Deliverable n°: 2.1

Title: **Denmark – National Report**

Date: December 2012

Authors: **Thomas Vangkilde-Pedersen, Anne Mette Nielsen (GEUS)**

Denmark – National Report

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TABLE OF CONTENT

1 Introduction 3

1.1 Current situation in your country 3

1.2 Barriers 5

2 Review of existing documents (or in progress)/Tools to support SGE development 7

2.1 National level 7

2.2 Local/Regional level 11

3 Subsidies /Financial Incentives available 11

3.1 National level 11

3.2 City or regional level 12

4 Insurance systems 12

5 Existing action plans 13

5.1 Elements of the NREAP applying to SGE (heating & cooling) 13

5.2 Sub-national energy scenarios: additional action plans 13

6 Legal framework and Cities Planning 14

6.1 Current legislation and permit procedures in relation to SGE 14

6.2 (Underground) Space planning 17

6.3 Integration of H&C systems in buildings 19

7 Additional Table 21

Definition of Shallow Geothermal Energy

Does a definition exist in your country? (X) Yes ○ No

There is no formal/official definition of Shallow Geothermal Energy in Denmark. The term geothermal energy is commonly associated with deep geothermal energy, while Shallow Geothermal Energy is commonly described as Ground Source Heating and Cooling which covers both open and closed loop systems. Thus Ground Source Heating and Cooling covers horizontal closed loop installations as well as borehole heat exchangers or closed loop boreholes (vertical or inclined) and groundwater based open loop systems.

The regulation of geothermal energy is based on different acts according to the purpose of the installation. Deep geothermal energy is regulated pursuant to the Danish subsoil act under the administration of the Danish Energy Agency. Ground Source Heating and Cooling is regulated pursuant to the Danish environmental protection act and permissions are issued by the Municipalities. An agreement between the Municipalities and the Danish Energy Agency has been made, that if planned boreholes for geothermal energy are deeper than 250 m, the Energy Agency must be consulted to clarify whether the installation are subject to the subsoil act or not[1].

1 Introduction

1.1 Current situation in your country

Designers are predominantly	X National	○ Foreign
Installers are predominantly	X National	○ Foreign
Technology providers are predominantly	(X) National	(X) Foreign
Designers are predominantly independent from installers	○ Yes	X No

If no, specify:

Designers' market is predominantly	X Local	○ Regional	○ National
Installers' market is predominantly	X Local	○ Regional	○ National

Market situation for the period 2006-2011

Ground source heat pumps were popular in Denmark during the first and second energy crisis in the seventies and early eighties and at that time there was a subsidy scheme supporting the development. However, changes in energy prices together with sometimes poor performance of installations caused a rapid decrease of the market which developed very slowly until a rapid increase in 2006. From 2006 and onwards, the number of ground source heat pumps sold in Denmark has increased from around 2000 to around 5000 per year (Danmarks Statistik[2] and

[1] http://www.ens.dk/da-DK/UndergrundOgForsyning/Anden_anvendelse_af_undergrunden/Geotermi/Sider/ Forside.aspx

[2] http://www.statistikbanken.dk/BYGB11

Energistyrelsen[3]). Today, the total number of ground source heat pumps in Denmark is around 27.000. By far the most of these are horizontal closed loop systems and a few hundred are borehole heat exchangers, while there are only some tens of groundwater well open loop systems. Some open loop systems were installed in the eighties for house heating, later installations were primarily for industrial cooling and now large systems are applied with alternating operation (heating in winter and cooling in the summertime). One local district heating company has established a borehole heat storage (48 boreholes, 45 m deep) in combination with a solar heat installation, while another has established a pit storage also combined with solar energy.

The improvement of the market is related to increasing energy prices, increasing awareness of environmental and climate aspects of energy use and improved heat pump technology. In the national energy policy, heat pumps are especially seen as a promising renewable alternative to oil and gas burners in buildings outside district heating areas.

Procedure for installation of borehole heat exchangers
The first step for an owner, who wishes to install a ground source heat system based on borehole heat exchangers, is to apply for permission at the local Municipality. The time of administration of permits may vary from a few weeks to a few months. For a typical one well installation, the following professionals are needed: Drilling company (with a Danish drilling license), Heat pump manufacturer, plumber for installation of heat pump, electrician, perhaps a building contractor for penetration of the foundation of the building and maybe an energy consultant.

Some companies offer turnkey solutions (e.g. plumbers and drilling companies), but an owner can also choose individual agreements with the different professionals involved.

Installation and drilling companies
Several hundred companies offer heat pump installations (many of them plumbers, refrigeration technicians, energy consultants etc.) and more than a hundred are voluntary members of an independent professional association with the purpose of ensuring quality work and advise and offering a guarantee agreement. Membership requires that minimum one employee has completed a 2-day training course offered by the association and passed a written test at the end of the course.

A few Danish companies have invested in drilling equipment especially designed for establishing borehole heat exchangers (vertical and inclined), while other drilling companies use their existing standard equipment. Some companies have agreements with German or Swedish drilling contractors operating under a licensed Danish drilling company.

Financial mechanisms
From the beginning of 2010 to mid-2011, a subsidy of DKK 20,000 (EUR 2,650) was available for switching from an oil-burner central heating system to a ground based heat pump system. Since then, a pool of DKK 42 million (EUR 5.6 million) annually in 2012-2015 has been established with the purpose of providing an incentive for the conversion of a greater number of individual heating systems to heat pumps and solar energy in particular, as a replacement for systems based on fossil fuels. At the present it is not clear how funding will be awarded and for what purposes.

Another pool of DKK 250 million (EUR 33 million) in 2013 and DKK 500 million (EUR 67 million) annually in 2014-2020 has been established to promote energy-efficient use of renewables in industrial production processes. Funding will be awarded as a construction subsidy to projects that

[3] http://www.ens.dk/da-DK/ForbrugOgBesparelser/IndsatsIBygninger/Varmepumper/Documents/3%20udbud%20vedr%C3%B8rende%20varmepumper/Peter%20Dal%20og%20Mikkel%20S%C3%B8rensen-DK%20statistik.pdf

replace fossil fuels with biomass, heat pumps or district heating as well as energy efficiency improvements directly linked to these conversion projects.

1.2 Barriers

Economic, organisational and information barriers
Even though heat pumps are regarded economically attractive compared to e.g. oil and natural gas and despite the fact, that the technology nowadays is reliable and mature and very friendly to the environment and climate, the application of ground source heat pumps in Denmark is still relatively limited. In 2010, the Danish Energy Agency carried out an investigation to shed light on the barriers against increasing use of domestic heat pumps[4]. The following is a summary of the result of the survey.

The survey has revealed that house owners regard installation companies and the internet to be the two most important sources of information about ground source heating. However, the information on the internet is often regarded to be too general and less valuable when it comes to making actual decisions for your own future installation. On the other hand, the experience from other house owners with existing installations is regarded the most reliable, whereas the installation companies are regarded to be superficial, overoptimistic and too eager to sell.

Three parameters are especially important for house owners considering installing a ground source heat pump or house owners summarizing the experience with their ground source heat pump installation:

1. The cost for heating the house must be reduced
2. The operation of the system must be uncomplicated
3. It has to be an environmentally friendly solution

Two of the main barriers against installing a ground source heat pump system are the installation cost and the time of payback for the investment. The time of pay back can either be too long because the house is well insulated and the energy demand already low, or because the house need further insulation and changes of the central heating system, increasing the investment. Another important barrier is doubt about whether the expectations to heating economy, energy savings and power consumption will be fulfilled. However the experience from existing installations proves that this doubt is essentially groundless.

Most of the house owners who ends up not installing a ground source heat pump system have invited tenders from at least two companies, and have experienced great differences regarding both price and dimensioning. Hence they did not trust the advice and calculations and thought that the companies should have spent more efforts evaluating the house and existing installations.

Two thirds of those actually installing a ground source heat pump system are satisfied with the advice and calculations from the companies and half of them have only invited a single company based on experience from friends and family or information on the internet. The last third, who was not satisfied, also accentuates that the evaluation of the house and existing installations performed by the installation company was inadequate.

The actual installation process has been unproblematic for more or less all house owners having chosen a ground source heat pump system, and e.g. digging up the garden has generally not been a

[4] http://www.ens.dk/da-DK/ForbrugOgBesparelser/IndsatsIBygninger/Varmepumper/Documents/varmepumper_i_helaarshuse.pdf

problematic issue for many. Many has experienced a need for adjustments of the operation of the system after a run-in period, but this is not regarded a major problem.

In practice, most installations prove to be very economic, even though the houses are often large, rather old and not very well insulated. Around two third of the house owners, experience savings in the heating costs more or less as they expected and generally between 25-50%. Two third of the house owners find that their ground source heat pump system is running smoothly and one third have experienced minor run-in problems, technical mistakes or mistakes by the installer which needed correction.

Most house owners having installed a ground source heat pump system are very satisfied with the performance and have not experienced problems with heating the house during wintertime. Only around 10% are not satisfied or less satisfied; mainly due to less economical saving, more operation problems, less smooth operation than expected or problems with insufficient heating during winter.

The house owners who have chosen not to install a ground source heat pump system can be divided into two groups. The first group is comfortable with changing to a new heating system, they have easily found information, received useful advice and transparent tenders, know someone who owns an installation, or are technicians themselves. Their reasons for discarding ground source heat pumps are the total installation costs, the time of payback or practical reasons like digging up the garden, radiator system in the house etc. The second group is not comfortable with the idea of a new heating system. They are sceptical about the economy and worry if the house will be warm enough during wintertime and about the durability of the installation. They have not found the invited tenders sufficiently transparent and not been able to obtain clear answers from the companies. These worries are particularly remarkable compared to the positive experiences and high degree of satisfaction among those who have actually installed ground source heat pump systems.

Legal/regulative barriers
In deliverable D.9 of the IEE EU Ground-Reach project, the strict regulations in Denmark regarding protection of groundwater resources are mentioned as a barrier. Installation of ground source heat pumps in Denmark requires permission in case of both horizontal collectors and borehole heat exchangers, as well as in case of groundwater based open loop systems (see also section 6.1), and the municipalities, who issue permits, must include groundwater interests in their considerations.

Protection of the groundwater is normally not a limitation for horizontal collectors, but for borehole heat exchangers the regulation provides the municipalities with a possibility to increase the required safety distance to water wells and to stipulate special conditions in the permit regarding e.g. the construction of the installation, in order to protect a water catchment against contamination. Some municipalities reject applications for borehole heat exchangers if there is uncertainty regarding a possible content of anti-corrosives in the brine. Others are generally very reluctant to issue permits for borehole heat exchangers because of general considerations regarding the groundwater protection and drinking water quality.

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

Another legal barrier is the obligation to join existing or planned district heating systems ("BEK nr 690 af 21/06/2011"). Exemptions can be made for existing buildings which fulfil the requirements for low-energy houses, or which receives more than half of their energy consumption from renewable energy. Exemptions can also be made for new buildings build as low-energy houses.

2 Review of existing documents (or in progress)/Tools to support SGE development

2.1 National level

- **Dedicated Web sites and GIS (general public)** **X Yes** **○ No**

There is a number of websites in Denmark dedicated to the use of heat pumps, which also includes information about shallow geothermal energy. They are all based on independent information and advice and with access for all, free of charge. The energy website http://www.goenergi.dk/ administrated by the Danish Energy Agency is no longer updated, but a new is on the way and expected to be up and running by the end of 2012.

Other independent websites:

- http://www.energitjenesten.dk/
- http://www.bolius.dk/
- http://varmepumpeinformation.dk/
- http://www.varmepumpesiden.dk/
- http://www.varmepumpeinfo.dk/

The website http://www.vp-ordning.dk provides general information about heat pumps and installation of systems, but is commercial in the way that it is an independent professional association of installation companies.

In addition to this there is a large number of commercial websites representing companies selling heat pumps, or involved in parts of the installation/design process of heat pumps systems, including shallow geothermal systems.

The project website http://www.geoenergi.org/ informs about the work and results of the GeoEnergy project. The objective of the project is to pave the way for a wider application of heat pump systems based on borehole heat exchangers in Denmark, by acquiring know-how and developing tools and best practice for the design and installation of systems as well as providing training and dissemination. The project is co-financed by the project partners and the Energy Technology Development and Demonstration Programme (EUDP) of the Danish Energy Agency.

- **Support tools** **(X) Yes** **○ No**

Until the end of 2011 the Danish Energy Agency kept an updated list of heat pumps that could be approved according to the building regulations and the demands herein to the normalized seasonal performance factor. The list has now been substituted by an energy label system on the website http://www.goenergi.dk/, which is currently not being updated.

The website http://www.vp-ordning.dk provides a list of more than a hundred installation companies being voluntary members of an independent professional association with the purpose of ensuring quality work and advice and offering a guarantee agreement. Membership requires that minimum one employee has completed a 2-day training course offered by the association and passed a written test at the end of the course.

As mentioned above, the research and development project GeoEnergy (http://www.geoenergi.org/) aim at developing tools for design and installation of borehole heat exchangers. Project activities include:

- Collection and analyses of existing information and experience and identification of key parameters for planning, designing and installing heat pump systems based on borehole heat exchangers.
- A comprehensive mapping and measuring program of surface temperatures, temperature gradients and thermal properties of different soil types and materials.
- Optimization of system design with respect to environment and economy based on experience from existing installations and a new test site. The analyses will include drilling and completion of boreholes, performance tests, system control and automation, calculation of energy balance, energy storage (heating and cooling) and modelling of heat and fluid flow.
- Construction of a database with results of information gathering, measuring programme and mapping efforts.
- Dissemination activities including public web-based database, course material for training and education, workshops and seminars, technical guidelines and recommendations for legal framework.

The main result of the project will be a website dedicated to shallow geothermal energy and with a facility to estimate the expected geological conditions and thermal properties of the shallow underground (0-250 m) at a specific location. This web based facility will utilise the information in the national borehole database Jupiter (see section 6.2) and the work and results of the GeoEnergy project.

Geothermal operations inventories ○ **Yes** (X) **No**

There is no general inventory of shallow geothermal operations in Denmark. However, borehole heat exchangers and boreholes for groundwater based open loop systems can be identified in the public national borehole database Jupiter. Reporting to the Jupiter database is mandatory for groundwater based open loop systems but voluntarily for borehole heat exchangers. In practice, most borehole heat exchangers have probably been reported to the Jupiter database, but definitely not all. GEUS (the national geological survey) has suggested making reporting to Jupiter mandatory also for borehole heat exchangers and expect/hope that this will be implemented in the regulations in the near future. However, a decision is pending whether it will be in conflict with EU legislation.

Underground operations inventories (X) **Yes** ○ **No**

There is no general inventory of all shallow underground operations in Denmark. However, inventories exist of underground operations for production of oil and gas as well as deep geothermal energy. There also exist more or less updated plans of pipelines, cables, sewers, and other utilities that can be made available from the public authorities upon request. Boreholes related to water catchment and raw materials are reported to the national borehole database Jupiter at GEUS. Inventories of onshore raw materials are provided by the regional authorities and offshore by the

Danish Nature Agency. The municipalities issue permits for raw material production and register the areas involved.

Geothermal resources evaluation ○ **Yes** **(X) No**

No evaluation exists of the shallow geothermal resources in Denmark. However, the deep geothermal resource was evaluated for the first time in the eighties with later updates, detailing and refining the evaluation, in 1998 and 2009.

Geothermal resources management ○ **Yes** **X No**

No resources management exists for shallow geothermal energy in Denmark. For deep geothermal energy, there is a license system in place administrated by the Danish Energy Agency.

Water resources management **X Yes** ○ **No**

The Danish water supply act specifies that the management of water resources include:

- Designation of areas with specific drinking water interests
- Designation of areas with drinking water interests
- Designation of areas with limited drinking water interests
- Delimitation of areas specifically sensitive to contamination
- Delimitation of areas where specific actions are necessary for groundwater protection

In the areas with specific drinking water interests and in water catchment areas outside these, a comprehensive groundwater mapping organised by the Danish Nature Agency is carried out. Based on this mapping, areas specifically sensitive to contamination are identified by the Nature Agency and the municipalities are establishing action plans for groundwater protection.

The water resources are administrated by the municipalities, who also issue permits for ground source heating and cooling systems. Based on the groundwater area designation, which is available from a public web based GIS, http://kort.arealinfo.dk/, they have a possibility to increase the required safety distance from a ground source heating and cooling system to water wells and to stipulate special conditions in the permit regarding e.g. the construction of the installation, in order to protect a water catchment against contamination.

Other

- **Best practice (or technical) Guideline documentation** **(X) Yes** ○ **No**

The report “D2 Parametre ved design af jordvarmeanlæg” (in English: “D2 Parameters for ground source heating systems”) gives an overview of the most important parameters for design of ground source heating systems and practical considerations related to the construction of the installation. The report is not a formal technical guideline, but is one of the deliverables of the GeoEnergy project.

In addition, the report “D3 Geologi og jordvarmeboringer” (in English: “D3 Geology and borehole heat exchangers”) gives an overview of the geological conditions in the upper 300 m of the Danish subsurface as well as the current state of knowledge on thermal properties of Danish soil types. The report also outlines the importance of knowledge of groundwater flow, hydraulic head and drinking water interests when planning borehole heat exchangers.

Both reports are available from the GeoEnergy project web site (http://geoenergi.org/) and more reports, e.g. on surface temperatures and temperature gradients, thermal properties of soil and materials, guidelines for drilling and results of heat and fluid flow modeling, are planned.

An earlier and third report "Varmepumper med lodrette boringer som varmeoptager" (in English: "Heat pump systems based on borehole heat exchangers") gives an evaluation of the potential for using heat pump systems based on borehole heat exchangers for space heating in Denmark. The conclusion is positive, but also highlights some of the uncertainties and to some extent the lack of experience in connection with this type of installation. The project was co-financed by the partners and the R&D programme "ELFORSK" of the Danish Energy Association and the report is available from the website http://www.elforsk.dk/.

If yes, do they include information about energy performances? (X) Yes ○ No

If yes, do they include information about economic performances? (X) Yes ○ No

To some extent, the reports include information about energy and economic performances.

- **Training activities dedicated to SGE** **X Yes** **○ No**

"Den jydske Haandværkerskole" educate electrical engineers and refrigeration and air-conditioning engineers and also offers in-service training for professionals. Their training activities have until now been focusing on refrigeration technique, but will presumably focus more on heat pump technology in the future.

"VIA University College, School of Technology and Business" in Horsens educate engineers and offers a 4 ECTS point course in "Shallow Geothermic" where borehole heat exchangers and shallow geothermal energy constitute the main part of the course. Another course, "Sustainable Energy", include elements of ground source heating corresponding to 1 ECTS point.

From August 2012 a new 4-ECTS course will be offered, focusing on energy efficiency, economic considerations and comparison of energy systems. Also from August 2012 a 1-day in-service training course for professionals involved in design and installation of ground source heat pump systems will be offered on an ad-hoc basis.

In November 2012, ENVINA, which is an educational cooperation between the municipalities, will offer a one day introduction course in ground source heating for administrative personnel.

- **certification for professionals** X and (X) Yes ○ No

Since 2001 a certification scheme for drillers has been in place. Responsible leaders in a drilling company must have an A-certificate. Members of a drilling crew must have a B-certificate. Persons without a B-certificate can be part of a drilling crew, provided the work is led by a person who has the B-certificate.

The Danish Energy Agency is working on the implementation of a certification/qualification scheme for installers of heat pump systems according to the requirements in the EU RES Directive 2009/28/EF.

If yes, is it mandatory?	X and (X) Yes	◯ No

The certification scheme for drillers has been mandatory since 2001.

The certification/qualification scheme for installers is expected to be voluntary in the beginning and mandatory from 2014 and onwards.

- **certification for organizations**	◯ Yes	X No
If yes, is it mandatory?	◯ Yes	◯ No
- **Codes and standards**	◯ Yes	X No
- **Other**		

2.2 Local/Regional level

In Denmark 29 cities has signed the Covenant of Mayors. Of these, 16 have issued a Sustainable Energy Action Plan (SEAP). Ground source heating is specifically mentioned in 9 of the SEAP's. In the remaining 7 SEAP's, only heat pumps in general are mentioned. However, it is reasonable to assume, that heat pumps in this case also include ground source heat pumps.

Two Danish cities (municipalities) have specifically expressed a clear interest in the Regeocities project by signing a Letter of Intend, Skanderborg Kommune and Odense Kommune (Kommune is Danish for municipality). Odense Kommune has signed the Covenant of Mayors, but has not submitted a SEAP, while Skanderborg Kommune has not signed the Covenant of Mayors.

Skanderborg Kommune
Skanderborg Kommune offers no specific information about shallow geothermal energy. On the website of the municipality, there is a link to a digital version of the documents for application for permission to establish a ground source heating system. In addition there is a very short summary of some of the conditions in the regulation and a reference, but no link, to the statutory order.

Odense Kommune
Odense Kommune also has a link to a digital application process for permission to establish a ground source heating system on the website of the municipality, and a link to the statutory order regulating closed loop systems. In addition, Odense Kommune also provides brief information on the function of different types of ground source heating systems in combination with heat pumps and a web based GIS facility to check for conditions that may have implications for the application/permission.

3 Subsidies /Financial Incentives available

3.1 National level (X) Yes ◯ No

None of the financial incentives, previous, current or future, have been or will be directed solely to shallow geothermal energy technology.

From the beginning of 2010 to mid-2011, a subsidy of DKK 20,000 (EUR 2,650) was available for switching from an oil-burner central heating system to a ground based heat pump system. Since then, a pool of DKK 42 million (EUR 5.6 million) annually in 2012-2015 has been established with the purpose of providing an incentive for the conversion of a greater number of individual heating systems to heat pumps and solar energy in particular, as a replacement for systems based on fossil fuels. At the present, it is not clear how funding will be awarded and for what purposes.

In 2013 and 2014, a pool of DKK 500 million will be available for energy renovation of existing buildings. Switching to renewable energy will be part of the subsidy scheme.

Another pool of DKK 250 million (EUR 33 million) in 2013 and DKK 500 million (EUR 66 million) annually in 2014-2020 has been established to promote energy-efficient use of renewables in industrial production processes. Funding will be awarded as a construction subsidy to projects that replace fossil fuels with biomass, heat pumps or district heating as well as energy efficiency improvements directly linked to these conversion projects.

As one of the means to overcome the consequences of the economic crisis, a tax-deduction has been applied for people having work carried out on their private houses. The deduction has a maximum of DKK 15,000 (EUR 2,000) pro persona (adults) per year and covers different kind of work improving the house, including renewable energy installations, e.g. ground source heat pumps. The main purpose of the incentive is to keep craftsmen and others in their jobs and to create new jobs, but indirectly it may serve as an incentive to switch to renewable energy.

Another indirect incentive is the possibility to "sell" CO_2 emission reductions in the form of energy savings to energy companies. The energy companies have an obligation to contribute to the reduction of CO_2 emissions in Denmark. If a house owner can document energy savings, an energy company can "buy" the savings. Switching to ground source heating and cooling is one of the ways to gain energy savings and thus the arrangement may serve as an indirect incentive to invest in the technology. Not all energy companies offer this solution, but the owner can "sell" his energy savings to any energy company and not only his own supplier of energy.

3.2 City or regional level ◯ Yes X No

At the moment there are no financial incentives available for shallow geothermal energy or other renewables neither at the city nor regional level.

4 Insurance systems X Yes ◯ No

When a ground source heating system is installed, it is insured as a part of the house insurance. However, an owner should always check with the insurance company to make sure that all parts of the geothermal heating system are covered by the insurance, including both indoor and outdoor parts of the system.

During construction of the ground source heating system, the professional insurance of the construction companies will cover damages that the companies can be held responsible for, but it is highly recommended also to sign your own construction insurance, covering damages that the construction companies cannot be held responsible for.

Insurance companies do generally not offer private house owners insurances covering the general performance of ground source heating systems. It may be possible to sign such insurance, but probably at a high cost. For larger projects it is probably more common and more recommendable to take out an insurance including the quality of the system performance.

Another precaution, which may serve as a kind of "insurance" is to have the ground source heating system registered in the Land Register. Such a registration is essential when heating pipes or boreholes are placed on properties owned by other persons and can serve to ensure the access rights and ownership in case such property is sold to third persons or in case of disputes.

5 Existing action plans

5.1 Elements of the NREAP applying to SGE (heating & cooling)

The National Renewable Energy Action Plan (NREAP) for Denmark states the contribution of geothermal heat pumps to the total energy consumption for heating and cooling in 2005 and 2010 and provides the targets for 2015 and 2020[5]:

- 2005: 52 ktoe, 0.6% of the total energy consumption for heating and cooling
- 2010: 119 ktoe, 1.5% of the total energy consumption for heating and cooling
- 2015: 166 ktoe, 2.1% of the total energy consumption for heating and cooling
- 2020: 199 ktoe, 2.6% of the total energy consumption for heating and cooling

The share and targets of deep geothermal heat in Denmark is stated to be 0 in the NREAP, which seems odd, since Denmark has two deep geothermal energy plans in operation and plans for several new ones. It is not clear whether the deep geothermal heat is included in the figures for geothermal heat pumps.

It is argued in the 2011 evaluation of the NREAPS[6] by the European Geothermal Energy Council (EGEC) that the Danish 2020 target of 199 ktoe, is conservative. It corresponds to a growth of 8 ktoe/year, while the growth 2005 to 2010 was more than 13 ktoe/year. Thereby the growth scenario is below "business as usual" despite the fact that the ground source heat pump market is still developing and that several measures are planned to have more renewable heating in buildings.

5.2 Sub-national energy scenarios: additional action plans

The municipalities in Denmark have a possibility to make strategic energy action plans. To facilitate this work, the Danish Energy Agency has prepared a guideline on how to:

- Map the current energy consumption and energy supply
- Project the future energy demand and supply
- Map the potential for energy saving
- Map the potential for exploitation of local energy resources

The guideline for strategic energy action plans does not mention shallow geothermal energy, but gives a detailed description of deep geothermal energy as a potential local energy resource.

[5] http://www.eea.europa.eu/data-and-maps/figures/national-renewable-energy-action-plan
[6] http://egec.info/wp-content/uploads/2011/03/NREAP-Evaluation-FINAL-March-2011.pdf

A new political energy agreement from the 22nd of March 2012 includes a pool of DKK 19 million (EUR 2.5 million) in 2013-2015 assigned for partnerships for strategic energy planning in the municipalities. Furthermore, the Danish Energy Agency and the municipalities have started a revision of the tasks and authority of the municipalities on the energy area, with the purpose of suggesting possible changes which may advance the energy switch envisaged in the new political agreement.

Legal obligation	◯ Yes	X No
Volunteer	X Yes	◯ No

- **Skanderborg Kommune**

Skanderborg Kommune has a Climate Policy for 2011-2013[7], but shallow geothermal energy is not mentioned as a specific renewable energy source to be part of the future solution.

- **Odense Kommune**

Odense Kommune has a climate plan for 2010-2012[8], but shallow geothermal energy is not mentioned as a specific renewable energy source to be part of the future solution.

6 Legal framework and Cities Planning

The regulation of shallow geothermal energy in Denmark is national and the steps and procedures to follow for establishing ground source heating and cooling are the same for the whole country. However, the permitting authority is the local municipality, which can introduce differences in the administration of the regulation.

6.1 Current legislation and permit procedures in relation to SGE

Ground Source Heating and Cooling is regulated pursuant to the Danish environmental protection act and permissions are issued by the municipalities. There are different regulations for closed and open loop systems, respectively.

The municipalities and the Danish Energy Agency have agreed, that if planned boreholes for geothermal energy are deeper than 250 m, the Energy Agency must be consulted to clarify whether the installation are subject to the subsoil act or not[9].

Closed loop systems

Permissions for closed loop systems are administrated pursuant to the statutory order "BEK nr 1019 af 25/10/2009". The purpose of the order is to prevent contamination of the groundwater, soil or underground, by setting up rules for construction, operation and inspection of ground source heating and cooling installations. Below is a summary of the most important content of the order:

[7] http://www.skanderborg.dk/Borger/Natur-og-miljø/Klima-og-bæredygtighed/Politik-og-aftaler.aspx#129705

[8] http://www.odense.dk/Topmenu/Borger/ByMiljoe/Natur%20Miljoe%20Baeredygtighed/Miljo/Emneindgang/Klima/Klimaarbejde/Klimaplan%202010-12.aspx

[9] http://www.ens.dk/da-DK/UndergrundOgForsyning/Anden_anvendelse_af_undergrunden/Geotermi/Sider/ Forside.aspx

- Ground source heating systems must not be established or changed without a permit.
- Horizontal installations must be placed at least 50 m from drinking water wells and at least 5 m from other water wells.
- Borehole heat exchangers must be placed at least 300 m from drinking water wells and at least 50 m from other water wells.
- Horizontal installations with direct expansion must be placed at least 10 m from drinking water wells supplying 10 or more households and at least 5 m from drinking water wells supplying less than 10 households.
- The municipality can increase the required safety distance to drinking water wells and stipulate special conditions in the permit regarding e.g. the construction of the installation, in order to protect a water catchment against contamination.
- The distance between boreholes for borehole heat exchanger systems must be at least 20 m.
- The order specifies the type of plastic pipes that can be used for horizontal and borehole systems, respectively.
- A specific statutory order for the execution of boreholes also applies for boreholes for closed loop systems ("BEK nr 1000 af 26/07/2007").
- If the void between plastic pipes and borehole wall in borehole heat exchangers is not entirely filled with sealing material, the system must be designed to ensure that the inlet temperature for the heat pump is always above 2 °C.
- Up to 35% antifreeze of the following types, are allowed in the heat carrier fluid of ground circuits (For the two latter, an exhaustive declaration of the content of anti-corrosives must be available):
  - Ethanol
  - Isopropanol
  - Ethylene Glycol
  - Propylene Glycol
- A ground source heating system must be tight and equipped with a pressure-drop alarm and auto-stop device in case of leakage.
- Before start-up of a ground source heating system, a leakage test must be performed. The leakage test must be performed using clean water at 1.5 times the working pressure.
- A yearly inspection of the ground source heating system must be performed by a professional.

An owner has to fill in an application to the municipality or alternatively give power of attorney to a drilling or installation company to apply for permit. The time of administration of permits may vary from a few weeks to a few months.

The statutory order for closed loop systems only deals with systems for heating. Cooling or alternating operation with both warming and cooling is in fact not covered by the order. Also, the order in practice only covers vertical borehole heat exchangers and not inclined/deviated boreholes as a consequence of the wording.

Open loop systems

Permissions for open loop groundwater based systems are administrated pursuant to the statutory order "BEK nr 1206 af 24/11/2006". By setting up rules for construction, operation and inspection of installations, the purpose of the order is to ensure that the aquifer groundwater quality is preserved and that no water catchments are contaminated. Below is a summary of the most important content of the order:

- Open loop groundwater systems must not be established or used without a permit.
- The applicant must document that groundwater will be produced from and re-injected into the same aquifer.
- The applicant must document that investigations have been performed that provides the following information about the aquifer:
  - The geology, hydrogeology and spatial extent
  - The hydraulic properties including connectivity to other aquifers
  - The hydrothermal properties
  - The chemistry and microbiology
- An application must include information documenting that:
  - There is no risk for groundwater contamination by agents used in the heating circuit
  - There is no risk for soil failure caused by the re-injection of produced groundwater
  - The installation is a closed system, with no possibility of invasion of atmospheric air and with no water treatment
- Numerical modelling is required in order to show that:
  - The temperature of the groundwater in existing water catchments will not increase more than 0.5 °C
  - The groundwater resource in "areas of specific drinking water interests" will be exploitable again 10 years after closing the installation
- No mixing of groundwater with other fluids must take place in the consumer circuit.
- The installation must be equipped with a pressure-drop alarm and auto-stop device in case of leakage.
- The monthly average outlet temperature of the groundwater for re-injection must not be lower than 2 °C
- The outlet temperature of the groundwater for re-injection must not exceed 25 °C and the monthly average outlet temperature must not exceed 20 °C.
- Before start-up, the owner must provide a chemical analysis of the water in the aquifer used for production and re-injection, including temperature measurements.
- Three months after start-up, and then on a yearly basis, the owner must analyse the outlet water for agents that could potentially be dissolved from the system.
- An open loop installation must be equipped with temperature sensors measuring the inlet and outlet temperature of the groundwater.
- The re-injection well must be equipped with temperature sensors connected to an automatic data-logging system and the logged outlet temperatures must be reported on a yearly basis to the municipality.
- The extraction and re-injection of groundwater must be monitored and reported on a yearly basis to the municipality.
- A yearly inspection of the open loop system must be performed by a professional.

The statutory order for execution of boreholes ("BEK nr 1000 af 26/07/2007") also applies to boreholes for open loop groundwater based systems. This is not specifically stipulated in the order for open loop systems, but implicitly understood from the wording of the order for boreholes.

An owner has to fill in an application to the municipality or alternatively give power of attorney to e.g. a consultant to apply for permit. The application evaluation procedure for open loop systems is more complicated than for closed loop systems and the time for obtaining a permit or rejection is in the order of months rather than weeks.

6.2 (Underground) Space planning

The use of the Danish underground for production or storage purposes is administrated by the Danish Energy Agency pursuant to the Danish subsoil act. They issue licenses for exploration and production of hydrocarbons and permits for exploration and production of geothermal energy. The exploration and production of raw materials is administrated pursuant to the Danish raw materials act. Offshore, the raw materials are administrated by the Danish Nature Agency. Onshore, the regional authorities are responsible for mapping and designation of raw material areas and guidelines for the exploitation, while the municipalities issue permits and are responsible for inspections of the pit areas.

The groundwater resources in Denmark are administrated by the Danish Nature Agency pursuant to the Danish water supply act as described in section 2.1. Mapping and designation of areas with drinking water interests and areas sensitive to contamination are carried out by the Danish Nature Agency, while the municipalities are establishing action plans for groundwater protection and issue permits for water extraction.

The administration of shallow geothermal energy is pursuant to the Danish environmental protection act and permits are issued by the municipalities. No mapping of the shallow geothermal potential has been, or is being, carried out in Denmark.

Is there a will in your country to link urban planning closer with renewable energy plans?

◯ Yes (X) No

District heating systems, water catchment and protection of the groundwater seem to have higher priority than shallow geothermal energy in Denmark.

Are there specific considerations of renewable energy integration (i.e. shallow geothermal energy) into construction licences?

(X) Yes ◯ No

The building regulation in Denmark is very ambitious regarding energy efficiency and rules have been set out for low energy buildings. The low energy building class is voluntary until 2020, where it will become mandatory. The building regulations focus on insulation and energy consumption, rather than type of heating system. However, for ground source heat pumps (and other heat pumps) there are different minimum requirements for the normalized seasonal performance factor, depending on the heating installation in the building (floor heating or radiators).

The political energy agreement from the 22nd of March 2012 set out deadlines for phasing out fossil fuel based central heating systems. From 2013, a stop for installation of oil- and natural gas burners in new buildings is introduced. In 2016, a stop for installation of oil burners in existing buildings is introduced in areas with district heating or natural gas infrastructure.

Is there a regulation concerning interactions between thermal uses of the underground and other utilisations (such as constructions, use of water, …)?

X Yes ○ No

The regulation of ground source heating and cooling systems (see section 6.1) takes wide consideration to groundwater interests. The municipalities has to include this in the administrative procedure and have a possibility to increase the required safety distance to drinking water wells and stipulate special conditions in the permit, in order to protect water catchments against contamination. For open loop groundwater based systems, there is a regulation in place concerning interaction between individual installations and between installations and the groundwater resource. Besides this, there is no regulation ranging one utilisation of the underground over the other, or concerning the interactions between utilisations.

Is there a national/regional/local database of wells?

X Yes ○ No

The Geological Survey of Denmark and Greenland, GEUS, maintain a national public database of boreholes, the Jupiter database[10]. The database currently includes more than 270.000 wells and the information can be viewed using a web based interface, free of charge. Reporting to the Jupiter database is mandatory for boreholes related to water catchment and raw materials. Hence, reporting is mandatory for groundwater based open loop systems but voluntarily for borehole heat exchangers. In practice, most borehole heat exchangers have probably been reported to the Jupiter database (see also section 2.1).

Denmark is divided into mapping areas, and all Jupiter boreholes are numbered successively within these areas. Borehole numbers are assigned upon application for drilling permit. The administrative information included for all boreholes comprise:

- Id. No./Location/address/map
- Owner
- Date of drilling
- Drilling contractor
- Purpose and use
- Depth
- Mapping area
- Coordinate system and datum, vertical reference system
- Coordinates and vertical reference

When a borehole is drilled, soil samples are sent to the laboratory at GEUS for geological description and other types of information included in the database, when available, are:

- Active permits (e.g. for water catchment)
- Pumping volumes
- Geology and stratigraphy
- Well completion
- Hydrological information (e.g. pumping tests, measurements of hydraulic head)

[10] http://www.geus.dk/jupiter/index-dk.htm

- Groundwater chemistry
- Sediment chemistry
- Water supply installations

Finally there can be links to available geophysical well logs in the geophysical database GERDA[11] and to other documents relating to the borehole.

Boreholes for petroleum exploration and deep geothermal energy are confidential for 5 years and furthermore, they are not publicly available, but can be bought upon request for a price covering the cost for storage and maintenance of data.

Are there public databases concerning all the uses of the underground?

◯ Yes X No

As described in section 2.1, the uses of the underground in Denmark are registered in different databases/inventories and no general database exists concerning all the uses.

6.3 Integration of H&C systems in buildings

Do you have specific targets for integration of H&C systems (in parallel to development of renewable energy) concerning renovation/refurbishment of buildings?

(X) Yes ◯ No

One of the goals of the new energy agreement is to reduce the energy consumption for heating and cooling of buildings. For new buildings, the energy requirements in the building regulation support this goal, but energy renovation of existing buildings will also be necessary to achieve the goal. Switching to renewable energy, including ground source heating and cooling, can be one of the solutions, but no specific goals for this is formulated.

Do you have a specific regulation on H&C systems concerning new constructions?

(X) Yes ◯ No

As described in section 6.2, oil- and natural gas burners will not be allowed in new buildings from 2013. Furthermore, the building regulation specifies minimum requirements for the normalized seasonal performance factor of heat pumps.

What are the intentions in the regulations and specific targets and how does it fit with geothermal energy development?

The regulation does not specifically promote shallow geothermal energy.

Are existing plants subject to periodic monitoring/report? X **Yes** ◯ **No**

According to the statutory orders for open and closed loop ground source heating and cooling installations, respectively, yearly inspections by professionals are required.

[11] http://gerda.geus.dk/Gerda/

Are existing plants subject to mandatory maintenance? ◯ **Yes** X **No**

No mandatory maintenance are specified for open and closed loop ground source heating and cooling installations, respectively, except for the yearly inspections.

Are operational performances (e.g. energy efficiency) guaranteed? (X) **Yes** ◯ **No**

There is various performance guarantees on the market for ground source heating and cooling installations.

Most installation companies offer a 2-year guarantee on the work carried out. In some cases, the offered guarantee may be longer if the yearly inspections are performed by professionals with an authorization.

Some companies offer a 10 year guarantee on the compressor part of the heat pump.

A voluntary, independent professional association of installation companies provides a guarantee agreement concerning the work carried out by the members.

One drilling company offers a 25-year performance guarantee on borehole heat exchangers based on mutually agreed preconditions.

7 Additional Table

We propose the tables below, from the publication of Haehnlein, Bayer, Blum, 2010 (To facilitate the comparison of the situations between countries)
We suggest 2 tables:

a) **For Ground Water Heat Pumps**
b) **For vertical Heat exchangers connected to Heat Pump**

For Ground Water Heat Pump	Possible answer	Comments
Are there temperature thresholds?	Yes	
If yes:	Technical thresholds	
Please report the specific values	Relative values	
	(limit for heating/cooling): 0.5 °C	The temperature of the groundwater in existing water catchments must not increase more than 0.5 °C
	Absolute values	
	(maximum/minimum temperature): 20 °C, 25 °C / 2 °C	The monthly average outlet temperature of the groundwater for re-injection must not be lower than 2 °C The outlet temperature of the groundwater for re-injection must not exceed 25 °C and the monthly average outlet temperature must not exceed 20 °C.
Are the thresholds legally binding?	Yes, state level	
Which are the relevant laws/ordinances?	BEK nr 1206 af 24/11/2006	

What is the basis for these values?	Partly rule of thumb regarding min. value and partly scientific studies of bacteria growth regarding max. Value	
If no:		
Is there a particular reason?		
Are regulations planned for the future?		
Are there regulations referring to minimum distances?	No	
If yes:		
Which are the relevant laws/ordinances?		
What is the basis for these values?		
If no:		
Is there a particular reason?	Impact on other water catchments are regulated via relative limit for heating	
Are any regulations planned for the future?	No	
Does your country have any other laws, ordinances or regulations concerning thermal groundwater use?	Yes	
If yes, which are the relevant laws or ordinances?	BEK nr 1000 af 26/07/2007	The statutory order for execution of boreholes ("BEK nr 1000 af 26/07/2007") also applies to boreholes for open loop groundwater based systems. This is not specifically stipulated in the order for open loop systems, but implicitly understood from the wording of the order for boreholes.

For vertical heat exchangers	Possible answer	Comments
Are there distance thresholds? Minimum distance between 2 systems Minimum between two vertical heat exchangers	Yes 20 m between systems/BHE's 300 / 50 m to water catchments	The distance requirement does not distinguish between individual systems or individual BHE's in a system Drinking water / other catchment
If yes:		
Please report the specific values	Technical thresholds Relative values (limit for heating/cooling) : 2 °C Absolute values (maximum/minimum temperature)	If the void between plastic pipes and borehole wall in borehole heat exchangers is not entirely filled with sealing material, the system must be designed to ensure that the inlet temperature for the heat pump is always above 2 °C
Are the thresholds legally binding?	Yes state level	
Which are the relevant laws/ordinances?	BEK nr 1019 af 25/10/2009	
What is the basis for these values?	 Rule of thumb 	
If no:		
Is there a particular reason?		
Are any regulations planned for the future?		
Are there regulations referring to minimum distances?		