumstances shown in Figure 2.4, a return of the additional investment into the energy-saving GSHP installation can hardly be expected. While this is a severe barrier for GSHP in the residential market, the situation is much better for non-residential installations due to several factors:

- a substantial cooling demand in most commercial, institutional and industrial buildings
- shallow geothermal cooling can be very cost-effective
- conventional cooling is also affected by high electricity prices

A comparison like above for the non-residential sector cannot be made, as each system is quite individual, and for larger costumers the prices for energy are negotiated on individual basis and thus can diverge substantially from the prices private consumers pay.

Figure 2.4 – Annual energy cost (incl. VAT) for heat in a single-family house in the region of Frankfurt/Main, showing the price range on the market as to several web-based price-finding tools (own elaboration)



2.4.2.2 Maintenance costs

De Carli et al. (2013) simulated the running and maintenance costs by using TRNSYS and EED 3.0 software. The results show that innovative systems require lower running and maintenance costs than traditional ones (Table 2.8).

Table 2.8 - Running and maintenance costs in all cases considered (De Carli et al., 2013)

Cases study		Low district		Medium district	
		Running and maintenance costs		Running and maintenance costs	
		Innovative system [k€]	Standard system [k€]	Innovative system [k€]	Standard system [k€]
HP	Semi-detached house	2	2	–	–
	4 apartments building	2	3	–	–
	24 apartments building	–	–	10	13
	Sub-district A	19	35	39	73
	Sub-district B	34	70	74	145
	Entire district	51	105	113	218
HP + S	Semi-detached house	1	2	–	–
	4 apartments building	2	3	–	–
	24 apartments building	–	–	8	13
	Sub-district A	15	35	36	73
	Sub-district B	30	70	71	145
	Entire district	45	105	106	218
HP + B	Semi-detached house	2	2	–	–
	4 apartments building	2	3	–	–
	24 apartments building	–	–	11	13
	Sub-district A	24	35	24	73
	Sub-district B	47	70	82	145
	Entire district	67	105	67	218
HP + PV	Semi-detached house	1	2	–	–
	4 apartments building	0	3	–	–
	24 apartments building	–	–	4	13
	Sub-district A	2	35	2	73
	Sub-district B	4	70	0	145
	Entire district	5	105	–37	218

2.4.3 Decommissioning and disposal costs

There are not data yet about decommissioning and disposal costs for these type of HVAC systems.

For Germany, the standards and guidelines require the borehole heat exchanger to be cleaned of any hazardous material (antifreeze) and to be sealed, while for the heat pump, the refrigerant has to be removed and safely disposed of. For the heat pump the relevant national legislation according to Directive 2002/96/EC (WEEE-Directive) might apply, which in Germany for private owners would mean a virtually free disposal; however, the relevant lists and definitions are not clear, and so this may concern small units only.

2.5 Overarching vision

The review of studies about the assessment of costs associated with GSHP systems confirms the difficulty collecting data about commissioning costs, regulations and legal permit costs, and decommissioning and disposal costs. The lack of data are linked to the complexity of estimating these costs because they are undefined in the early stage of stages of the asset life.

Moreover, the analyses that integrate more item costs permit a cost-effective comparison between GSHP systems and other technologies. An example is represented by a study of ASUE (an association funded by the German natural gas utilities), then adapted by EGEC, for appraising different modern heating types in a residential house with 150 m^2 floor area and the up-to-date insulation standards in force in Germany.

The study calculates the full cost of heat, including the capital cost, energy cost, and operating and maintenance cost for a certain standard building. The values in the study are given in €/year for the standard building, including all taxes, and take into account storage for hot water and the heat distribution system; this explains the rather high values when compared with simpler assumptions.

Figure 2.5 shows that, except for conventional and geothermal district heating, GSHP system has lower full cost of heat than natural gas, LPG and fuel oil.

Figure 2.5 – Full heat cost of a residential house in Germany (EGEC, 2012)

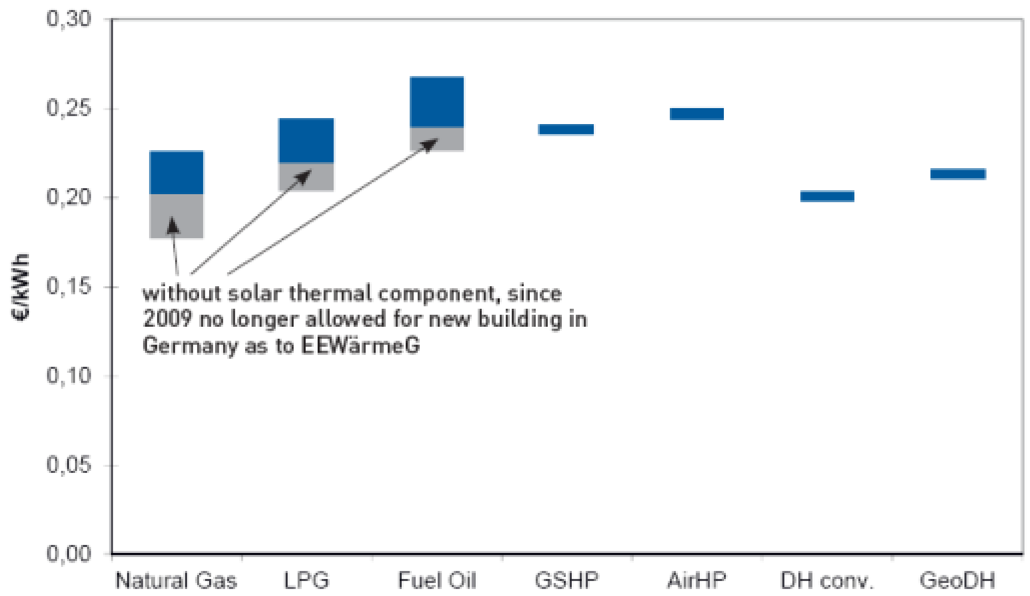
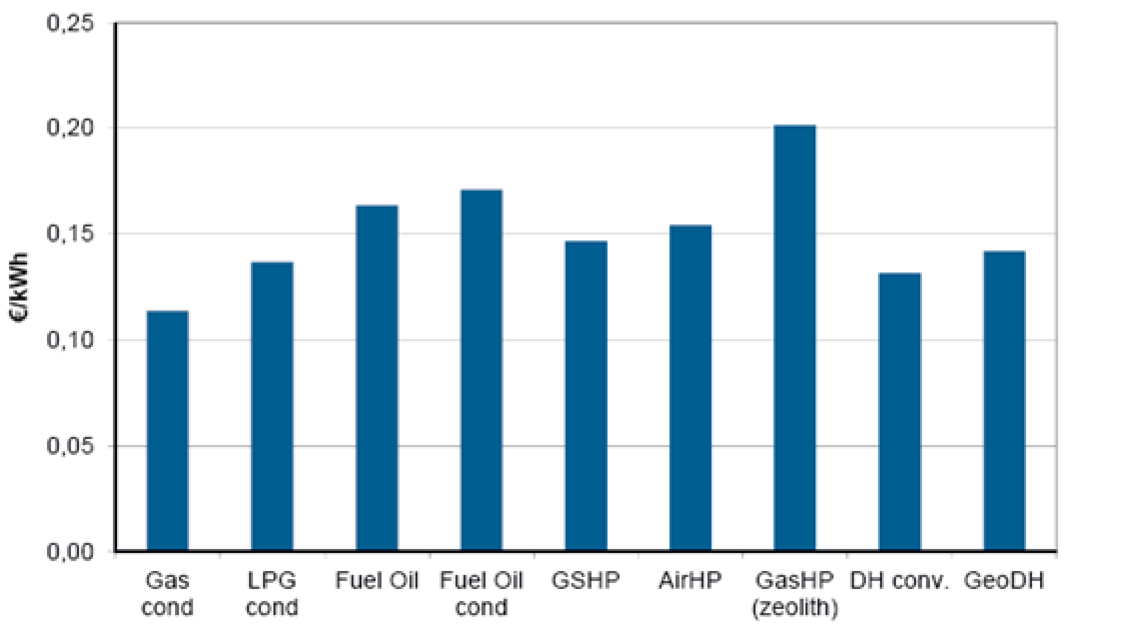


Figure 2.6 shows the values of full heat cost without VAT and without heat distribution and hot water storage in order to better compare the different technologies in a European perspective. This estimation confirms the convenience of GSHP system (except for conventional and geothermal district heating) compared to other technologies that use fossil fuels.

Figure 2.6 – Full heat cost for a residential house in (EGEC, 2012)



This study demonstrates the importance of adopting a LCC approach in the assessment of possible technological options for heating and cooling in order to take into account all item costs.

2.6. Conclusions

- The report reviewed the studies about LCC analyses of GSHP systems in Europe in order to investigate the impact of single costs and in particular permitting costs caused by standards and regulations.
- The major costs of GSHP system are capital or investment costs that are mainly influenced by the drilling that forms the heat source, one of the most important component of GSHP system, and in general by installation costs.
- The analysis of regulations and legal permit costs in some European countries (France, Germany, The Netherlands and Sweden) showed the difficulty of estimate exact costs because the cost of study about the effects that the GSHP system will have on the environment is influenced by contextual factors, administrative fees vary at local level and in some countries municipality can ask some requirements to fulfil the law that produce extra costs.
  - Then, the review of studies highlighted that the capital costs (including or excluding installation costs) of solutions with GSHP system are higher than traditional solutions, but these high initial costs are balanced by lower maintenance and operating costs (if there are low electricity prices and high-efficiency heat pumps). Therefore, the analysis confirms that the assessment of investments

without a life-cycle costing approach jeopardises the selection of cost-effective technological solution for heating and cooling, such as GSHP system.

- A detailed analysis of costs can also support policy makers in the development of more effective regulations, guidelines and standards for the promotion of SGE systems and in particular GSHP systems. In fact, regulations, guidelines and standards have to support civil servants involved in the permitting procedures in order to guarantee environmental protection and technical reliability of GSHP systems, but they have to establish cost-effective requirements balanced to the characteristics of GSHP system without imposing useless extra costs.
- Moreover, an analysis according to life-cycle costing approach can identify all phases and their criticality related to GSHP systems. For instance, it is very useful to collect economic data about decommissioning and disposal costs in order to improve and support the management of this phase. Then, a LCC analysis gives investors and policy makers the opportunity to understand better the characteristics of GSHP systems compared with other technologies.

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Appendix

Annex 1

DIRECTIVE 2014/24/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 26 February 2014

on public procurement and repealing Directive 2004/18/EC

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Subsection 3

Award of the contract

Article 67

Contract award criteria

1. Without prejudice to national laws, regulations or administrative provisions concerning the price of certain supplies or the remuneration of certain services, contracting authorities shall base the award of public contracts on the most economically advantageous tender.

2. The most economically advantageous tender from the point of view of the contracting authority shall be identified on the basis of the price or cost, using a cost-effectiveness approach, such as life-cycle costing in accordance with Article 68, and may include the best price-quality ratio, which shall be assessed on the basis of criteria, including qualitative, environmental and/or social aspects, linked to the subject-matter of the public contract in question. Such criteria may comprise, for instance:

(a) quality, including technical merit, aesthetic and functional characteristics, accessibility, design for all users, social, environmental and innovative characteristics and trading and its conditions;

(b) organisation, qualification and experience of staff assigned to performing the contract, where the quality of the staff assigned can have a significant impact on the level of performance of the contract; or

(c) after-sales service and technical assistance, delivery conditions such as delivery date, delivery process and delivery period or period of completion.

The cost element may also take the form of a fixed price or cost on the basis of which economic operators will compete on quality criteria only.

Member States may provide that contracting authorities may not use price only or cost only as the sole award criterion or restrict their use to certain categories of contracting authorities or certain types of contracts.

3. Award criteria shall be considered to be linked to the subject-matter of the public contract where they relate to the works, supplies or services to be provided under that contract in any respect and at any stage of their life cycle, including factors involved in:

(a) the specific process of production, provision or trading of those works, supplies or services; or

(b) a specific process for another stage of their life cycle,

even where such factors do not form part of their material substance.

4. Award criteria shall not have the effect of conferring an unrestricted freedom of choice on the contracting authority. They shall ensure the possibility of effective competition and shall be accompanied by specifications that allow the information provided by the tenderers to be effectively verified in order to assess how well the tenders meet the award criteria. In case of doubt, contracting authorities shall verify effectively the accuracy of the information and proof provided by the tenderers.

5. The contracting authority shall specify, in the procurement documents, the relative weighting which it gives to each of the criteria chosen to determine the most economically advantageous tender, except where this is identified on the basis of price alone.

Those weightings may be expressed by providing for a range with an appropriate maximum spread.

Where weighting is not possible for objective reasons, the contracting authority shall indicate the criteria in decreasing order of importance.

Article 68

Life-cycle costing

1. Life-cycle costing shall to the extent relevant cover parts or all of the following costs over the life cycle of a product, service or works:

(a) costs, borne by the contracting authority or other users, such as:

(i) costs relating to acquisition,

(ii) costs of use, such as consumption of energy and other resources,

(iii) maintenance costs,

(iv) end of life costs, such as collection and recycling costs.

(b) costs imputed to environmental externalities linked to the product, service or works during its life cycle, provided their monetary value can be determined and verified; such costs may include the cost of emissions of greenhouse gases and of other pollutant emissions and other climate change mitigation costs.

2. Where contracting authorities assess the costs using a life- cycle costing approach, they shall indicate in the procurement documents the data to be provided by the tenderers and the method which the contracting authority will use to determine the life-cycle costs on the basis of those data.

The method used for the assessment of costs imputed to environmental externalities shall fulfil all of the following conditions:

(a) it is based on objectively verifiable and non-discriminatory criteria. In particular, where it has not been established for repeated or continuous application, it shall not unduly favour or disadvantage certain economic operators;

(b) it is accessible to all interested parties;

(c) the data required can be provided with reasonable effort by normally diligent economic operators, including economic operators from third countries party to the GPA or other international agreements by which the Union is bound.

3. Whenever a common method for the calculation of life- cycle costs has been made mandatory by a legislative act of the Union, that common method shall be applied for the assessment of life-cycle costs.

A list of such legislative acts, and where necessary the delegated acts supplementing them, is set out in Annex XIII. The Commission shall be empowered to adopt delegated acts in accordance with Article 87 concerning the update of that list, when an update of the list is necessary due to the adoption of new legislation making a common method mandatory or the repeal or modification of existing legal acts.

Annex 2: Contents of ISO 15686-5 standard

ISO/DIS 15686-5:2014(E)

Contents

Page

Annex 3:

Table A - Administrative requirements adding cost to the permitting process in Germany

When	What	Where
As part of submission of the application for permit	Mandatory geological information / exploration with extra cost	*Berlin*: minimum ca. 180 €. *Bavaria*: prognosed cross section and expert opinion by Privatwirtschaftliche(r) Sachverständige(r) Wasserwirtschaft (PSW), namely a registered private expert. *Hamburg*: written opinion of Geological Survey (geological opinion may also be requested in other states, case-by-case). *Sachsen*: information from mining authority in old mining areas, ca. 40 €.
	Mandatory TRT	*Hessen*: often with projects >30 kW. *Baden-Württemberg*: larger projects.
	Modelling of temperature field	Regularly in Berlin, locally also in other states (e.g. Baden-Württemberg und Hessen)
During review of application	Opinion of geological survey, with extra cost	*Hessen*: always in „unfavourable“ areas , minimum ca. 200 €. *Hamburg*: minimum ca. 100 €.
With granting of permit	License fee	Between 0 € und 350 € for projects <30 kW (depending on state), with larger projects higher (in Hessen capped at 3000 €).
During drilling	Supervision by own geologist (drilling company)	Regularly in Baden-Württemberg, Bayern, Hessen, Rheinland-Pfalz, Sachsen-Anhalt, Sachen and Thüringen.
	Supervision by third-party geologist/expert/PSW	Often in Baden-Württemberg, Bayern and Hessen, sometimes in Hamburg and Nordrhein-Westfalen.
	Supervision by public administration	*Berlin*: by city authority (Senat).
After first drilling	Geophysical log	*Berlin*: mandatory Gamma-Log, up to 1000 € (for projects >30 kW one log per 1000 m^2).
Commissioning	Check and report by external expert/PSW	*Bayern*: mandatory by PSW. Often In Baden-Württemberg, in other states only in few cases.
	Check by public administration	Regularly In Berlin, sometimes in other states also.
	Initial check and regular repeated checks	In all of Germany with commercial projects. Hessen: now often required also for residential projects, other states seems to be willing to follow that example.
Monitoring	Heat flows at the ground side	Requirement with larger projects or in „unfavourable areas“ (e.g. in Hessen).
	Temperatures	*Berlin*: temperature measurement in the underground with larger projects (sometimes even requiring additional monitoring boreholes), can also be made an obligation in Hessen, Baden-Württemberg and Nordrhein-Westfalen at a case-by-case basis.
	Chemical analysis of groundwater	With large water-water-projects (GSHP or Aquifer Thermal Energy Storage), in Hessen

		sometimes also with BHE-projects (samples from additional monitoring well, e.g. in Frankfurt).
	Monitoring of SPF / SCOP	Only known as obligation regionally in Hessen.

Table B - State abbreviations for Germany

Abbreviation	State
BB	Brandenburg
BE	Berlin
BW	Baden-Württemberg
BY	Bayern
HB	Bremen
HE	Hessen
HH	Hamburg
MV	Mecklenburg-Vorpommern
NI	Niedersachsen
NW	Nordrhein-Westfalen
RP	Rheinland-Pfalz
SH	Schleswig-Holstein
SL	Saarland
SN	Sachsen
ST	Sachsen-Anhalt
TH	Thüringen

Contribution to the Covenant of Mayors Sustainable Energy Action Plans (SEAPs):

5.2 Analysis of existing Sustainable Energy Action Plans (SEAPs) from Cities

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May 2015

Analysis of existing Sustainable Energy Action Plan (SEAP) from Cities

1 Introduction

This report carried out the analysis of Sustainable Energy Action Plan (SEAP) that is a voluntary energy planning document which each city or town or group of towns joining the Covenant of Mayors (COM) initiative must draw up. In 2008, the COM initiative was launched by European Commission in order to endorse and support the efforts deployed by local authorities in the implementation of sustainable energy policies[8]. In particular, signatories commit to a minimum CO2 emission reduction target of 20 % by 2020 and define the actions they need to put in place to reach their commitment. The SEAPs foresee actions in different sectors:

- Buildings, equipment/facilities and industries;
- Transport; Local electricity production;
- Local district heating/cooling, Combined Heat and Power systems;
- Land-use planning;
- Public procurement of products and services;
- Working with the citizens and stakeholders;
- Other sectors.

At the time of the beginning of the analysis in January 2014, 3628 SEAPs were submitted. Of these 56 set strategy and measures for fostering the development of shallow geothermal energy for thermal purposes. This report analysed 47 SEAPs[9] which are publicly available on the website of the Covenant of Mayors (Table 1). Even though the number of SEAPs with measures for the promotion of shallow geothermal energy for thermal purpose is small, we have decided to analyse them because shallow geothermal energy is an effective, but not common options within renewable energy sources for heating and cooling. Therefore, the analysed SEAPs can provide a support for the adoption of shallow geothermal energy systems within actions for the development of renewable energy sources and energy efficiency.

[8] Joint Research Centre, 2013. The Covenant of Mayors in Figures 5-Year Assessment. Luxemburg. See: http://edgar.jrc.ec.europa.eu/com/JRC-CoM_in_Figure-WEB_version.pdf

[9] The following SEAPs are not publicly available: Dunkerque Grand Litoral, Essen, Milos (Aegean Islands), Portugalete, San Sebastián – Donostia, Sant Cugat del Vallés, Santa Perpetua de Mogoda, Satu Mare and Tiana.

Table 1 – Sustainable Energy Action Plans with strategy and/or actions for shallow geothermal energy for thermal uses available on the website of the Covenant of Mayor (January 2014)

Municipality or group of municipalities	Country	Region
Banja Luka	Bosnia Herzegovina	Banja Luka
Gradiska	Bosnia Herzegovina	Banja Luka
Bonn	Germany	KreisfreieStadt
Eggenfelden	Germany	Niederbayern
Frankfurt	Germany	Germany
Hamburg	Germany	Hamburg
Hannover	Germany	Hannover
Köln	Germany	Nordrhein-Westfalen
Vaterstetten	Germany	Oberbayern
Willich	Germany	Düsseldorf
Worms	Germany	Rheinhessen-Pfalz
Copenhagen	Denmark	Hovedstaden
Alella	Spain	Cataluña
Caldes d’Estrac	Spain	Cataluña
Igualada	Spain	Cataluña
Irun	Spain	País Vasco
Paterna	Spain	ComunidadValenciana
Piera	Spain	Cataluña
Pujalt	Spain	Cataluña
Sant Quirze del Valles	Spain	Cataluña
Santa Coloma de Gramanet	Spain	Cataluña
Taradell	Spain	Cataluña
Paris	France	Île de France
Poissy	France	Île de France
Nisyros	Greece	ΝότιοΑιγαίο (NotioAigaio)
Abbiategrasso	Italy	Lombardia
Canegrate	Italy	Lombardia
Castel Mella	Italy	Lombardia
Cesano Boscone	Italy	Lombardia
Comunità Pioniera del Marghine	Italy	Sardegna
Comunità Pioniera del SECS	Italy	Sardegna
Forlì	Italy	Emilia Romagna
Maranello	Italy	Emilia Romagna
Mirandola	Italy	Emilia Romagna
Poncarale	Italy	Lombardia
Rescaldina	Italy	Lombardia
Romano di Lombardia	Italy	Lombardia
San Possidonio	Italy	Emilia Romagna
Sassuolo	Italy	Emilia Romagna
Settala	Italy	Emilia Romagna
Vanzaghello	Italy	Lombardia
Vignate	Italy	Lombardia
Nadlac	Romania	Sud-Vest Oltenia
Genève	Switzerland	Lake Geneva region
Karşıyaka	Turkey	İzmir
Bath and North East Somerset	United Kingdom	Dorset and Somerset

Cornwall Council	United Kingdom	Cornwall and Isles of Scilly

The majority of SEAPs (28) are developed in municipalities or group of municipalities with less than 50,000 inhabitants. 8 SEAPs are drawn in municipalities with more than 100,000 and less than 500,000 inhabitants (Table 2). These results show that SEAPs were adopted by small municipalities.

Table 2 – Sustainable Energy Action Plans with strategy and/or actions for shallow geothermal energy for thermal uses per size of municipalities

Size of Municipality (or group of municipalities) –inhabitants	**Number of SEAPs**
< 50000	28
50,001 – 100,000	4
100,001 – 500,000	8
500,001 – 1,000,000	4
> 1000,000	3
Total	**47**

2 Organizational collaborations

The process for the design of SEAP can be complex. Therefore, some municipalities (15) declared to be supported in the design of strategy and actions for the SEAP by public authorities, research centres, universities, associations, firms and other municipalities (Figure 1). These collaborations provide know-how, knowledge, economic and human resources in order to achieve the purposes of SEAPs:

"*In cooperation with NGO organize workshops and round tables on topic of reduction of emission of greenhouse gases and measures which citizens can apply themselves in order to achieve energy efficiency in their own home*" SEAP Gradiska (Bosnia Herzegovina)

"*The City of Paris will initiate talks with the banking networks operating in Paris, as well as with other players directly involved, such as the regional authority, the State (ANAH, ADEME, etc.) and the Paris chamber of commerce and industry, with the aim of facilitating investments in the renovation of old buildings*." SEAP Paris (France)

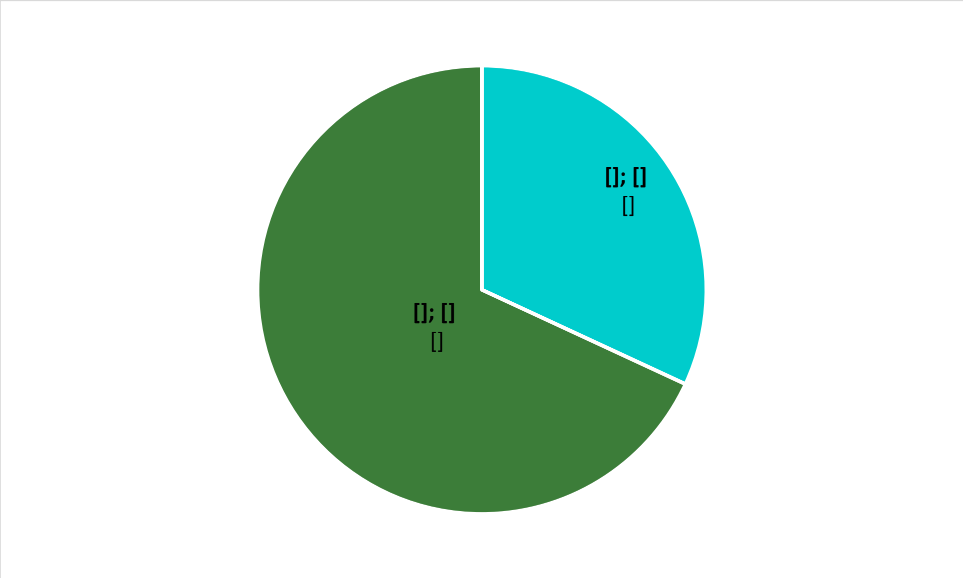
"[…] *Establishment and management of technical-institutional working group with municipality of Poncarale, municipality of Castel Mella, municipality of Capriano del Colle and municipality of Azzano Mella. Objective: adoption of common analytical approaches and operative strategies among municipalities in order to design SEAP with a common vision at local level*" SEAP Castel Mella (Italy)

"*The Municipality will be supported for the collection of data and monitoring by technicians of Maranello Patrimonio Company.*" SEAP Maranello (Italy)

"***A range of support services from Community Energy Plus***
Community Energy Plus is an award-winning social enterprise that provides complete energy answers to help householders and communities reduce their energy use and create a more sustainable future for all in Cornwall." SEAP Cornwall Council (UK)

The collaborations with other actors in the definition of strategy and actions for SEAP represent a great opportunity in order to exploit all options related to renewable energy sources and energy efficiency. The analysis shows that municipalities have adopted different kinds of collaborations with other public authorities, universities, etc. according to their peculiarities. On the other hand, there is still a great potential for the diffusion of these collaborations.

Figure 1 – Sustainable Energy Action Plans that mentioned or not the presence of organizational collaborations



3 Influencing factors for shallow geothermal energy systems

This section identifies the influencing factors for the development of energy efficiency and renewable energy sources in SEAPs, particularly shallow geothermal energy systems. We discovered 3 types of crucial influencing factors:
- Natural resources
- Cognitive resources
- Determinants.

3.1 Natural resources

The presence of geothermal resource potential (low, medium and high enthalpy) in the surrounding area of municipality can promote the development of shallow geothermal energy systems. Our analysis identified 19 SEAPs that mentioned the existence of geothermal energy potential (Figure 2):

"*Banja Luka has a great potential for exploiting renewable energy sources (geothermal, hydro, solar energy).* […] *Geothermal energy can be used for heating and electricity in the Banja Luka area.*" SEAP Banja Luka (Bosnia Herzegovina)

"*Existence of hydro-geothermal system, even though research and appearance of thermal surface sources in surroundings on neighboring municipalities Laktaši and Banja Luka, south of municipality Gradiška, determined existing of hydro-geothermal system such as appearance of thermal water on the territory of Republic of Croatia in Lipik, north from municipality, for area of municipality Gradiška there is not data on its existence.* […]" SEAP Gradiska (Bosnia Herzegovina)

"*The territory of Fordongianus has a hot spring with hot water at 56/57° C degrees: currently this hot spring was exploited by a pipe which supplies water to fountains in the town and a swimming pool.*" SEAP Comunità Pioniera del SECS (Italy)

This potential is also represented by medium and high enthalpy geothermal resources for the production of electricity.
In some cases, the presence of geothermal energy potential should be assessed in order to design suitable installations. Therefore, 9 SEAPs planned a detailed assessment of geothermal energy potential:

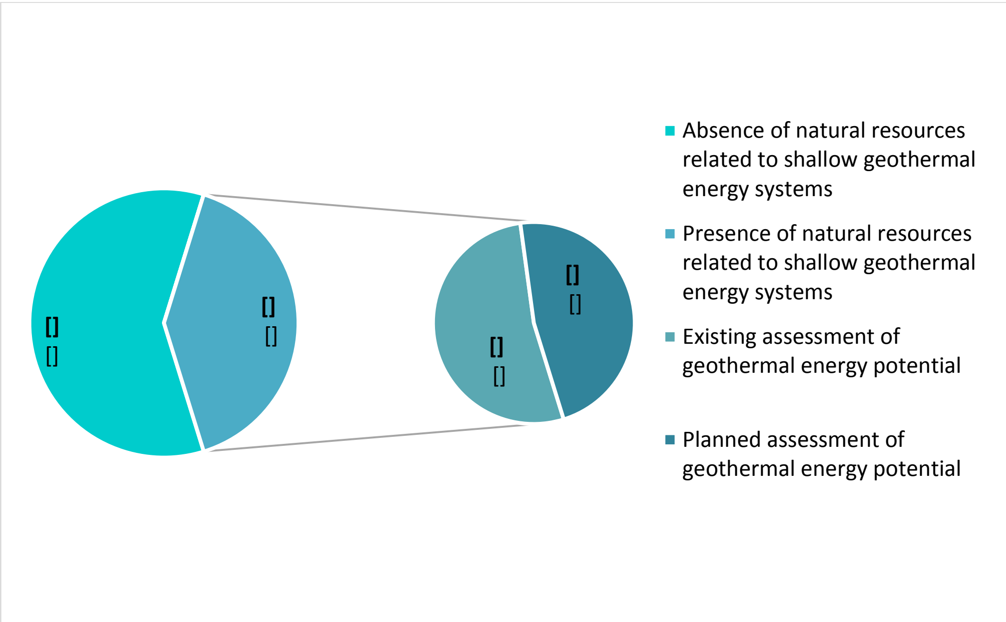
"*Geothermal energy is not used on the area of municipality Gradiška; hence a detailed research of possibilities of usage of thermal pumps for the needs of exploitation of geothermal energy is suggested*." SEAP Gradiska (Bosnia Herzegovina)

"*Nisyros has one the greatest geothermal field in Greece with a power capacity (high enthalpy) of several tens of MW. It is also important to use the heating from shallow*

geothermal energy in order to satisfy thermal and energy needs in agricultural sector. However, some worries of residents can hinder the development of geothermal energy Therefore, the presence of suitable information can improve the negative attitude of people towards geothermal energy.
[….]
There is a significant geothermal energy potential. The geothermal field of Nisyros provides a great potential for the application of high and low enthalpy. Anyway, all investments have to take into account the environmental protection and safety." SEAP Nisyros (Greece)

This result points out that the presence of geothermal energy potential is a good driver for the implementation of shallow geothermal energy systems, because municipalities have a preliminary knowledge about the opportunities and risks associated with geothermal energy. This knowledge can boost feasibility studies for the realization of shallow geothermal energy installations. On the other hand, the lack of mention of geothermal resource potential at local level in the majority of analysed SEAPs shows the opportunity of the promotion of shallow geothermal energy as a real option for thermal needs in public and private buildings.

Figure 2 – Sustainable Energy Action Plans that mentioned or not the presence of natural resources related to shallow geothermal energy systems



3.2 Cognitive resources

Cognitive resources consist of the presence of knowledge, know-how and supportive actions within municipal organizations that fosters the integration of energy efficiency and renewable energy sources in the design and the implementation of strategy and actions in SEAPs. Figure 3 depicts that 10 signatories have cognitive resources for the successful implementation of SEAPs. In particular, 8 SEAPs mentioned the presence of existing know-how:

"The City of Paris accordingly produced a sustainable development guide, intended primarily for municipal officers in charge of managing development operations and project managers in the urban-planning departments. It also addresses a wider audience of all those involved in development (developers, social landlords and so on)." SEAP Paris (France)

"The results of Local Agenda 21 are a good starting point in order to design the vision, targets and priorities of SEAP. SEAP will implement some projects related to the Local Agenda 21." SEAP Maranello (Italy)

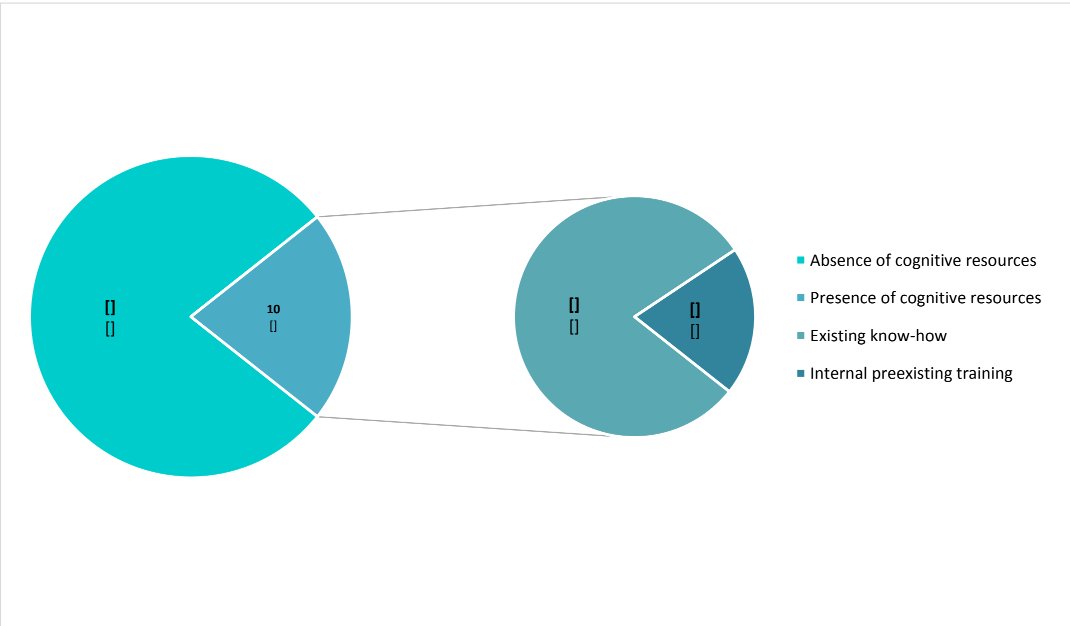
Only 2 municipalities declared the fulfilment of internal training course for civil servants before the draft of SEAP:

"The Municipality carried out a training programme about energy efficiency, retrofitting of buildings and energy performance certificate for its technical staff. [….]
This training programme aims to establish a team with suitable skills for the periodic update of SEAP [….]." SEAP Rescaldina (Italy)

"The training activity aimed to strengthen the skills of personnel involved in the implementation of SEAP." SEAP Settala (Italy)

The majority of municipalities do not have already a suitable knowledge and know-how that foster the integration of the concept of energy efficiency and the use of renewable energy sources in SEAPs. Therefore, they need to carry out training courses for their civil servants in order to increase the effectiveness of SEAPs.

Figure 3 – Sustainable Energy Action Plans that mentioned or not the presence of cognitive resources



3.3 Determinants

3.3.1 Possible determinants

The analysis tried to identify institutional determinants that influence participants at the Covenant of Mayors in the definition of strategy and actions for developing energy efficiency and renewable energy sources in the SEAP. We categorizes 8 kinds of determinants:

- *Environmental Issues*
- *Firms' involvement*
- *Macro-economic aspects*
- *Need for synergies*
- *Pre-existing experiences*
- *Regulation and planning*
- *Socio-economic characteristics*
- *Technological issues*

We will define and describe each determinant in the following sub-sections.

Environmental issues

The environmental issues highlight the role of municipality in the preservation of natural resources and the reduction of environmental impacts and energy consumption associated with economic activities through the implementation of specific actions and strategy for the development of energy efficiency and renewable energy sources. 11 SEAPs declared the presence of environmental determinants in their design and realization (Table 3):

"*There are more frequent extreme meteorological events (dry summers and rainy winters). The city has to face heat waves in summer and increasing heavy storms in autumn and winter. Therefore, Hamburg could be affected by storms and floods due to its geographical location between North Sea and Elba*." SEAP Hamburg (Germany)

"*The island is an important site for the community and integrated in the network NATURE 2000*." SEAP Nisyros (Greece)

"*The Local Community has to adapt production industry to territorial peculiarity, quality of life for citizens, promotion of environmental and cultural heritage, and rediscovery of country life* […]." SEAP Comunità Pioniera del Marghine (Italy)

"[…] *natural resources are exhaustible and have to be properly managed and respected.*"
[…]
"*The recent strong urbanization has triggered the promotion of a more aware territorial development in order to maintain an equilibrium between use and protection of territory through the minimization of environmental impacts and effective use of local resources*." SEAP Maranello (Italy)

“*Bath & North East Somerset benefits from a rich diversity of natural habitats and features including many internationally, nationally and locally protected sites. These range from ancient woodlands, veteran and notable trees, hedgerows, to flower-rich grasslands and important bat foraging corridors. These green assets are vital for the health and wellbeing of the community, since there are strong links between mental and physical health and access to natural open spaces. The natural environment is also crucial for our economic prosperity; Defra’s “UK National Ecosystem Assessment” 2011 estimates that natural resources are worth £15bn to our national economy*.“ SEAP Bath and North East Somerset (UK)

Firms' involvement

This category describes the influence of firms in the design and implementation of strategy and actions in SEAP.
The analysis shows that 6 Italian municipalities have arranged technical meetings in order to collect idea and suggestions from local firms and practitioners for the design and implementation of strategy and actions in SEAP (Table 3):

“*These Technical Meetings have showed stakeholders’ needs (mainly practitioners and firms) by influencing the identification and design of actions for SEAP* […].” SEAP Canegrate (Italy)

Macro-economic aspects

Another determinant is related to the macro-economic aspects that influence directly and indirectly the development of strategy and actions in SEAP. 5 SEAPs highlight the presence of macro-economic aspects in the design of strategy and actions for the development of energy efficiency and renewable energy sources (Table 3):

“*Stipulated global growth of prices of energy-generating products and electricity in future will additionally motivate citizens and stakeholders to invest in projects for increase of energy efficiency and reduction of energy consumption*.” SEAP Gradiska (Bosnia Herzegovina)

“*The development of the Paris Climate Protection Plan should be seen in the light of rising energy prices. Oil prices are currently fluctuating between $60 and $75 a barrel. The price of natural gas – widely used for heating in Paris – is indexed on the price of oil. Electricity prices have risen also, mainly because of the end of Europe’s production overcapacity and liberalization of the market*.” SEAP Paris (France)

“*At present, residents are dependent on fossil fuels to power their homes. As fuel prices rise, this dependency leads to an increase in fuel poverty, which is currently defined as a household needing to spend more than ten per cent of its income on fuel to maintain an adequate level of warmth*.” SEAP Bath and North East Somerset (UK)

Need for synergies

The need for synergies points out the importance of identifying and implementing actions in SEAP that results from cooperation between other public administrations and well-trained civil servants. 2 SEAPs identify this kind of determinant (Table 3):

"*The lack of coordination among different public administrations is one of biggest issues, namely removing problems related to different criteria, lack of information and several officials and authorities involved in energy and environmental sector. In order to guarantee an effective management of public resources, it is necessary to coordinate actions among different public administrations and arrange related skills and resources*." SEAP Santa Coloma de Gramanet (Spain)

"*In many cities it very common the lack of a person that is able to identify and implement effective actions for the reduction of energy consumption at municipal level. Therefore, this person has to take into account the orientations of city council.*" SEAP Taradell (Spain)

Pre-existing experiences

This category considers actions, projects, studies and initiatives carried out at local/regional/national level influencing the design and implementation of strategy and actions in SEAP. Almost all SEAPs (40) mentioned previous projects, studies, etc. as a support and influencing factor in the identification of strategy and actions in the development of energy efficiency and renewable energy sources, but in particular shallow geothermal energy systems (Table 3):

"*Bonn has been involved in the safeguard of climate since 19941995*." SEAP Bonn (Germany)

"*Since 1983 the Department of Buildings started carrying out actions for the implementation of energy savings. This commitment has produced the implementation of energy efficiency measures in new and existing buildings*."
[…]
"*In order to tackle climate change, the municipality of Frankfurt has established the department of energy since 1990*." SEAP Frankfurt (Germany)

"*We have a great expertise thanks to the programme on climate change implemented in 1996*." SEAP Hannover (Germany)

"*Köln is a member of Climate Alliance of European Cities that represents more than 1.500 cities, counties, landers, provinces, ONG and other institutions*." SEAP Köln (Germany)

"*Climate is a one of more important challenges for the city of Copenhagen. The city has decrease CO2 emission by more than 20% in the period 1990-2005 thanks to district heating, wind turbines, etc.*." SEAP Copenhagen (Denmark)

"*In Catalonia the fight against the climate change is coordinated by the Catalan Plan for Climate Change 2008-2012. The SEAP is part of actions foreseen by Catalan Government*. SEAP Sant Quirze del Valles (Spain)

"*Since 2001, the City of Paris has undertaken measures to reduce our lifestyle's environmental footprint, particularly as concerns transport. Today, it intends to step its action up a gear through this Climate Plan. It now has a far-reaching action plan together with figure-based targets in many fields: transport, housing, town planning, resource and waste management, food*." SEAP Paris (France)

"*The Local Energy Action Plan is a component of Local Agenda 21. In order to avoid replication, the operation and monitoring of SEAP is carried out by the managing board of Agenda 21. There is only a working group for the implementation of SEAP*." SEAP Poissy (France)

"*The Municipality of Vaganzello has joined the network of helpdesks for energy and environment - established by the Province of Milan – through the inauguration of municipal helpdesk since 1997. In 2006 it carried out energy audit in municipal buildings thanks to funds by Cariplo Foundation*." SEAP Vaganzello (Italy)

"*It was carried out a study about the potential of renewable energy sources in Romania (solar, wind, biomass, micro-hydro, geothermal energy) in order to identify the best investment options for the production of electricity from renewable energy sources.*" SEAP Nadlac (Romania)

Regulation and planning

This category describes the influence of national, regional and local regulation and planning in the design and implementation of strategy and actions for the implementation of energy efficiency and development of renewable energy sources in SEAP.
The analysis shows that 25 SEAPs mentioned the regulation as a crucial determinant in the identification and definition of their strategy and actions (Table 3):

"*In order to foster the development of renewable energy sources, the City Council of Piera enacted decree for the integration of solar systems in the buildings in 2006*." SEAP Piera (Spain)

"*Article 75 of the Law of 12 July 2009 on France's Commitment to the Environment states that by 31 December 2012 all authorities of more than 50,000 inhabitants must adopt a Local Climate and Energy Plan (PCET) compatible with the Regional Climate-Air-Energy Strategy (SRCAE) adopted at regional level*."
[…]
"*For the first time in France, the next set of thermal regulations, due for introduction in 2010, will set targets for major renovations of old housing and tertiary buildings. The same type of*

regular build-up in requirements was used in the European "Euro" emission standards to reduce air pollutant emissions in new vehicles." SEAP Paris (France)

"*In 2007 the municipality enacted a Building Code that fosters actions for sustainable development in the building sector (e.g. promotion of renewable energy sources, minimum requirements for thermal insulation and energy efficiency for installations, incentives for energy efficiency measures)*." SEAP Canegrate (Italy)

"*In 2008 the municipality adopted the Municipal Energy Plan in order to reduce CO2 emissions at local level and consider energy as a crucial factor in the improvement of urban environment and quality of life*." SEAP Forlì (Italy)

"*In 2007 the Region of Lombardy enacted Energy Action Plan (EAP) in order to achieve targets associated with EU 20-20-20 package at regional level: EAP is the operative tool of Regional Energy Plan, enacted in 2003*.“ SEAP Romano di Lombardia (Italy)

Socio-economic characteristics

This category consists of socio-economic characteristics at local level that influence the design and implementation of strategy and actions for the implementation of energy efficiency and development of renewable energy sources in SEAP.
25 SEAPs identified and described socio-economic characteristics that affect their local area and accordingly their strategy and actions (Table 3):

"*The increase of population and construction of individual houses caused the conversion of rural productive lands in the north and north-west into urban areas. The status of other rural areas got worse due to the abandonment of agricultural activities*." SEAP Banja Luka (Bosnia Herzegovina)

"*Immigration of population during civil war had speeded up the construction of residential houses which are not completely finished. Energy consumption in individual residential facilities represents a significant part in total consumption of energy on the territory of municipality Gradiška*." SEAP Gradiska (Bosnia Herzegovina)

"*The municipality of Caldes d'Estrac is an urban town. In fact, it is all urbanized (83,79%), namely 0,62 km^2, included residential, general and complementary systems. There are not industrial lands. Economic activities are located in residential area*."
[....]
"*The municipality of Caldes d'Estrac has to face an increase of population during summer beacuse it is a turist town.*" SEAP Caldes d'Estrac (Spain)

"[…] *Territory is mainly characterized by agriculture and then by commercial activities, services and manufacture*. […]" SEAP Comunità Pioniera del Marghine (Italy)

"*The socio-economic structure of our community is affected by demographic and economic issues. The ageing of population and migration of young and well-educated people decrease the availability of working force and hinder local economic development*." SEAP Comunità Pioniera del SECS (Italy)

"*Residents within Bath and North East Somerset benefit from an exceptional natural environment and live in a variety of settings, within 47 rural parishes, three market towns and the World Heritage City of Bath*."
[….]
"*At present, residents are dependent on fossil fuels to power their homes. As fuel prices rise, this dependency leads to an increase in fuel poverty, which is currently defined as a household needing to spend more than ten per cent of its income on fuel to maintain an adequate level of warmth*." SEAP Bath and North East Somerset (UK)

"[…] *Cornwall suffers higher than average in terms of fuel poverty and the Council has a responsibility to tackle this as well as rising energy prices*."
[…]
"*Cornwall suffers higher than the UK average in terms of fuel poverty, deprivation, unemployment, 'hard to treat' homes and fuel bills. 55% of properties are off gas and a high proportion of properties are of hard to treat solid wall construction.*" SEAP Cornwall Council (UK)

Technological issues

This category identifies the technological dimension as an influencing factor in the design and implementation of SEAPs. In particular, specific technological characteristics are mentioned in 2 SEAPs (Table 3):

"*Furthermore, low temperatures favour solar energy, geothermal energy and burner gas for incinerator. If the return temperature decreases, the direct exchange of heating is well used and it needs smaller heat pumps*." SEAP Copenhagen (Denmark)

"[…] *it aims to investigate real criticalities and options related to technologies for energy efficiency* [….]." SEAP Settala (Italy)

3.3.2 Interaction of existing determinants

The analysis shows that the majority of municipalities (35) have cited more than one type of determinants that affect them in the definition of strategy and actions for the development of energy efficiency and renewable energy sources in SEAPs (Figure 3). These results highlight the importance of defining integrated and effective strategies and actions in order to react to all identified determinants.
Only one municipality of Rescaldina (Italy) has mentioned the major number of determinants (5 types of determinants) and other 10 signatories have identified 4 type of determinants. 14

SEAPs have described 3 types of determinants. The majority of these municipalities (21) were influenced by “pre-existing experiences” and “regulation and planning” in the definition of SEAP. These types of determinants can be judged as driver to foster the development of energy efficiency and renewable energy sources, because they provide a framework that can hold the strategy and actions of SEAP. Then, 18 of all municipalities that have identified more than 2 types of determinants were affected by “socio-economic characteristics”. This type of determinant points out the influence of the local context in the definition of SEAPs.

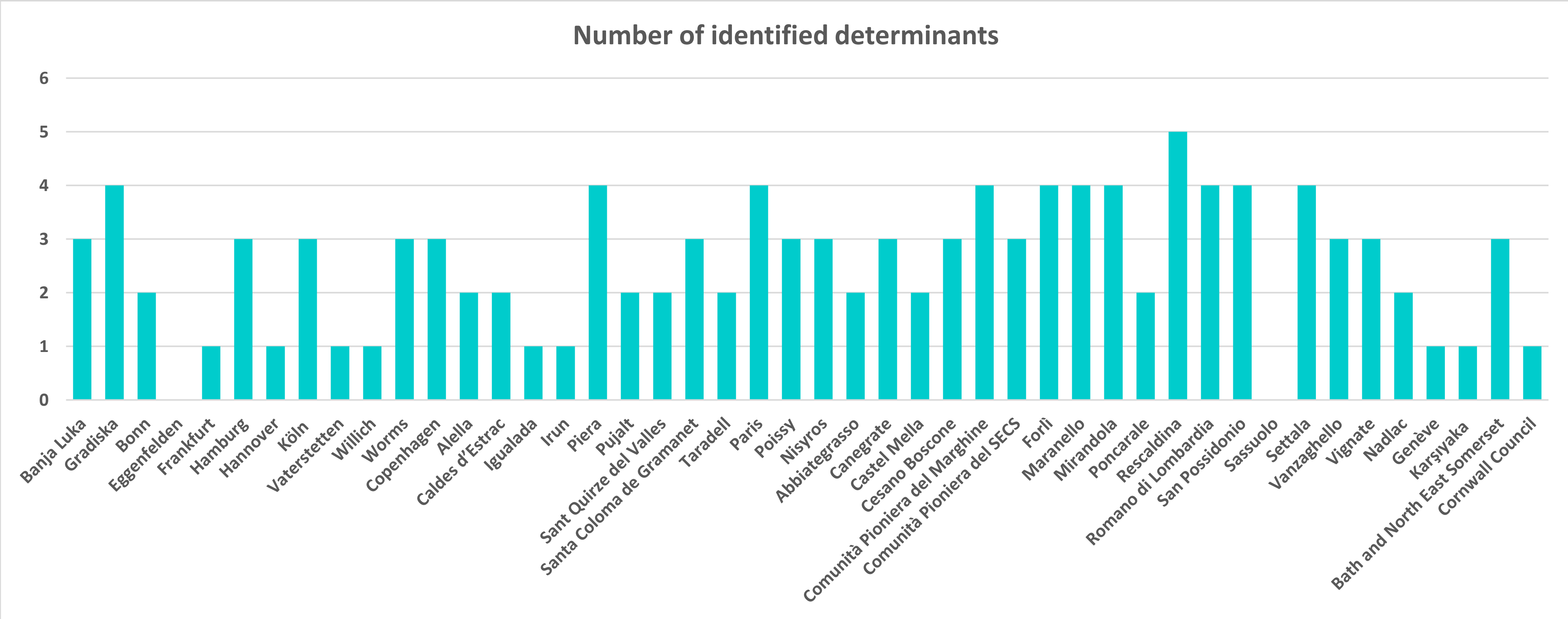
Table 3 – Sustainable Energy Action Plans that mentioned or not the presence of determinants in the design and development of strategy and/or actions for the development of energy efficiency and renewable energy sources

Municipality or group of municipalities	Type of determinants								Presence of determinants
	Environmental Issues	Firms' involvement	Macro-economic aspects	Need for synergies	Pre-existing experiences	Regulation and planning	Socio-economic characteristics	Technological issues	
Banja Luka					X	X	X		X
Gradiska			X		X	X	X		X
Bonn					X	X			X
Eggenfelden*									
Frankfurt					X				X
Hamburg	X				X	X			X
Hannover					X				X
Köln			X		X	X			X
Vaterstetten					X				X
Willich					X				X
Worms					X	X	X		X
Copenhagen			X		X			X	X
Alella					X	X			X
Caldes d'Estrac					X		X		X
Igualada					X				X
Irun					X				X
Paterna									
Piera	X				X	X	X		X
Pujalt					X		X		X
Sant Quirze del Valles					X		X		X
Santa Coloma de Gramanet				X	X		X		X
Taradell				X	X				X
Paris			X		X	X	X		X
Poissy					X	X	X		X
Nisyros	X				X		X		X
Abbiategrasso		X			X				X
Canegrate		X			X	X			X

Castel Mella					X		X		X
Cesano Boscone		X			X	X			X
Comunità Pioniera del Marghine	X				X	X	X		X
Comunità Pioniera del SECS					X	X	X		X
Forlì	X				X	X	X		X
Maranello	X				X	X	X		X
Mirandola	X				X	X	X		X
Poncarale						X	X		X
Rescaldina	X	X			X	X	X		X
Romano di Lombardia	X				X	X	X		X
San Possidonio	X				X	X	X		X
Sassuolo									
Settala		X			X	X		X	X
Vanzaghello		X			X	X			X
Vignate					X	X	X		X
Nadlac					X		X		X
Genève					X				X
Karşıyaka						X			X
Bath and North East Somerset	X		X				X		X
Cornwall Council							X		X
Total	**11**	**6**	**5**	**2**	**40**	**25**	**25**	**2**	**44**

*SEAP consists of excel tables with the actions and related effects

Figure 3 – Interaction of determinants in the design and development of strategy and/or actions for the development of energy efficiency and renewable energy sources in SEAPs



4 Strategy for shallow geothermal energy systems

This analysis tried to identify specific mention of strategy that promotes the development of energy efficiency and renewable energy sources, and in particular shallow geothermal energy for thermal purposes within the SEAP. In particular, SEAPs have developed two kinds of strategy that aims to:

- plan the implementation and development of energy efficiency and renewable energy sources;
- realize pilot projects and installations for renewable energy sources.

4.1 Identification of strategies

Planning for energy efficiency and renewable energy sources

This kind of strategy considers the general planning of measures for energy efficiency and renewable energy sources an effective way to reduce CO2 emissions and environmental impacts (Table 4):

"*Development of energy efficiency in buildings (the design of buildings in city and rural area by integrating renewable energy sources in order to reduce environmental impacts; Adoption of general principles for use of passive solar in city planning and design)*;" SEAP Banja Luka (Bosnia Herzegovina)

"[…], it is necessary to approach to elaboration of repairing project of old buildings as well as change in regulations in civil engineering and their adjustment with standards of the European Union. "

[…]

"Heating system of residential facilities needs to be centralized and propose solution which will result with the smallest energy consumption with the acceptable financial indicators of investment." SEAP Gradiska (Bosnia Herzegovina)

"*Frankfurt has a great potential for the development of energy efficiency in non-residential buildings. Therefore, great banks and insurance companies, but also small and medium enterprises can benefit these measures. In particular, they can share experiences and information, and exploit incentives in order to development of energy efficiency*." SEAP Frankfurt (Germany)

"*The reduction of CO2 emissions requires the decrease of energy consumption in buildings, particularly heating and sanitary hot water, and the development of renewable energy sources and combined heat and power*."

[…]

"*Deep geothermal energy is an innovative strategy for the reduction of CO2 emissions and the protection of climate*." SEAP Hamburg (Germany)

"*All municipal buildings and heating systems must be renovated by 2020*." SEAP Hannover (Germany)

"*The fields of action is the inter-municipal geothermal energy project, the construction of three wind turbines and the implementation of energy efficiency in municipal and private buildings*." SEAP Vaterstetten (Germany)

"*Energy efficiency measures in residential sector*, […]"
[…]
"*The use of renewable energy sources is crucial for the renovation of regional energy system, the production of heating and reduction of CO2 emissions*."
[….]
"*The use of geothermal energy potential and the development of renewable energy sources (e.g. wind and biomass) are crucial for the reduction of CO2 emissions and sustainable future of the city of Willich*." SEAP Willich (Germany)

"*Combined Heat and Power system in Copenhagen can use a wide set of renewable energy sources (e.g. geothermal, wind and solar energy, heat pumps and electrical boilers) independently of heating needs. In order to integrate geothermal energy, solar energy, heat pumps, electrical boilers and existing power station, one solution could be the realization of a seasonal storage system*."
[….]
"*The implementation of energy efficiency measures in new and existing buildings in Copenhagen can decrease energy consumption and produce a better indoor air quality*." SEAP Copenhagen (Denmark)

"*These measures are designed for residential sector and municipality in order to implement energy efficiency, renewable energy sources,* […]" SEAP Irun (Spain)

"*There is a high potential for the local production of energy from renewable sources in order to achieve an optimal local energy self-supply*." SEAP Taradell (Spain)

" […] *Building sector and renewable energy sources provide the major contribution for reducing CO2 emissions*." SEAP Comunità Pioniera del SECS (Italy)

"[…] *The installation of district heating systems in order to supply efficiently different areas in the city* [….]" SEAP Forlì (Italy)

"[….] *Promotion of energy efficiency, energy saving and renewable energy sources in the urban planning tools and in general local forms of government*; [….]" SEAP Maranello (Italy)

"[…] *City Council and mayor, in cooperation with all stakeholders and particularly citizens, put effort into the achievement of the following objectives:*

1. *Implementing energy efficiency in residential buildings*

2. *Implementing geothermal district heating system*

[….]

The adoption of energy efficiency criteria in urban planning." SEAP Nadlac (Romania)

"*This group is convened by the Council and contains representatives from public sector and voluntary organisations who are in contact with vulnerable people. It aims to promote energy efficiency to those most in need. For example, over 800 people responded to an insulation flyer posted with an influenza injection reminder.*" SEAP Bath and North East Somerset (UK)

"*Take advantage of any opportunities to minimise energy consumption, with an emphasis on building fabric, for example achieving high levels of insulation, use of natural lighting, ventilation, heating and orientation. This should achieve at least Zero Carbon new builds from 2016 for domestic buildings and from 2019 for non-domestic buildings. Additionally, the development of decentralised low carbon heat networks is particularly encouraged to connect or be designed to facilitate future connection to an existing or planned heat network.*" SEAP Cornwall Council (UK)

Pilot projects and installations for renewable energy sources

This type of strategy identifies pilot projects and installations for renewable energy sources as a crucial element for the development of energy efficiency and renewable energy sources (Table 4):

"*It is recommended to approach to elaboration of project research and use of geothermal energy on the area of municipality, first of all for the purposes of heating people and industry, and as first research work, the elaboration of geothermal bore of 3000 m depth is recommended*."

[….]

"*Systems of solar energy, wind energy, heating pumps and biomass today are used where it is possible to do so*." SEAP Gradiska (Bosnia Herzegovina)

"[….] *There is a great potential for residential and non-residential sector. The union of separated district heating systems can simplify the choice of combustible in the long term. Current combustibles have to be converted into low-carbon combustibles in the mid-term. All proposed measures aim to develop centralized and decentralized heat production*:" SEAP Frankfurt (Germany)

"*Hamburg evaluated if and how energy networks should be a priority in the investments in local energy infrastructures in order to tackle climate change, guarantee energy security and support local economy*."

[…]

"[…] *Moreover, there are other options for energy supply of the city. These options support the development of energy networks through the optimization of networks, storage and* *control such as "smart grid" and the promotion of renewable energy sources and combined heat and power systems*." SEAP Hamburg (Germany)

"*Increasing energy efficiency in buildings and the use of renewable energy efficiency. […] There is a great potential of geothermal energy. Therefore, the geothermal energy centre was established in the old iron and steel plant "Becker"*." SEAP Willich (Germany)

"*In order to fulfil this vision, it is necessary to develop an integrated energy system. In particular, it could be useful a smart heating system that balances demand and supply for electricity and heat. It is necessary to improve the diffusion and management of renewable energy sources and their volatility*."

[….]

"*In order to increase the development of renewable energy sources and in particular biomass, a thermal power station was built in Amager Copenhagen. This installation can be fulfilled in patch close to the power station Amager, owed by the municipality of Copenhagen. Climate Plan foresee that this system will use biomass. However, the plan considers also the use of geothermal energy and energy saving*." SEAP Copenhagen (Denmark)

"*<u>Geothermal installations</u>:*

- the municipality of Paterna has adopted this technology for heating and cooling in new buildings." SEAP Paterna (Spain)

"*Kindergarten, elementary school and swimming pool can install geothermal heat exchangers in order to satisfy their heat requirement*." SEAP Piera (Spain)

"*The municipality of Pujalt are taking into account the option to realize a district heating system from biomass in cooperation with two farm businesses. Furthermore, city council wants to build a new town hall by using geothermal energy and biomass.*" SEAP Pujalt (Spain)

"*The municipality has the potential for the implementation of installations from renewable energy sources*.

[….]

This SEAP has assessed the potential for the development of renewable energy sources in municipal area by concluding that San Quirze del Valles has 24 suitable buildings for solar panels (around 7682 sqm)." SEAP Sant Quirze del Valles (Spain)

"[…] *In the field of renewable energies, we are implementing innovative projects involving geothermal energy, heat recovery and building insulation;* […]" SEAP Paris (France)

"[…] – *local heat production, not only by solar energy (in public and private buildings), but especially through the realization of district heating system for a residential neighbourhood*;" SEAP Cesano Boscone (Italy)

“*In order to guarantee environmental protection and landscape preservation, new installations using renewable energy sources, beyond photovoltaics, will be realized not only for public buildings*.” SEAP Comunità Pioniera del Marghine (Italy)

“*- Increasing the development of renewable energy sources for service and residential sector* [...].” SEAP Poncarale (Italy)

“[…] - *local heat production foresees the installation of thermal solar plant at the municipal sports facility and the regulatory streamlining for the installation of shallow geothermal energy systems*.” SEAP Rescaldina (Italy)

“*Increasing the local energy production and supply from renewable energy sources. According to local peculiarity, installations with renewable energy sources (photovoltaics, heat pumps, etc.) will be foreseen in residential, commercial and industrial buildings. If there is not opportunity, certified green power will be bought*.” SEAP Romano di Lombardia (Italy)

“[…] – *Realizing solar power plant in municipal buildings and promoting installation of photovoltaic power plant in residential and commercial*;” SEAP Sassuolo (Italy)

“*Houses are heated by wood and geothermal energy potential is underdeveloped. Therefore, the installation of geothermal heat pumps in residential buildings can exploit all geothermal energy potential for electricity and heating*.” SEAP Nadlac (Romania)

“[…] *have been involved in projects to install over 1 MW of renewable energy capacity in community buildings and projects across Cornwall.”*
[…]
“*Targeted support for renewable energy and environmental technologies will be prioritised. In particular, we will build on the Wave Hub and PRIMARE research programme to explore marine renewables and opportunities such as Clay Country eco-town with links to geothermal and sustainable construction technologies*.” SEAP Cornwall Council (UK)

4.2 An integrated approach

The two kinds of strategy identified in the previous sections promote the development of energy efficiency and renewable energy sources, and in particular shallow geothermal energy for thermal purposes within the SEAP. The presence of both types of strategy points out that the signatories have adopted an integrated approach in the development of energy efficiency measures and renewable energy sources. In particular, there are 25 SEAPs that have adopted both types of strategy (Table 4):

Table 4 – Sustainable Energy Action Plans that mentioned or not strategy for the development of energy efficiency and renewable energy sources in SEAPs

Municipality or group of	Type of strategy	Strategy for energy

municipalities	Pilot projects and installations for renewable energy sources	Planning for energy efficiency and renewable energy sources	Integrated approach	efficiency and renewable energy sources
Banja Luka	X	X	X	X
Gradiska	X	X	X	X
Bonn		X		X
Eggenfelden*				
Frankfurt	X	X	X	X
Hamburg	X	X	X	X
Hannover		X		X
Köln		X		X
Vaterstetten	X	X	X	X
Willich	X	X	X	X
Worms		X		X
Copenhagen	X	X	X	X
Alella		X		X
Caldes d'Estrac	X			X
Igualada				
Irun		X		X
Paterna	X	X	X	X
Piera	X	X	X	X
Pujalt	X			X
Sant Quirze del Valles	X			X
Santa Coloma de Gramanet		X		X
Taradell	X			X
Paris	X			X
Poissy				
Nisyros	X	X	X	X
Abbiategrasso	X	X	X	X
Canegrate	X	X	X	X
Castel Mella				
Cesano Boscone	X	X	X	X
Comunità Pioniera del Marghine	X	X	X	X
Comunità Pioniera del SECS		X		X
Forlì		X		X
Maranello	X	X	X	X
Mirandola	X	X	X	X
Poncarale	X	X	X	X
Rescaldina	X	X	X	X
Romano di Lombardia	X	X	X	X
San Possidonio	X	X	X	X
Sassuolo	X	X	X	X
Settala		X		X
Vanzaghello	X	X	X	X
Vignate				
Nadlac	X	X	X	X
Genève	X	X	X	X
Karşıyaka		X		X
Bath and North East Somerset		X		X
Cornwall Council	X	X	X	X
Total	**30**	**37**	**25**	**42**

*SEAP consists of excel tables with the actions and related effects

5 Actions for shallow geothermal energy systems

5.1 Possible actions for shallow geothermal energy systems

The actions that promote the development of shallow geothermal energy for thermal purposes are categorized in:

- *Regulation*
- *Urban and energy planning*
- *Administrative end economic incentives*
- *Regulatory Streamlining*
- *Pilot projects and installations*
- *Training and information campaigns*
- *Feasibility studies and energy audits*

This categorization also includes actions that are not strictly related to the installation of shallow geothermal energy systems but act as facilitator by simplifying and raising awareness of the use of renewable energy sources and energy efficiency in public and private buildings.

Regulation

This category considers the development of regulations, such as building codes, municipal council resolutions, etc., in order to promote and foster energy efficiency and the integration of renewable energy sources for thermal purpose (particularly shallow geothermal energy systems) in existing and new buildings. 24 SEAPs have adopted a specific regulation for improve energy efficiency and develop renewable energy sources for thermal uses (Table 5):

"*This action aims to draw up the decree for the control and promotion of renewable energy sources in order to foster the rational use of energy, energy efficiency and the correct implementation of renewable energy installations. In particular, the decree will define the installation of photovoltaic and thermal solar systems in residential and public buildings*." SEAP Pujalt (Spagna)

"*The development of municipal decree for the promotion of sustainable energy systems: renewable energy sources, energy efficiency and sustainable buildings. Then, the municipality will promote this decree among citizens*." SEAP Sant Quirze del Valles (Spain)

"*If the building code foresees active air-conditioning systems, it will be selected the following options:*
- Ground Source Heat Pump systems (open or close);
- Solar systems for cooling and air-conditioning.
Furthermore, it will be necessary to carry out an information campaign for citizens in cooperation with practitioners." SEAP Abbiategrasso (Italy)

"*The Municipality will update the building code currently in force and in particular a title for the management of energy and improvement of energy performance in buildings by* *including mandatory rules for the integration of new national regulation and nearly zero energy buildings concept according to EU Directive. It aims to improve housing conditions, energy performance of building envelope and installations, reduce energy consumption for air-conditioning, limit energy losses and CO2 emissions through energy efficient buildings*." SEAP Canegrate (Italy)

"*A new building code will be drawn up in order to foster energy and natural resource saving and use of renewable energy sources in new and existing buildings.*
The building code has to be easy to adopt and understand in order to increase its efficacy in cooperation with voluntary incentive tools." SEAP Forlì (Italy)

"*Adoption and monitoring of energy efficiency standards and use of renewable energy source in building code. […] Building code should foresee the implementation of renewable energy installations, combined heat and power systems, heat pumps, centralized heating and cooling systems in new or existing industrial buildings (with a heated surface of more than 1000 sqm) in association with feasibility study*." SEAP Maranello (Italy)

Urban and energy planning

This category consists of all actions that promote urban and energy planning for the development of energy efficiency and the integration of renewable energy sources (particularly shallow geothermal energy systems) in existing and new buildings, but also in industrial areas. 12 SEAPs have adopted urban and energy planning as tool for implementing sustainable energy solutions al local level (Table 5):

"*Development of district heating in industrial areas in order to change energy supply by using 100% of energy from renewable sources*." SEAP Eggenfelden (Germany)

"*The integration of energy efficiency criteria in existing and new buildings. […] However, it is necessary to include specific sustainable energy criteria in regulations through: a) definition of criteria for energy planning for urban sustainability. b) Analysis of possible inclusion of sustainable energy criteria in plans and activities*." SEAP Alella (Spain)

"[...] *Launch of local energy plan that achieve the reduction of 20% in energy consumption*; […]" SEAP Abbiategrasso (Italy)

"*Integration of energy efficiency, use of renewable sources and reduction of CO2 emissions concepts in future urban plans in order to achieve sustainable energy territories*." SEAP Comunità Pioniera del SECS (Italy)

"*The Municipalities have to include criteria for decreasing energy consumption in new and existing buildings within local planning tools. In particular, the implementers have to assess the techno-economic feasibility of renewable energy installations, combined heat and power systems, heat pumps, centralized heat systems […] in new and existing buildings with a* *surface of more than 1000 sqm, according to Regional Law 26/2004, art. 5*.” SEAP Maranello (Italy)

Administrative and economic incentives

This category identifies administrative and economic incentives in order to support the development of energy efficiency and the integration of renewable energy sources (particularly shallow geothermal energy systems) in existing and new buildings. 13 signatories has introduced incentives for the development of energy efficiency and renewable energy (Table 5):

“*Incentives for individual households for connecting on district heating system.*” SEAP Gradiska (Bosnia Herzegovina)

“*Economic incentives for the substitution of old heat pumps more energy efficient ones (also geothermal heat pumps).*” SEAP Frankfurt (Germany)

“*In order to guarantee the sustainable development it is necessary to foster energy efficiency and integration of renewable energy sources in buildings. City council can adopt tax credit for buildings, installations and works with advanced renewable energy systems (compared to mandatory systems), e.g. solar energy for thermal needs and electricity, etc.*.” SEAP Pujalt (Spain)

“*Promotion of renewable energy sources in private sector through fiscal advantage*.” SEAP Piera (Spain)

“*The municipality of Forlì can foster local property renovation market through information campaigns, new effective building code and a revolving fund of 10 Millions of EUR*.” SEAP Forlì (Italy)

“*In order to foster energy efficient buildings (classes A and B or zero energy) the Community can launch a system of economic incentives that decrease planning fees within sectorial regulation*.” SEAP Comunità Pioniera del Marghine (Italy)

“*The agreement on a 20% bonus on the Coefficient d’Occupation des Sols (land-use coefficient) was been incorporated in the Climate Protection Plan as part of the PLU (local urban-planning plan) to construct very energy-efficient housing or buildings with renewable energy production facilities (solar or photovoltaic panels, heat pumps, etc.)*.” SEAP Paris (France)

“*The project will test a range of interventions in a range of community types and will use local substation readings to measure energy savings achieved. Communities that cut their electricity demand will receive a financial reward*.” SEAP Cornwall Council (UK)

Regulatory streamlining

Regulatory streamlining consists of initiatives in order to simplify and accelerate administrative and permitting procedure for the development of renewable energy sources and energy efficiency, particularly the installation of shallow geothermal energy systems. 7 SEAPs have identified regulatory streamlining as action for achieving sustainable energy targets (Table 5):

"*SEAP foresees action for improving regulation in order to simplify the investments and decrease administrative barriers to the implementation of energy efficiency, the development of renewable energy sources and the reduction of CO2 emissions*." SEAP Banja Luka (Bosnia Herzegovina)

"*Simultaneously, the Municipality puts effort into the simplification of administrative procedures to install ground source heat pumps within the building*." SEAP Abbiategrasso (Italy)

Pilot projects and installations

This kind of actions describe pilot projects and installations that will be fulfilled in order to foster the development of shallow geothermal energy systems at local level.
29 signatories have planned to realize pilot projects and/or install shallow geothermal energy systems (Table 5):

"*It is recommended to approach to elaboration of project research and use of geothermal energy on the area of municipality, first of all for the purposes of heating people and industry, and as first research work, the elaboration of geothermal bore of 3000 m depth is recommended.*" SEAP Gradiska (Bosnia Herzegovina)

"*Installation of thermal pumps that use heat of underground waters for households needs*."
SEAP Gradiska (Bosnia Herzegovina)

"*Geothermal project in cooperation with local communities in order to connect new residential and commercial buildings to district heating* [….]." SEAP Bonn (Germany)

"*Enlargement of geothermal plant at Margretheholm – The city of Copenhagen, in cooperation with other actors, aims to implement a geothermal system with a thermal capacity five/six times larger than current system. Margretheholm has been taken into operation since August 2005 and is owned by KE (now HOFOR) and then the municipality of Copenhagen*." SEAP Copenhagen (Denmark)

"[…] *Implementation of at least one pilot project with ground source heat pumps or solar thermal systems for heating and cooling in a municipal building in order to improve energy* *efficiency and use renewable energy sources or low CO2 emission systems*." SEAP Alella (Spain)

"*Implementation of heating and cooling systems that use biomass and/or geothermal energy in new public buildings*."
[…]
"*Addition of shallow geothermal energy systems for heating in new buildings*." SEAP Irun (Spain)

"*The creation of a geothermal well in the Claude Bernard urban development zone (19th)" SEAP Paris*"
[…]
"*Urban development zone and major urban renewal projects are long-term investment areas. They will continue to be the scene of innovations which will equip the city of the future, such as geothermal energy in the Albien district with a relief well in the Clichy-Batignolles urban development zone, and the integration of logistical installations (under consideration at Porte de la Chapelle and Bercy-Charenton)*." SEAP Paris (Italy)

"*A new geothermal installation of 400 m^2 will heat the new residential area between Saint Exupéry and EOLES districts*." SEAP Poissy (France)

"*The Municipality wants to carry out a project for the use of geothermal energy trough the realization of geothermal power plant and district heating system*." SEAP San Possidonio (Italy)

"*The integration of geothermal energy into district heating* [...]" SEAP Nadlac (Romania)

"*An important future project will use open loop ground source heat pumps in order to satisfy thermal needs in four new residential areas*." SEAP Gèneve (Switzerland)

Training and information campaigns

This category considers training activities, helpdesks, information campaigns and websites for the promotion of shallow geothermal energy systems and in general the implementation of energy efficiency and renewable energy sources within civil servants and citizens.
The majority of SEAPs (37) have designed training activities and information campaigns for the deployment of energy efficiency and renewable energy sources (Table 5):

"*Education of employees in public facilities on energy efficiency*"
[…]
"*Campaign on raising awareness of citizens on energy efficiency*"
[…]
"*Continuous informing consumers on possibilities of energy savings through short messages on the back of the bills for electricity*"

[….]
"*Organizing education for key actors and employees in public facilities on technical-technological aspects of improvement of energy efficiency and given methods and means of project action*" SEAP Gradiska (Bosnia Herzegovina)

"*The online access to official information about shallow geothermal energy was simplified. Moreover, the supply of other information (drilling profile) is available*." SEAP Hamburg (Germany)

"[…]
• *To provide advices, because these systems require more information than other systems that use renewable energy sources, (if possible) with visit at pilot installations*.

• *To provide financial advice […]*" SEAP Worms (Germany)

"*Information campaigns in schools in order to make students aware of the use of renewable energy sources and energy saving*." SEAP Paterna (Spain)

"*Training of civil servants on energy efficiency and energy saving plan*." SEAP Sant Quirze del Valles (Spain)

"*The objective consists of the promotion of renewable energy sources in residential sector through the establishment of information channel for citizens in the following themes:*
- Renewable energy sources tariffs for residential buildings;
- Subsidies or grants in force;
- List of firms in renewable energy sources;
- *Other*." SEAP Santa Coloma de Gramanet (Spain)

"*The City will continue its partnerships with housing, building and real estate stakeholders, in order to:*

• *Improve thermal renovation training to develop skills and create the jobs […]*" SEAP Paris (France)

" […] *Training courses for condominium managers are useful in order to foster energy efficiency measures and actions for sustainable residential buildings.* […]" SEAP Abbiategrasso (Italy)

"*After the approval of the SEAP, the municipality will be carried out an information campaign for the involvement of stakeholders and citizens in order to fulfill SEAP's actions*."
[….]
"*The Municipality of Cesano Boscone has implemented a website with all information about this project (www.comune.cesano-boscone.mi.it/servizi/menu/ dinamica.aspx?idArea=19648&idCat=20413&ID=22760) in order to highlight preliminary objectives, describe planned work and provide more details about Covenant of Mayors and SEAP*." SEAP Cesano Boscone (Italy)

“*Promotion of geothermal installations for heating and cooling in buildings: the municipality aims to promote knowledge and diffusion about this technology in residential and/or commercial buildings through information campaign and training events for practitioners, trade associations and citizenship*.” SEAP Sassuolo (Italy)

“*Training is addressed to municipal technicians, administrators (i.e. mayor, town councillors, etc.) involved in the design of SEAP. Furthermore, local practitioners (architects, designers, engineering) will be involved in the fulfilment of SEAP’s actions*.” SEAP Vignate (Italy)

“*The distribution of handbook about best practices in sustainable development and energy saving in public authorities*.”
[….]
“*The Municipality of Nădlac will arrange technical seminars for architects and developers*.” SEAP Nadlac (Romania)

“*As participants in the LEAP project, funding has enabled the Council to prepare a series of renewable energy planning guidance notes to assist householders, communities and developers in bringing forward their development ambitions. These guidance notes include: Solar Photovoltaic, Solar Thermal, Onshore Wind, Anaerobic Digestion Hydropower, Biomass, Heat Pumps, Deep Geothermal and Waste. It is intended that the guidance documents will be adopted by the Council as a "Supplementary Planning Document" following consultation and adoption of the Council's Local Plan proposed after 2013*”
[….]
“*The programme of seminars is being planned to include the Green Deal, development of the National Solar Centre in Cornwall, Geothermal opportunities, Sustainable Buildings, Marine Energy development in Cornwall, retrofit projects and more […]*.” SEAP Cornwall Council (UK)

Feasibility studies and energy audits

This categories consists of the fulfilment of energy audits for the assessment of energy performance in buildings for the implementation of energy efficiency measures and renewable energy sources, and feasibility studies for the use of geothermal energy. 22 SEAPs have adopted this kind of actions (Table 5):

“*It will promote energy audits in municipal and private buildings in order to improve energy efficiency, decrease energy consumptions and operative costs, and use of renewable energy sources*.” SEAP Banja Luka (Bosnia Herzegovina)

“*Elaboration of study for using geothermal energy for purposes of heating the narrow area of municipality*” SEAP Gradiska (Bosnia Herzegovina)

“*Thanks also to the economic support of federal government, a study about assessment and modelling of geothermal energy potential and identification of existing and potential customers will be carried out.*” SEAP Hamburg (Germany)

"*It will be carried out an analysis for the implementation of geothermal district heating*." SEAP Willich (Germany)

"*The municipality will carry out a detailed study for the implementation of geothermal installations for cooling*." SEAP Caldes d'Estrac (Spain)

"*There are some hot springs in West area of the city. Therefore, the municipality will carry out a study for the assessment of the environmental and economic feasibility of geothermal installation (for self-consumption or sell heat to third party)*." SEAP Taradell (Spain)

"*The City of Paris will study the possible energy choices for the new urban development zone as a matter of priority, favoring as much as possible the use of local renewable energies or connection to the local heating system (CPCU–Paris Urban Heating Company) and/or cooling system (Climespace) networks, whilst also improving air quality. As an example, studies will be carried out to identify the geothermal potential of the Bercy-Charenton urban development zone*."
[….]
"*Beginning in 2008, the City of Paris will carry out an energy audit of all of its facilities to gain a deeper insight into their energy consumption. The operation has been scheduled over three years*." SEAP Paris (France)

"*Since there are fumaroles in Dualchi area, the municipality of Dualchi and Community will carry out a study for assessing the geothermal energy potential for the production of electricity*." SEAP Comunità Pioniera del Marghine (Italy)

"*Working with Curo, the local social housing provider, and Bath & West Community Energy, the Council has commissioned a study to investigate how best to take a community-based, partnership approach to delivering the Green Deal in order to tackle fuel poverty, benefit the local economy and provide opportunities for social enterprise*." SEAP Bath and North East Somerset (UK)

Table 5 – Sustainable Energy Action Plans that mentioned or not actions for shallow geothermal energy for thermal uses

Municipality or group of municipalities	Type of actions						
	Regulation	Urban and energy planning	Administrative end economic incentives	Regulatory Streamlining	Pilot projects and installations	Training and information campaigns	Feasibility studies and energy audits
Banja Luka				X	X	X	X
Gradiska	X		X		X	X	X
Bonn					X		X
Eggenfelden*		X					X
Frankfurt	X		X				
Hamburg	X		X			X	X
Hannover						X	
Köln	X						
Vaterstetten					X		
Willich					X	X	X
Worms		X				X	
Copenhagen					X	X	
Alella	X	X			X	X	
Caldes d’Estrac						X	X
Igualada					X	X	
Irun					X	X	
Paterna					X	X	X
Piera	X		X		X	X	X
Pujalt	X		X		X	X	
Sant Quirze del Valles	X				X	X	X
Santa Coloma de Gramanet						X	X
Taradell							X
Paris		X	X		X	X	X
Poissy					X		
Nisyros					X		
Abbiategrasso	X	X		X		X	X
Canegrate	X			X		X	

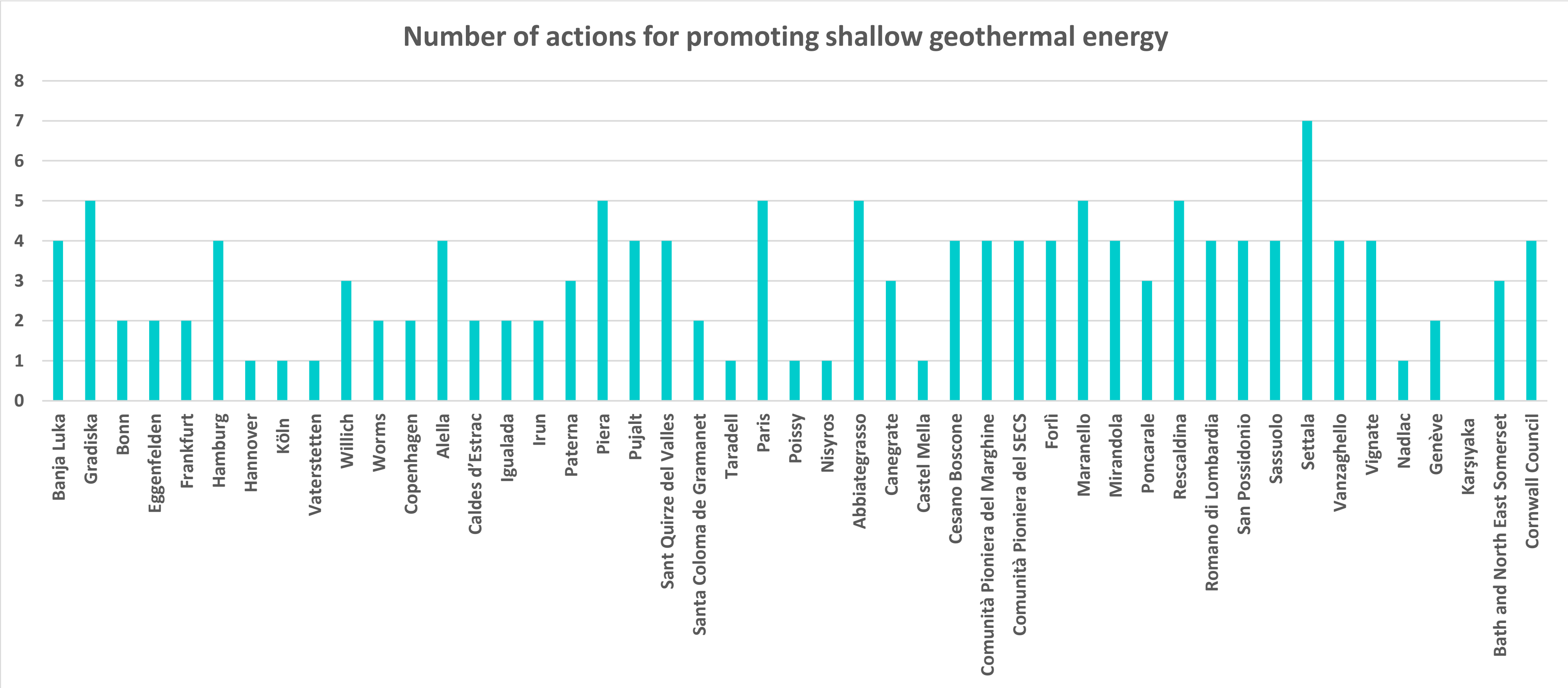
Castel Mella						X	
Cesano Boscone	X	X		X		X	
Comunità Pioniera del Marghine	X		X			X	X
Comunità Pioniera del SECS	X				X	X	X
Forlì	X		X		X	X	
Maranello	X	X			X	X	X
Mirandola	X	X			X	X	
Poncarale	X				X	X	
Rescaldina	X		X	X		X	X
Romano di Lombardia	X		X		X	X	
San Possidonio	X	X			X	X	
Sassuolo	X	X			X	X	
Settala	X	X	X	X	X	X	X
Vanzaghello	X		X	X		X	
Vignate	X				X	X	X
Nadlac						X	
Genève					X		X
Karşıyaka							
Bath and North East Somerset					X	X	X
Cornwall Council		X	X		X	X	
Total	**24**	**12**	**13**	**7**	**29**	**37**	**22**

*SEAP consists of excel tables with the actions and related effects

5.2 Integration of actions for shallow geothermal energy systems

The implementation of a set of actions for the development of shallow geothermal energy systems can strengthen and accelerate the adoption of shallow geothermal energy for thermal needs. Therefore, the analysis identified the presence of SEAPs which integrate more actions that foster the development of shallow geothermal energy (Figure 4). The joined adoption of actions tries to overcome technical and non-technical barriers to the development of this renewable energy source. Only the municipality of Settala (Italy) has implemented all identified categories of actions for the promotion of shallow geothermal energy systems. 6 SEAPs have adopted 5 categories and 16 SEAPs have adopted 4 categories of actions. There are 4 categories of actions that very often are integrated: “regulation”, “pilot projects and installations”, “training and information campaigns” and “feasibility studies and energy audits”. The association of these kinds of actions attempts to solve the lack of information about benefits, possible risks, potential and operation of shallow geothermal energy systems and overcome related scepticism and opposition, because shallow geothermal energy is little known by civil servants and citizens.

Figure 4 – Integration of actions for shallow geothermal energy in SEAPs



6 Overarching vision

This section aimed to investigate the relations between the identified peculiarities and influencing factors, and actions planned for the development of shallow geothermal energy systems in SEAPs by summarizing the findings arisen in the previous sections.

The presence of collaborations with public authorities, research centres, universities, associations, firms and other municipalities is more frequent in SEAPs that have planned more than one action for the development of shallow geothermal energy systems (Table 6). Therefore, these collaborations providing know-how, knowledge, economic and human resources support the deployment of a set of actions for the promotion of shallow geothermal energy systems.

Table 6 – Sustainable Energy Action Plans that mentioned the presence of organizational collaborations per number of actions planned for the development of shallow geothermal energy systems

Number of actions					
7 Actions	**5 Actions**	**4 Actions**	**3 Actions**	**2 Actions**	**1 Action**
	Gradiska	Alella	Willich	Copenhagen	Poissy
	Paris	Comunità Pioniera del Marghine	Poncarale		Castel Mella
	Maranello	Comunità Pioniera del SECS			
		Forlì			
		Vanzaghello			
		Vignate			
		Cornwall Council			
					Total: 15 SEAPs

Both natural and cognitive resources were mentioned mainly by municipalities that have planned more than one action related to the development of shallow geothermal energy systems within their SEAP (Table 7 and 8). Natural and cognitive resources provide favourable conditions, knowledge and know-how in order to implement a set actions for the development of energy efficiency and renewable energy sources (in particular shallow geothermal energy systems).

Table 7 – Sustainable Energy Action Plans that mentioned the presence of natural resources related to shallow geothermal energy systems per number of actions planned for the development of shallow geothermal energy systems

Number of actions					
7 Actions	**5 Actions**	**4 Actions**	**3 Actions**	**2 Actions**	**1 Action**
Settala	Gradiska	Banja Luka	Willich	Copenhagen	Hannover
	Paris	Comunità Pioniera del Marghine	Paterna	Caldes d’Estrac	Taradell
		Comunità Pioniera del SECS			Nysiros

		Mirandola			Nadlac
		Romano di Lombardia			
		San Possidonio			
		Cornwall Council			
					Total: 19 SEAPs

Table 8 – Sustainable Energy Action Plans that mentioned the presence of cognitive resources per number of actions planned for the development of shallow geothermal energy systems

Number of actions					
7 Actions	**5 Actions**	**4 Actions**	**3 Actions**	**2 Actions**	**1 Action**
Settala	Paris	Alella	Canegrate		Castel Mella
	Abbiategrasso	Romano di Lombardia			
	Maranello	Vanzaghello			
	Rescaldina				
					Total: 10 SEAPs

Table 9 shows that greater is the number of types of determinants identified by SEAPs more types of actions have been designed in order to foster the development of shallow geothermal energy systems for thermal purposes. In particular, there are three types of determinants that influence mainly the design of more than 4 type of actions for shallow geothermal energy systems in SEAPs: "pre-existing experiences" and "regulation and planning", and "socio-economic characteristics" (Table 10). These determinants influence the correct definition of local context in order to increase the effectiveness of SEAPs.

Table 9 – Sustainable Energy Action Plans that mentioned more than 2 types of determinants per number of actions planned for the development of shallow geothermal energy systems

Number of determinants	**Number of actions**					
	7 Actions	**5 Actions**	**4 Actions**	**3 Actions**	**2 Actions**	**1 Action**
			Banja Luka	Canegrate	Worms	Köln
			Hamburg	Bath	Copenhagen	Poissy
3 types of determinants			Cesano Boscone		Santa Coloma de Gramanet	Nysiros
			Comunità Pioniera del SECS			
			Vanzaghello			
Total: 14 SEAPS			Vignate			
	Settala	Gradiska	Comunità Pioniera del Marghine			
4 types of determinants		Piera	Forlì			
		Paris	Mirandola			

		Maranello	Romano di Lombardia			
Total: 10 SEAPs			San Possidonio			
5 types of determinants *Total: 1 SEAP*		Rescaldina				

Table 10 – Sustainable Energy Action Plans that mentioned more than 2 types of determinants and identified common types of determinants per type number of actions planned for the development of shallow geothermal energy systems

Type of determinants	**Number of actions**					
	7 Actions	**5 Actions**	**4 Actions**	**3 Actions**	**2 Actions**	**1 Action**
“pre-existing experiences” and “regulation and planning”	Settala	Gradiska	Banja Luka	Canegrate	Worms	Köln
		Piera	Hamburg			**Poissy**
		Paris	Cesano Boscone			
		Maranello	Comunità Pioniera del Marghine			
		Rescaldina	Comunità Pioniera del SECS			
			Forlì			
			Mirandola			
			Romano di Lombardia			
			San Possidonio			
			Vanzaghello			
			Vignate			
Total: 21 SEAPs						
“socio-economic characteristics”		Gradiska	Comunità Pioniera del Marghine		Worms	Poissy
		Piera	Forlì		Santa Coloma de Gramanet	Nysiros
		Paris	Mirandola			
		Maranello	Romano di Lombardia			
Total: 18 SEAPs		Rescaldina	San Possidonio			

The adoption of a strategy that integrates the general planning of measures for energy efficiency and renewable energy sources, and the implementation of pilot projects and installations for renewable energy sources is more common when municipalities have adopted a set of actions for the development of shallow geothermal energy systems (Table 11). A strategy with an integrated approach foster the design of a set of measures because it provides an overarching vision in the implementation of energy efficiency and renewable energy sources for thermal purposes.

Table 11 – Sustainable Energy Action Plans that mentioned the presence of a strategy with an integrated approach per number of actions planned for the development of shallow geothermal energy systems

Number of actions					
7 Actions	**5 Actions**	**4 Actions**	**3 Actions**	**2 Actions**	**1 Action**
	Gradiska	Banja Luka	Willich	Frankfurt	Vaterstetten
	Piera	Hamburg	Paterna	Copenhagen	Nysiros
	Abbiategrasso	Cesano Boscone	Canegrate	Genève	Nadlac
	Maranello	Comunità Pioniera del Marghine	Poncarale		
	Rescaldina	Mirandola			
		Romano di Lombardia			
		San Possidonio			
		Sassuolo			
		Vanzaghello			
		Cornwall Council			
					Total: 25 SEAPs

7 Conclusions

This report analysed SEAPs that have adopted specific actions for the development of shallow geothermal energy systems for thermal purposes. The analysis was carried out in order to identify peculiarities, influencing factors and the type of actions planned and implemented for the development of shallow geothermal energy systems.

The analysis identified the presence of collaborations with public authorities, research centres, universities, associations, firms and other municipalities in order to support the design of SEAPs and foster the adoption of a set of actions for the development of shallow geothermal energy systems. These collaborations have still a great development potential, because the majority of signatories have not yet implemented them. In general, the collaborations with other actors can improve the effectiveness of SEAPs by providing know-how, knowledge, economic and human resources.

During the analysis we identified three types of crucial influencing factors: natural and cognitive resources, and different kinds of determinants. These influencing factors play a crucial role in the development of strategy and actions within SEAPs and affected the variety and integration of actions planned for the development of shallow geothermal energy systems because they fostered the municipalities in the correct definition of local context and the exploitation of potential benefits associated with the adoption of shallow geothermal energy system by providing knowledge and know-how.

The analysis highlights the importance of an integrated strategy where the general planning of measures for energy efficiency and renewable energy sources, and the implementation of pilot projects and installations for renewable energy sources are both present. This integrated approach can promote the adoption of an effective set of actions for the development of shallow geothermal energy systems.

In the analysed SEAPs, the more adopted actions are training activities and information campaigns for the deployment of energy efficiency and renewable energy sources followed by pilot projects and installations for the development of shallow geothermal energy systems at local level. These findings show that municipalities want to raise awareness about the possible options for the development of renewable energy sources and energy efficiency within citizens and then to provide tangible projects in order to remove scepticism towards shallow geothermal energy systems.

Some SEAPs integrate more than one action that foster the development of shallow geothermal energy in order to strengthen the effort to overcome technical and non-technical barriers to the development of this renewable energy source. Moreover, the analysis shows that integration of actions for the promotion and development of shallow geothermal energy systems in the SEAP is a step-by-step process that involves the municipality and its organization, all local economic actors but also citizens. In fact, the first efforts should solve the lack of information about benefits, possible risks, potential and operation of shallow geothermal energy systems and overcome related scepticism and opposition, because shallow geothermal energy is still little known by civil servants and citizens. In particular, the assessment of local geothermal resource potential can be a crucial step in the development of shallow geothermal energy systems because it can foster public and private investors. Therefore, policymakers should assume crucial role in setting off and spreading the knowledge and skills related to the promotion of shallow geothermal energy systems.