Geothermal Energy Use, Country Update for Norway

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ABSTRACT

In Norway, the emphasis on energy efficiency and new building codes that restrict the use of energy for heating have increased the interest for Ground Source Heat Pump (GSHP) systems. More than 90 % of the GSHP systems utilize energy from boreholes in crystalline rock. There is a trend towards deeper boreholes and Borehole Heat Exchangers (BHE), systems involving 500 m depths have been successfully delivering heat for more than two years.

So far Norway has no deep geothermal installations in operation, but there are preliminary plans for utilizing deep geothermal energy in a district heating system in mainland Norway and to replace fossil fuels with geothermal energy in Ny Ålesund, an insulated settlement on Svalbard.

1. INTRODUCTION

As the third-largest exporter of energy in the world and an electricity supply almost totally dominated by hydropower, Norway is unique with respect to energy resources. Norway has one of the largest share of renewable energy both in its total primary energy supply (TPES) and in electricity supply. Norway has set itself an ambitious target to reduce global greenhouse gas emissions by 30% relative to 1990 levels by 2020, and to become carbon-neutral by 2050 Meeting the 2020 target will be challenging because both the country's electricity supply and energy use in buildings are already essentially carbon-free (IEA, 2011).

In 2002 Enova SF was established as a public enterprise to promote energy saving and new renewable sources of energy. Enova is funded through an Energy Fund made up partly from an earmarked grid levy and partly from the state budget. Today the Energy Fund is about 25 billion NOK (3.4 billion Euro) and will increase by 10 billion NOK (1.4 billon Euro)by 2013. Funding from Enova has resulted in energy savings of 21 TWh since 2002, (www.Enova.no)

Over the last decade Norway has strengthened its energy R&D efforts and the government funding is almost tripled in this period (IEA,2011). A new national collective R&D strategy for the energy sector, Energi 21, was launched in 2008 and revised in 2011. The vision of the strategy is to be the leading energy and environment conscious nation in Europe.

In 2008 the Parliament adopted the Climate Agreement to increase energy research, development and deployment (RD&D) by 600 million NOK (80 million Euro) for CCS and non-fossil based energy systems. Public funding for energy RD&D is among the highest in the world (IEA, 2011). To develop expertise and promote innovation in targeted energy R&D areas eight centers for environment –friendly energy research (FME) were established in 2009. Each of the centers receives annual funding of 10-20 million NOK (1.4 - 2.7 million Euro) for eight years. Geothermal energy was not a prioritized area in 2009 but a new Climate Agreement was approved by the Parliament last year with a specific decision to establish a research center in geothermal energy.

Geothermal energy is considered as a highly significant alternative for the future and a subject of growing interest in our industry, universities or research institutes.

To plan, coordinate and promote research and development within geothermal energy in Norway, the

"Norwegian Centre for Geothermal Energy Research" (CGER) was established in 2009 and has today 16 partners from industry, universities and research institutes. This centre aims to facilitate the exploitation of geothermal energy as a national energy source and an international business opportunity.

Building on strong national competence, amongst others related to the petroleum industry, this centre will contribute to the development of knowledge and technology. The Norwegian petroleum industry utilize advanced drilling and reservoir technologies. These technologies and methods are transferable to geothermal applications, but for successful application, e.g.to crystalline rocks, the technologies needs to be adapted.

Norway is located on the Fennoscandian Shield. The bedrock consists of Precambrian rocks with a belt of Caledonian rocks extending from SW to N Norway. Permian volcanic and intrusive rocks are found in the Oslo region. The porosity of the crystalline bedrock is low (Midttømme et al. 2010). The lithosphere is cool and thick and characterized by a low heat flow density that is below the continental average (Kukkonen, 2002).

The quality of the Norwegian heat flow data are improving. The Geological Survey of Norway has collocated a new heat flow data set from new and existing deep onshore boreholes. The new palaeoclimatical and topographical corrected values shows higher heat flow values than previous expected, with surface heat flow varies between 50 and 60 mW/m2 in south and central Norway (Slagstad et al, 2009).

2. GEOTHERMAL UTILISATION

The major geothermal activity in Norway is ground source heat pumps. According to the heat pump organisation NOVAP there are about 5000 installations per years.

More than 90 % of the GSHP systems utilize energy from boreholes in crystalline rocks by use of borehole heat exchangers (BHE). The Norwegian standard system is a 50-350 m deep borehole of 139mm (115mm) diameter with a single 40 mm U tube installed. Most of the BHE is kept open without grouting. There is a trend towards deeper BHEs, an installation with a 500 m deep single U tube has successfully delivering heat for more than two years. Some of the BHE fields established recently has boreholes of 300 m depth.

There has been an increase in GSHP particular for larger buildings after a new building code with strict requirements for energy efficiency was introduced in 2007 and revised in 2010. These new energy performance requierments are expected to cut the need for energy for heating purposes by around 25% (IEA 2012). The new regulations also specify that, as a main rule, a minimum of 60% of the energy required for heating and hot water in new and refurbished buildings above 500m^2 must be supplied by energy carriers other than electricity and /or fossil fuels. This opens up the possibility that a lot of medium sized GSHP installations will be needed for ubiquitous locations such as school buildings. The building code will be revised in 2015. The target level is the passive house standard or active houses producing energy.

Another new legislation which has contributed to increased interest for GSHPs is the energy labelling scheme. From 2010 this scheme requires buildings to have an energy certificate and an energy consumption label when built, leased or sold These schemes are assumed to promote increased knowledge and awareness of the energy consumption in buildings.

Table 1: Large GSHP system in Norway

Installation	Borehole No x depth	Effect GSHP	UTES type	Year
Oslo Airport	18 x 45	8MW	ATES	1998
Ahus Hospital	228 x 200	8MW	BTES	2007
Nydalen N.park	180 x 200	6MW	BTES	2004
Østfold Hospital	100 x 250		BTES	2013
Kalnes Energy Central	100 x 250		BTES	2012
Ullevål Stadion	120 x 200	4MW	BTES	2009
Arcus	91 x 300		BTES	2012
Stavanger Forum	85 x 250		BTES	2011
Postterminalen	90 x 200		BTES	2010
Haukeland Hospital	75 x 250		BTES	2012
Høgskolen Bergen	81 x 220	1,4MW	BTES	2012
Sørlandssenteret	90 x 200		BTES	2011
IKEA, Oslo	86 x 200		BTES	2009
Torp Airport	60 x 250		BTES	2012
Speilen Mandal	90 x160		BTES	2012

A potential study of “Ground source heat in Norway – mapping of economic potential” initiated by the Norwegian Water Authorities (NVE) (Ramstad, 2011) concluded with that (nearly) the entire heat and cooling demands of Norwegian buildings can be covered by the use of ground source heat pumps. The unit price of heating and cooling based on the ground source heat pump technology for middle sized to large installations is competitive to other energy alternatives. For the household segment, profitability is lower, but still interesting. The study does not include the indoor heat and cooling distribution system, but the heat pump, energy well and installations costs. The relatively good thermal conductivity of the crystalline bedrock makes Norway well suited for energy wells with closed loop collector systems. Due to the abrasive work from the ice age the Norwegian bedrock is quite fresh and borehole instability does not appear too often.

As a result of a competition for an innovative heating system solution organized by Undervisningsbygg, the school building owner in Oslo municipality built BTES system at Ljan School in Oslo. Here the ground is used in interplay with solar heat collected in the asphalt of the schoolyard. The solar collector is integrated into the asphalt and used to heat the brine for the heat pump during spring, summer and autumn, and maybe during some sunny and warm days throughout (late) winter. Excess heat from the solar collector in the summer is used for charging the energy wells.

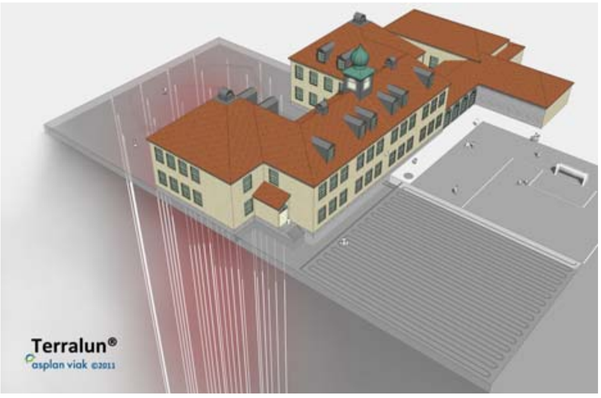

Figure 1: GSHP system at Ljan school, Oslo (Ref Asplan Viak)

Two large GSHP systems that have recently been established (Stavanger Forum and Høgskolen i Bergen) combines BHEs from than 80 boreholes with ice storage tanks. Most of the large BHE systems have additional heating systems for use in the coldest days in the winter. The size of the BHE field is therefore designed for the buildings cooling demand.

Some locations in Norway can also utilize groundwater resources in superficial deposits. The largest UTES system in Norway is at Oslo’s Gardermoen international airport. This ATES system has been in operation since the airport opened in 1998 and comprises an 8 MW heat pump, coupled to 18 wells of 45 m depth, 9 for extraction of groundwater and 9 for re-injection. Like many other unpressurized open systems there are problems witch clogging of the groundwater loop, and the filter screens, and heat exchangers require cleaning too. The airport will expand, but due to the operational problems they will not expand the ATES system but rather utilize a nearby sewage plant to supply the existing ATES system. For effect purposes it’s installed a snow storage system to provide cooling on the hottest days.

There are no geothermal installations deeper than 500 m in operation. An EGS demonstration project was planned in Oslo but are not realised due to lack of funding. The plan was to drill a closed loop system of 3.5 – 5.5 km depth. There has been preliminary investigations including drilling of a 800m deep test well for utilizing deep geothermal energy in a district heating system in the Oslo region. The energy company has not yet decided if they will continue this geothermal project.

Svalbard is an archipelago in the Arctic Ocean, located north of mainland Europe. The Svalbard Treaty of 1920 established full Norwegian sovereignty over Svalbard. Ny Ålesund is an insulated settlement on the west coast of Spitsbergen, the main island of Svalbard. Funding is being sought for investigations relating to the replacement of fossil fuel with geothermal energy for this settlement, where research of the artic environment is a main activity. There are lots of uncertainties regarding the geothermal potential and the geology in this region, but there exist hot springs in an area north of Ny Ålesund

Figure 2: Ny Ålesund, Svalbard located on 79 ˚ N.

There are emerging small and large companies who are interested in penetrating geothermal market, especially within drilling. Some examples are:

- Norwegian Hard Rock Drilling AS, NORHARD is a company that develops technology and production/operation equipment for long distance drilling. Further development for drilling of geothermal wells and for oil and gas applications are ongoing.

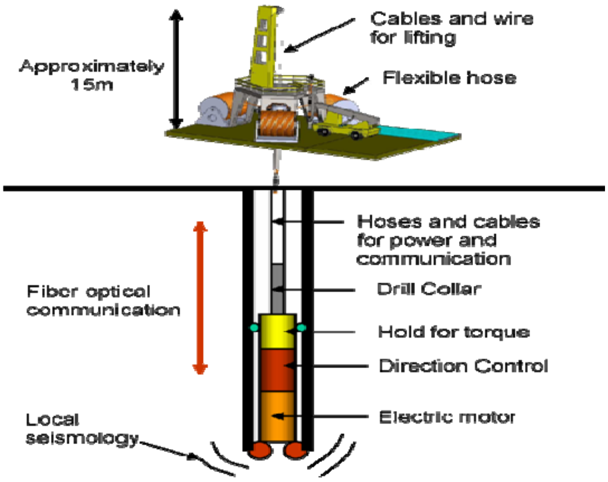

Figure 3: Sketch illustrating NORHARDs innovative technology.

- The company 'Resonator' is developing a powerful electric hammer for improved percussion drilling, based upon a new proprietary technology. This work is taking place at the University for Life Sciences (UMB) south of Oslo. Demonstration of the technology is planned to take place in about 2 years

Figure 4: Photo from RESONATORs laboratory showing some of its equipment.

- Norwegian companies are also working on development of thermal machines. Viking Heat Engines has developed and are testing a heat engine for electricity production from low tempereature geothermal sources.

2. INTERNATIONAL ACTIVITY

Green Energy Group AS (GEG) is a Norwegian Company established in 2008, manufacturing and commissioning prefabricated modular geothermal power plants. Their concept reduces the time from successfully drilled geothermal well to power online. In 2009 GEG signed a R&D contract with KenGen, the national power company of Kenya, to deliver the first 5 MW wellhead power plant. In 2011 GEG raised a combined MNOK 87 million (11.7 million Euro) in equity. The first modular power plant was sat in operation in Kenya in January 2012.

The state owned oil company Statoil has an ambition to gradually build a international position in renewable energy production. In addition to the established interest within offshore wind, geothermal has been identified as a potential business area for further growth. The aim of Statoil is to build upon its core expertise from oil and gas, such as geology, drilling and reservoir management, in order to realize the full potential of geothermal power in markets where the company already has a presence.

The Research Council of Norway is funding a geothermal project in North Western Indian Himalayas. The project is a joint effort between India, Norway and Iceland and the vision is to develop and demonstrate innovative and sustainable technologies for utilization of geothermal sources to supply the high mountain region.

3. CONCLUSIONS

Ground Source Heat Pumps (GSHP) are regarded both economically and technically as one of the best alternatives for energy efficient heating and cooling of new large and medium sized buildings, and these applications will be important in reaching national energy targets.

Deep geothermal energy is set on the agenda, research projects are emerging, and hopefully we will establish a Norwegian demonstration plant within some years.

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Tables A-G

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

*Geothermal power plants are not available in the country.

Table B: Existing geothermal power plants, individual sites*

*Geothermal power plants are not available in the country.

Table C: Present and planned geothermal district heating (DH) plants and other direct uses, total numbers *

*Geothermal district heating plants are not yet available in the country.

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

*Geothermal district heating plants are not yet available in the country.

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

	Geothermal Heat Pumps (GSHP), total			New GSHP in 2012		
	Number	Capacity (MW_{th})	Production (GWh_{th}/yr)	Number	Capacity (MW_{th})	Share in new constr. (%)
In operation end of 2012						
Projected by 2015						

Table F: Investment and Employment in geothermal energy

No data available

Table G: Incentives, Information, Education,

	Geothermal el. power	Geothermal direct uses	Shallow geothermal
Financial Incentives – R&D	Yes, RCN or IN	Yes, RCN or IN	Yes RCN or IN
Financial Incentives – Investment	Yes up to 50% from Enova	Yes up to 50% from Enova	Yes up to 30% for large and medium size installations and up to NOK 10 000 (1340 Euro) for single house installation from Enova
Financial Incentives – Operation/Production	No	No	No
Information activities – promotion for the public	No	No	No
Information activities – geological information	Existing geological information is free available from Geological Survey of Norway		
Education/Training – Academic	three of the country's eight universities teach in shallow or deep geothermal energy. There are educated two dr students in shallow geothermal (NTNU)and one in deep geothermal (UiB)		
Education/Training – Vocational	CGER organize courses and technical meetings		CGER, the drilling organizations and the heat pump organization organizes courses and technical meetings

Key for financial incentives:

DIS	Direct investment support	RC	Risc coverage	FIP	Feed-in premium
LIL	Low-interest loans	FIT	Feed-in tariff	REQ	Renewable Energy Quota
RCN	Research Council of Norway	IN	Innovation Norway		