Geothermal Energy Use, Country Update for Denmark

Søren Erbs Poulsen[1], Henrik Bjørn[1], Anders Mathiesen[2], Lars Henrik Nielsen[2], Henrik Vosgerau[2], Thomas Vangkilde-Pedersen[3], Claus Ditlefsen[3], Birte Røgen[4]

[1] VIA University College, Chr. M. Østergaardsvej 4, 8700 Horsens, Denmark

[2] Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, 1350 Copenhagen.K, www.geus.dk.

[3]Geological Survey of Denmark and Greenland (GEUS), C. F. Møllers Allé 8, 8000 Aarhus, Denmark

[4]Energistyrelsen, Carsten Niebuhrs Gade 43, 1577 København, Denmark

soeb@via.dk

Keywords: Deep geothermal energy, Thisted, Copenhagen, Sønderborg, district heating, absorption heat pumps, ground source heating and cooling, borehole heat exchangers,

ABSTRACT

A number of publicly financed research projects during the last decade have identified the presence of huge deep geothermal resources in the Danish subsurface and have stimulated the interest for utilizing the resource as an important component of a green sustainable energy mix. An ongoing three-year project (GEOTHERM) will further address and remove geological, technical and commercial obstacles for utilization of the geothermal resources.

The use of shallow geothermal resources is still scarce in Denmark. In recent years, the Termonet concept for collective GSHP-based sustainable heating and cooling outside the district heating network (1/3 of consumers) has emerged. Different business models are compatible with the Termonet, which in three actual cases is shown to be economically feasible when compared to alternative solutions. Moreover, the Termonet facilitates passive cooling/seasonal heat storage and balancing of the power grid by storing electrically heated water when electricity prices are favourable, giving it significant added value compared to traditional alternatives.

1. INTRODUCTION

Denmark has moderate temperature gradients, but widespread geothermal aquifers and district heating networks in most of the Danish towns supplying heat to 60 % of Danish houses. Aquifers have been identified around many of these towns with sufficient heat to cover 20 – 50 % of their heat demand for hundreds of years.

A recent study has assessed the reserves in a licence for Greater Copenhagen Area to 60,000 PJ or 1/3 of the heat demand for about 5000 years. This study is reported in Magtengaard 2010.

Present plants use absorption heat pumps and produces heat for district heating. Absorption heat pumps can be driven for free if other heat producers such as biomass boilers can supply 160°C driving heat at district heating cost levels.

The Danish legal framework is in place and there is an increasing interest in geothermal energy among district heating companies and municipalities. Geothermal plants receive no funding, but high taxes on fossil fuels and the focusing on CO_2 makes it attractive to substitute the burning of fossil fuels on CHP plants with wind turbine power, biomass and geothermal heat.

Danish aquifers have not been found suitable for power production, as sufficiently permeable layers are too cold. They may, however, be considered used for power production based on stored heat from the sun, excess incineration plant heat etc. or heat pumps driven by excess wind turbine power.

Geothermal plants can be used for long term heat storage with low temperature losses and a study has been initiated to investigate the possibilities and problems.

Shallow geothermal energy has been utilized in Denmark since the late 1970's following the oil crisis. Energy is produced primarily by means of ground source heat pumps with horizontal collectors but also from a limited number of borehole heat exchangers (BHE). In one case, a pilot borehole thermal energy storage (BTES) with 48 BHEs is used for seasonal heat storage by the local district heating company in Brædstrup, Denmark. In addition to closed loop borehole heat exchangers, aquifer thermal energy storage (ATES) systems are used mostly for cooling of e.g. hospitals and larger office buildings but to some extent also for heating.

2. DEEP GEOTHERMAL ENERGY

The geothermal resources in the Danish underground are enormous (corresponding to around 3 times the heat from our North Sea oil) and may potentially constitute the district heating to 1/3 - 1/2 of the Danish households for hundreds of years. At present, only a very limed fraction of the resources are utilized in the three existing geothermal power plants in Thisted, Sønderborg and on Margretheholm near Copenhagen (see locations in Figure 1).

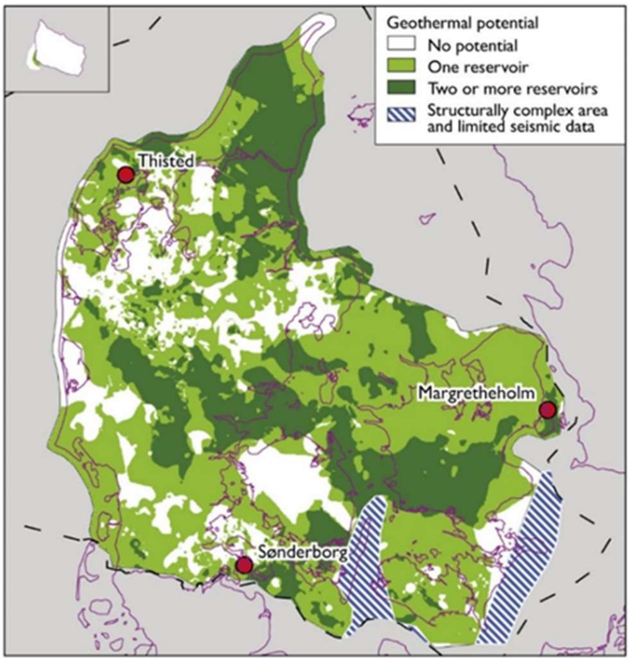

Figure 1: Distribution of lithostratigraphic units with reservoir properties suitable for geothermal exploration in the geothermal depth zone (800–3000 m). After Vosgerau et al. 2016.

Several initiatives has been undertaken in order to stimulate the exploitation of the geothermal resource and thus the transformation to a more sustainable energy mix in Denmark. A number of public financed research projects has thus been carried out over the last decades, focusing on the implementation of deep geothermal energy for district heating and thereby replacing fossil fuel, especially coal and oil. These projects has considerably increased our knowledge of the Danish subsurface, and confirmed the presence of its huge geothermal resource and indicated where the geological conditions are most suitable for the extraction of deep geothermal energy. An outcome of one of the recent studies is a user-friendly WebGIS portal providing an overview of the amount and quality of existing geodata, the geological composition of the subsurface, and interpreted thematic products such as depth and thickness maps of potential geothermal reservoirs in the deep Danish subsurface (http://DybGeotermi.GEUS.dk; Vosgerau et al. 2016). An important thematic map outlines where in Denmark the geothermal potential appears most promising based on current knowledge and may thereby ensure that future explorations are directed towards these areas, thereby also reducing the risk of making unsuccessful wells in areas where the geothermal potential is low (Figure 1).

An ongoing project, GEOTHERM, initiated in 2017 and running for three years under the Innovation Fund Denmark focusses on the entire geothermal life cycle as well as the whole geothermal brine circuit from reservoir to the plant on the surface and back to the reservoir. The goal of the project is to be able to advice how to ensure stable operation and realization of commercially profitable geothermal projects by describing the governing key elements for utilizing geothermal energy and for optimal integration into the existing district heating infrastructure. The project will also develop a business case model for large-scale utilization of geothermal energy. Furthermore, the Danish Government has just recently established an expert committee to evaluate applications from license holders who wish to insure themselves against the economic risk associated with geothermal drilling projects.

2.1 Geology and Deep Geothermal resources

The deeper geothermal resources in Denmark relates to two deep sedimentary basins: the Danish Basin (including the Sorgenfrei–Tornquist Zone and the Skagerrak-Kattegat Platform) and the North German Basin (Figure 2).

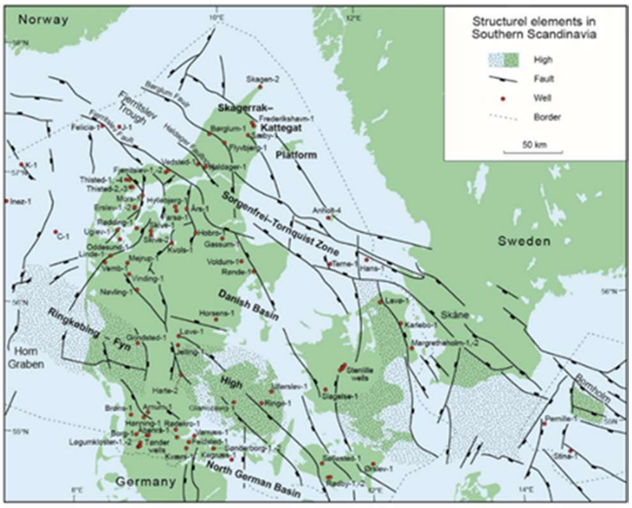

Figure 2: Well locations and principal structural elements in southern Scandinavia. Based on Nielsen (2003).

The two basins are separated by the Ringkøbing-Fyn High; a regional WNW–ESE striking high-lying bedrock area in the subsurface, which in places is intersected by north-south orientated rift structures and troughs. Both basins are classic sedimentary basins characterized by long-term subsidence and infilling by sediments. The geological and geophysical data that provide information about Denmark's deep subsurface mainly consist of information from deep wells and 2D seismic surveys collected over a number of years during oil and gas exploration activities, and to a lesser extent during studies of potential gas storage and geothermal exploration. The geographical coverage and quality of the data vary considerably.

In Denmark, successful geothermal exploitation in the deep subsurface requires the presence of thick and laterally coherent sandstone reservoirs with high porosity and permeability, which can ensure effective and long-term extraction and re-injection of formation water. A thick and coherent reservoir that is not hydraulically compartmentalized by faults, lateral lithological changes (e.g. grain size) or diagenetic features implies that a large volume of warm water may be accessible, and that production and injection wells can be placed at appropriate distances from each other while remaining hydraulically connected. The temperature gradient of typical 25–30°C/km in the Danish subsurface implies that at depths shallower than 800 m the temperature is generally not sufficiently high to be economically profitable for a district heating plant, whereas at depths greater than 3000 m, diagenetic alterations related to high pressure–temperature conditions reduce the porosity and permeability of the reservoir sandstones. Thus, as a rule of thumb, the potential geothermal reservoirs must occur within the 800–3000 m depth interval.

The widely distributed fluviatile Lower Triassic Bunter Sandstone Formation and the mainly marginal marine Upper Triassic–Lower Jurassic Gassum Formation constitute important geothermal reservoirs, and are utilized in the present geothermal plants. Furthermore, formations with more local distribution, such as the Skagerrak, Haldager Sand, Flyvbjerg and Frederikshavn formations, have geothermal potentials. In many areas, where existing detailed geological subsurface data are limited, predrilling reservoir prognosis are associated with large uncertainties, especially regarding the reservoir permeability (Kristensen, et al., 2016).

Reliable information on structural development, hydraulic and thermal conditions of the subsurface is fundamental for the planning and use of geothermal energy. GEUS has therefore constructed a regional 3D geological model, which outlines the structural-stratigraphical evolution from the Late Permian through Late Cretaceous of the Danish onshore subsurface as well as the lateral extent of the lithostratigraphic units known to contain geothermal reservoir sandstones, and the location of major faults. The created structural and stratigraphic framework builds on an integration and interpretation of all available seismic reflection data and exploration well data. This work includes a consistent subdivision of the subsurface into structural elements and regional depth and thickness maps of all important formations. The maps are accessible from the WebGIS portal mentioned above, as is a number of seismic cross-sections and an interactive 3D tool that exemplify the structural distribution of the onshore subsurface units.

The WebGIS portal thus provides a robust and consistent frame for more comprehensive estimates of the geothermal potential in specific areas. Such estimates in local geothermal license areas must be based on detailed analysis of the local dataset defining local geological models that may serve as the geoscientific background for technical and economic considerations.

During the later years there has been an increasing interest for using the subsurface for seasonal heat storage. Several ongoing projects (among others the GEOTHERM project) are investigating the possibilities of integrating heat storage with exploitation of the geothermal resource. One scenario may thus be to inject surplus heated water in the production well in the summer time, and then extract it when needed during the winter (c.f. Major et. al. 2018).

2.2 Legislation and Administration of Deep Geothermal Energy

Exploration for and production of geothermal energy requires a license pursuant to the provisions of the Danish Subsoil Act. It is the Danish Energy Agency, which administrates and supervise the licenses. The newly updated map of geothermal licenses and applications in Denmark reveals applications for large license areas by private investors whereas the existing holders primarily are municipal holders (Figure 3). This illustrates that the industry now is taking interest in geothermal exploration and sees it as a promising business case into which it is willing to invest and share the exploration risks. As an example, A.P. Møller Holding has made a statement of intent to produce geothermal district heating for more than 100,000 consumers in the country's second largest city, Aarhus. The plan is to carry out exploration wells within the next years and if the subsurface conditions are as expected, the first geothermal facilities can be built in the period 2021–2024. Furthermore, A.P. Møller Holding takes full responsibility for exploration, establishment and operational risks the next 30 years.

2.3 Geothermal District Heating plants

At the three existing geothermal power plants, warm formation water is pumped to the surface from a production well using no stimulation of the geothermal reservoir. After heat is extracted and distributed to the district heating system, the cooled water is returned to the reservoir through injection well(s). In Thisted, the production well produces c. 44°C warm water from the Gassum Formation at a depth of 1.25 km where the water has a salinity of 15%. The plant produces up to 7 MW from 200 m^3/h geothermal water and transfer 10 MW heat to the district heating net by heat exchange and through absorption heat pumps driven by heat primarily from a biomass boiler. In Sønderborg, the production well produces 48°C warm water from the Gassum Formation at a depth of 1.2 km where the water has a salinity of 15%. The plant is designed to produce up to 12 MW from 350 m^3/h geothermal water with the use of absorption pumps driven by biomass. The Margretheholm plant exploits a geothermal reservoir in the Lower Triassic Bunter Sandstone Formation at 2.6 km depth where 19% saline geothermal water is available at c. 74°C. The plant is designed to extract 14 MW heat from 235 m^3/h geothermal water and transfer 27 MW heat to the district heating net by heat exchange and through 3 absorption heat pumps driven by 14 MW steam primarily from wood pellet based CHP plant. Comprehensive descriptions of the technical part of the three geothermal plants is given in previous Country updates, e.g. Mahler et al. 2013 and Røgen et al. 2015.

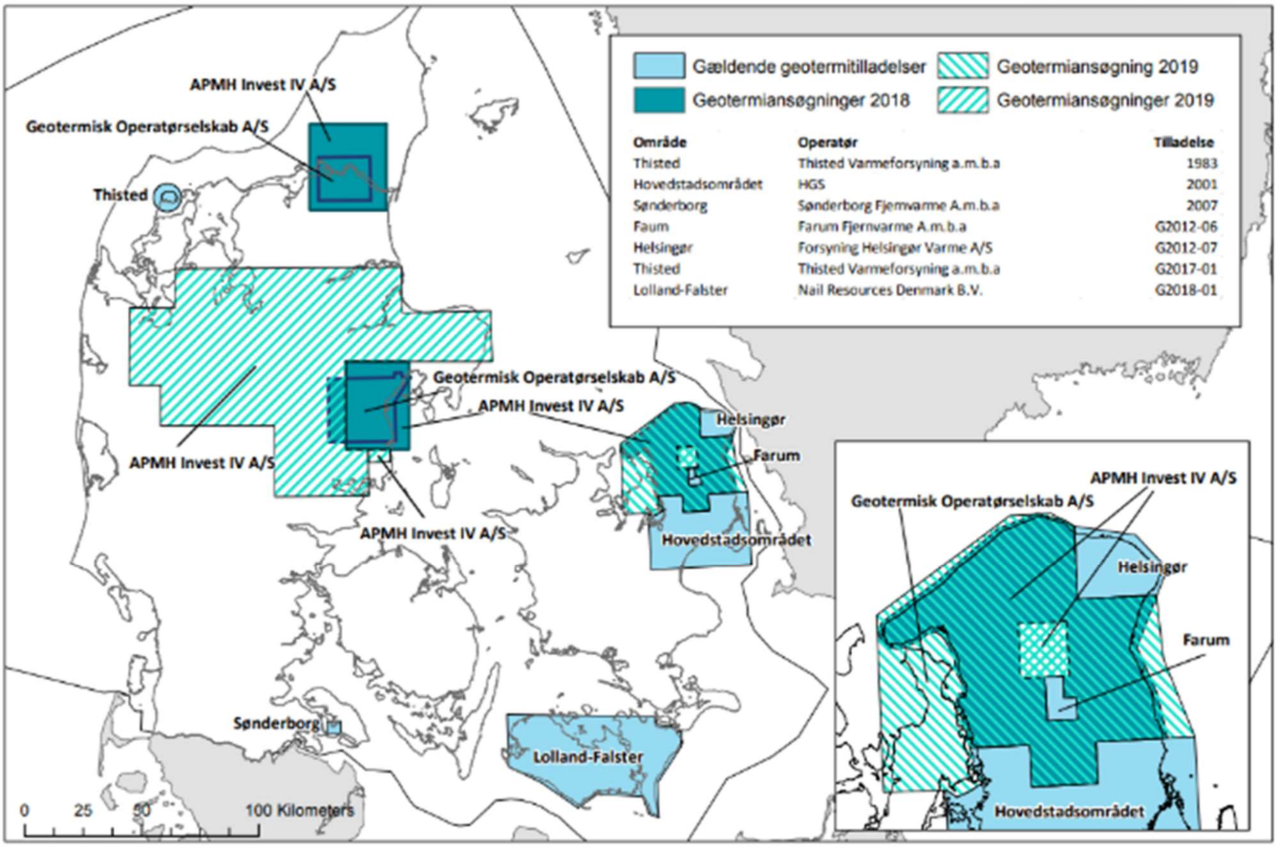

Figure 3: Geothermal licenses and applications in Denmark, February 2019. www.ens.dk

The plants on Margretheholm and in Sønderborg has experienced problems with reinjection causing the plants to be temporary out of operation. Research into the causes for this is ongoing, among others in the GEOTHERM project mentioned above. In contrast, the Thisted plant has been running seamlessly since it came in operation in 1984 and without experiencing any breakthrough to the production well of the cooled, re-injected water from the injection well situated c. 1.5 km from the production well. However, an extra injection well was added to the plant in 2018 as the existing injection well over the years gradually demanded more and more electricity for the pumps to inject the cooled water into the reservoir. The new injection well reduces the electricity consumption and extends the lifetime of the plant and will furthermore increase the proportion of geothermal heat of the total district heating supply in Thisted from 15 to 25%.

3. SHALLOW GEOTHERMAL ENERGY

In Denmark shallow Geothermal Energy is commonly described as Ground Source Heating and Cooling which covers horizontal collectors as well as borehole heat exchangers (vertical or inclined) and groundwater based open loop systems.

Energy extraction by heat pump technology from shallow geological formations is beginning to play a significant role in Denmark in the transition towards a sustainable heat supply, especially in areas without district heating.

3.1 Geology

The shallow geology is dominated by soft sediments and characterized by a variable depth to the groundwater table. The sediments consist of glacial sand and clay deposits of variable thickness. To the West they are found on top of Miocene fluvio-deltaic sands and marine silts and muds. To the East and Northeast, the glacial deposits overlay relatively soft limestone from the Danien and Cretaceous.

The energy extraction from shallow installations depends on the thermal properties of the sediments surrounding the heat collectors, (e.g. Vangkilde-Petersen et al., 2012). However only few investigations of thermal properties of Danish sediments have been carried out (Balling et al. 1981; Porsvig 1986), and thermal conductivity values for different rock and sediment types published by e.g. VDI (2010) show large variations for sediments relevant in a shallow geological context.

3.2 Legislation and administration

Ground Source Heating and Cooling is regulated pursuant to the Danish environmental protection act and permissions are issued by the Municipalities, who 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 modeling. These requirements are rather costly and imply that only larger installations are economically feasible.

3.3 Extent and distribution

Despite a large potential, the application of shallow geothermal energy in Denmark is relatively limited compared to e.g. Sweden or Germany. Today, the total number of ground source and air-to-water heat pumps in Denmark is around 57,000 and currently increasing with around 5,000 per year. It is not possible to assess the number of GSHP systems exclusively. Most of the existing installations are horizontal collectors. Only a few hundred are borehole heat exchangers and >40 are groundwater well open loop systems. During the last couple of years the number of installed BHEs/year has declined somewhat relative to five-ten years ago, see Figure 4.

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 thermal energy storage (BTES) (48 boreholes, 45 m deep) in combination with a thermal solar installation, while 3-5 others have established pit thermal energy storage (PTES) also combined with solar energy.

A new concept for collective shallow geothermal district heating and cooling of residential areas, without the possibility of traditional district heating, has emerged in Denmark in the past two years. The concept is coined Termonet (Thermo-net) and comprises BHEs connected to a horizontal distribution network of uninsulated geothermal piping from which individual consumers extract energy with heat pumps (Figure 5).

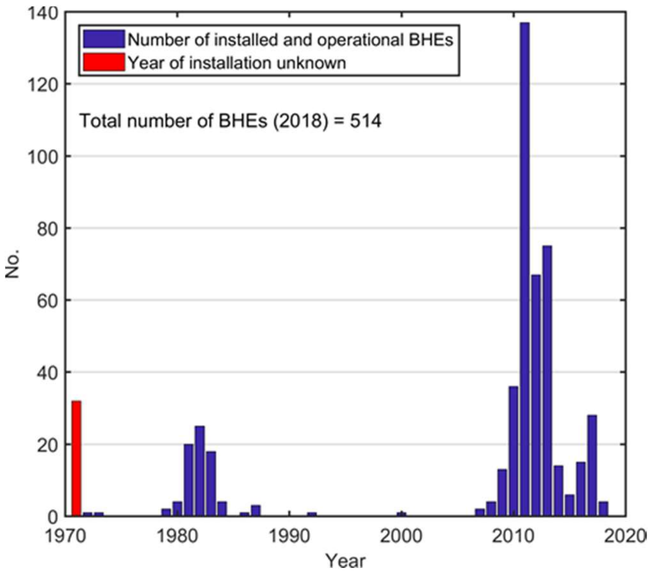

Figure 3: Number of installed and operational borehole heat exchangers (BHE). BHEs that have not been put into operation are excluded from the plot. Source: geus.dk.

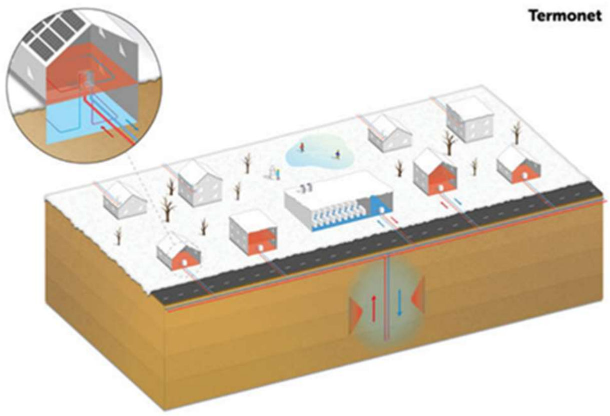

Figure 4: The Termonet with borehole heat exchangers (BHE) and the horizontal distribution network that supplies houses with heating by means of individual heat pumps and passive cooling/seasonal heat storage. Source: Termonet.dk

During the hot season, excess heat is stored for the winter by passive cooling of the connected buildings. In addition to improving the COP of the heat pump, seasonal heat storage/passive cooling significantly improves the thermal comfort during the hot season.

Three Termonet have been established in Denmark in 2017 and 2018 for which three different business models have been developed. The Silkeborg Termonet is owned and operated by the non-profit and consumer-owned, local district heating company (Silkeborg Forsyning), and supplies 15 residential units, utilizing 6 BHEs connected to the horizontal uninsulated distribution network. In the village of Skjoldbjerg, three houses are supplied by three BHEs in a collective district heating and cooling network, whereby savings are made possible relative to establishing individual BHEs. Here, the private company HeatPlan A/S owns and operates the Termonet. In a yet-to-be developed residential area in the city of Brenderup, Middelfart

Municipality has established a Termonet that is jointly owned by the future landowner association. The Termonet will supply 13 residential units from 8 BHEs.

All Termonet projects are based on a worst-case scenario, where all energy is supplied by the BHEs. BHEs can be established anywhere, but they are a relatively costly energy source. In spite of this, all three projects conclude that the Termonet is competitive with the alternatives.

3.4 New initiatives

The project ”Evaluation of the potential for geological heat storage in Denmark” (EUDP, jour.nr. 1887-0017) has recently been finalized and one of the main results of the project is a web-based GIS application for assessment of the possibilities for heat storage in the shallow subsurface. The application shall support planning and construction of underground thermal energy storage (UTES) facilities and is based on existing geological and hydrogeological information, location of existing district heating networks and environmental designation areas. Other activities has been evaluation of the potential for heat storage in deeper geological formations in the city of Aalborg, Denmark and modelling of the efficiency of different geological heat storage scenarios.

UTES project activities will be continued in the project “High Temperature Underground Thermal Energy Storage – HEATSTORE” (EUDP, jour.nr. 64018-0301, EU GEOTHERMICA–ERA NET 170153-4401) and activities in Denmark will comprise compilation of lessons learned from existing UTES systems internationally and development of general specification and design for UTES systems. Pilot UTES projects will be developed in the Netherlands (high temperature aquifer thermal energy storage, HT-ATES) Switzerland (HT-ATES), France (BTES) and Germany (mine thermal energy storage, MTES), while in Denmark the geological conditions will be characterized in selected areas with a potential for UTES as well as new software and workflows developed in the HEATSTORE project will be tested.

The ongoing project “Renewable, building-integrated heating and cooling supply for future resilient cities” (EUDP, jour.nr. 64017-05182) explores the possibilities of implementing foundation pile heat exchangers (energy piles) for collective, GSHP-based heating and cooling (Termonet, as described in section 3.3) in a new urban area in Rosborg, Vejle, Denmark. So far, the project has found that most buildings founded on energy piles are able to produce excess energy that forms the basis for supplying additional buildings with heating and cooling, when connected to a collective heating and cooling network.

4. CONCLUSIONS

Assessment of the geothermal resources in Denmark indicates a great potential in large parts of the country. The three existing geothermal plants may potentially produce geothermal heat for district heating from deep Danish geothermal aquifers with a total design rate of 33 MW heat extraction from the 15-20 % saline geothermal water and a number of district heating companies are conducting exploration and are considering establishing a geothermal plant.

Shallow geothermal energy, either as individual or collective supply, is expected to become more widespread in the future especially in areas with no district heating or natural gas supply. Most of the present ground source systems are using horizontal collectors.

REFERENCES

Balling, N., Kristiansen, J.I., Breiner, N., Poulsen, K.D., Rasmussen, R. & Saxov, S, 1981. Geothermal measurements and subsurface temperature, modelling in Denmark. GeoSkrifter 16, 176 pp. Aarhus University, Denmark.

Kristensen, L., Hjuler, M.L., Frykman, P., Olivarius, M., Weibel, R., Nielsen, L.H. and Mathiesen, A., 2016. Pre-drilling assessments of average porosity and permeability in the geothermal reservoirs of the Danish area. Geotherm Energy, 4(6), 2–27, http://dx.doi.org/ 10.1186/ s40517-016-0048-6.

Mahler, A., Røgen, B., Ditlefsen, C., Nielsen, L.H. & Vangkilde-Petersen, T., 2013. Geothermal Energy Use, Country Update for Denmark. European Geothermal Congress 2013.

Major, M., Poulsen, S.E., Balling, N., 2018. A numerical investigation of combined heat storage and extraction in deep geothermal reservoirs. Gethermal Energy, 6(1), 1.

Nielsen, L.H., 2003. Late Triassic–Jurassic development of the Danish Basin and the Fennoscandian Border Zone, southern Scandinavia. In: Ineson, J.R. & Surlyk, F. (eds): The Jurassic of Denmark and Greenland. Geological Survey of Denmark and Greenland Bulletin 1, 459–526.

Porsvig, M., 1986. Varmeovergangsforhold omkring jordslanger. Energiministeriets varmepumpeforsk-nings-program 33, 56 pp. (1986).

Røgen, B., Ditlefsen; C., Vangkilde-Petersen, T., Nielsen, L.H. & Mahler, A., 2015. Geothermal Energy Use, 2015 Country Update for Denmark. World Geothermal Congress 2015.

Vangkilde-Pedersen, T., Ditlefsen, C. and Højberg, A.L, 2012. Shallow geothermal energy in Denmark. Geological Survey of Denmark and Greenland Bulletin 26, 37–40.

VDI (Verein Deutscher Ingenieure), 2010. Thermische Nutzung des Untergrundes: Grundlagen, Genehmigungen, Umweltaspekte. Richtlinie 4640, Blatt 1, 33 pp. Dusseldorf: Verein Deutscher Ingenieure. 2010.

Vosgerau, H., Mathiesen, A., Andersen, M.S., Boldreel, L.O., Hjuler, M.L., Kamla, E., Kristensen, L., Pedersen, C.B., Pjetursson, B. and Nielsen, L.H., 2016. A WebGIS portal for exploration of deep geothermal energy based on geological and geophysical data. Geological Survey of Denmark and Greenland Bulletin, 35, 23–26.

Acknowledgements

The EUDP program (Det Energiteknologiske Udviklings- og Demonstrationsprogram) and Innovationsfonden are thanked for their financial support to the R&D projects.

Stig Niemi Sørensen from Enopsol has kindly provided input for table D2

Tables A-G

Table A: Present and planned geothermal power plants, total numbers

There are no geothermal power plants in Denmark

Table B: Existing geothermal power plants, individual sites

There are no geothermal power plants in Denmark

Table C: Present and planned deep geothermal district heating (DH) plants and other uses for heating and cooling, total numbers

	Geothermal DH plants		Geothermal heat in agriculture and industry		Geothermal heat for buildings		Geothermal heat in balneology and other **	
	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)	Capacity (MW_{th})	Production (GWh_{th}/yr)
In operation end of 2018 *	33							
Under constru-ction end 2018								
Total projected by 2020								
Total expected by 2025	500							

Table D1: Existing geothermal district heating (DH) plants, individual sites

Locality	Plant Name	Year commis-sioned	CHP	Cooling *	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion (GW_{th}/y)	Geoth. share in total prod. (%)
Thisted	Thisted Varmeforsyning	1984	N	N, RI	7			
Copenhagen	HOFOR	2006	N	N, RI	14			
Sønderborg	Sønderborg Fjernvarme	2013	N	N, RI	12			
total					**33**			

* In case the plant applies re-injection, please indicate with (RI) in this column after Y or N.

Table D2: Existing geothermal large systems for heating and cooling uses other than DH, individual sites

Locality	Plant Name	Year commis-sioned	Cooling	Geoth. capacity installed (MW_{th})	Total capacity installed (MW_{th})	2018 produc-tion (GWh_{th}/y)	Geoth. share in total prod. (%)	Operator
40-50 plants	Airports, hotels, hospitals, industries. district heating, office buildings	ca. 1998-2018	Y	ca. 50				
total				**ca. 50**				

Table E: Shallow geothermal energy, ground source heat pumps (GSHP)

	Geothermal Heat Pumps (GSHP), total			New (additional) GSHP in 2018		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2018	<57000 *		<4-6 *	<5000 *		
Projected total by 2020	<62000 *					

* values include air-to-water heat pumps.

Table F: Investment and Employment in geothermal energy

No information available

Table G: Incentives, Information, Education

	Geothermal electricity	Deep Geothermal for heating and cooling	Shallow geothermal
Financial Incentives – R&D			
Financial Incentives – Investment			
Financial Incentives – Operation/Production			
Information activities – promotion for the public			
Information activities – geological information			
Education/Training – Academic		5 ECTS Course at VIA UC	5 ECTS Course at VIA UC
Education/Training – Vocational			Part of Drillers Certification (VIA UC)

Key for financial incentives:

DIS	Direct investment support	FIT	Feed-in tariff	-A	Add to FIT or FIP on case the amount is determined by auctioning
LIL	Low-interest loans	FIP	Feed-in premium		
RC	Risk coverage	REQ	Renewable Energy Quota	O	Other (please explain)