IEA GEOTHERMAL

IEA Geothermal
Implementing Agreement

Norway
Country Report
2014

Norway

Figure 1 Norway has plans to replace fossil fuels with geothermal energy in Artic Svalbard (Photo courtesy of Jiri Muller).

1.1 Introduction and overview

Norway is a young nation when it comes to the utilisation of geothermal energy. So far, there is no electricity production from geothermal resources. Geothermal energy use is dominated by the deployment of heat pumps, which are quite widespread. 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, a remote settlement in Artic Svalbard.

There is a strong lobby from academic institutions (universities and research institutes) and industry to promote all aspects of geothermal energy amongst politicians and the public. The umbrella organisation for this lobby is the "Norwegian Centre for Geothermal Energy Research" (CGER) which was established in 2009, and which at the end of 2013 has increased its number of partners to 17 coming from universities, research institutes and industry. The main argument for establishing geothermal energy in an "oil country" like Norway is the country´s official energy policy to increase the use of renewable energy resources. Additionally, the valuable experience and know-how in off-shore technologies possessed by Norwegian industry and academia could be readily utilised by the emerging geothermal industry.

The major geothermal activity in Norway is ground source heat pumps (GSHP). There is no national overview of installed GSHP systems. According to the National Drilling Associations (Norwegian Association of Heavy Equipment Contractors; MEF and Norwegian drilling association; NBF) there are about 5000 installations per year. The Norwegian heat pump organization (NOVAP) have registered the number of heat pumps sold by their member companies since 1996, but not all heat pump suppliers are members of NOVAP. For example, in 2011 3677 brine-water heat pumps were sold. Most of these were GSHPs. More than 90% of the GSHP systems use energy from boreholes in crystalline rocks through borehole heat exchangers (BHE). The Norwegian standard system is a 50-350 m deep borehole of 139 mm (115mm) diameter with a single 40 mm U tube installed.

According to the National Water Directive, all boreholes and wells drilled have to be reported by drillers to the Geological Survey of Norway (NGU). This boreholes/wells archive, which is available at NGUs website (http://geo.ngu.no/kart/granada/), contains information on the technical design, depth, yield, groundwater level, geographical location, soil depth etc. of around 60 000 wells and boreholes. A significant proportion of the wells drilled have not been reported, particularly those drilled in large BHE systems, but the numbers reported are increasing. In 2011, a total of 3591 BHEs were reported to the borehole archive; 2930 were single BHE systems, while 661 boreholes/wells were drilled in large GSHP systems with two or more boreholes/wells.

In estimating the total installed capacity of the GSHPs, both the information from the boreholes archive and the NOVAP sales statistics are used. Depending of the size, the heat pumps are divided into 6 groups from 7 kW to 3 MW. The proportion of heat pumps in each size group is estimated using previous sales statistics from NOVAP. These statistics are also the basis for calculating the number of installations, with an added 10% more installations to account for heat pump suppliers who are not members of NOVAP.

European Union guidelines on calculating renewable energy from heat pumps from different heat pump technologies (2013/114/EU) pursuant to Article 5 of Directive 2009/28/EC of the European Parliament and of the Council is used in calculations of the total annual energy use from the GSHP installations. Europe is divided into three climatological areas. Norway is situated in the cold climate zone. The default value, H_{HP}, for equivalent full load hours of operation for GHPs are 2470 h. Previously, in national calculations of the energy savings from GHPs an annual operation time for the GHPs in heating mode was set to 4000 h. It is worth noting that new buildings have lower heating demands than the ones already established. Norway spans over 13 degrees of latitude, some of which is north of the Polar circle with no sunshine in the coldest season. In addition, there is a large diversity of climate zones from coastal, high mountains to typical inland climate. There will be large differences in building heating and cooling demands depending on location, building type and age.

Table 1 summarises the status of geothermal energy use in Norway in 2014.

Table 1 Geothermal energy use in Norway for 2014. (The data is based on gross estimates. na=data not available)

Electricity	
Total Installed Capacity (MW_e)	0
Contribution to National Capacity (%)	0
Total Generation (GWh)	0
Contribution to National Demand (%)	0%
Direct Use	
Total Installed Direct Use (MW_{th})	na
Total Heat Used TJ/yr Total Heat Used TWh/yr	8260 2,3
Total Installed Capacity for Heat Pumps (MW_{th})	1300

1.2 Highlights and achievements

As the third-largest exporter of energy in the world, with a domestic electricity supply almost totally dominated by hydropower, Norway is unique with respect to energy resources. Norway has one of the largest proportions of renewable energy both in its total primary energy supply and in its 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. For more details see Section III: National Programme.

1.3 National Programme

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 billion Euro) within 2013 with further increases in 2014 and 2105. Funding from Enova has resulted in energy savings of more than 21 TWh since 2002 (www.Enova.no).

Over the last decade, Norway has strengthened its energy Research & Development (R&D) efforts and the government funding has almost tripled. A new national collective R&D strategy for the energy sector, ENERGI 21, was launched in 2008. It was revised in 2011. The vision of the strategy is to be the leading energy- and environmentally-conscious nation within Europe. The implication of the 2011 version of the ENERGI 21 document has been dealt with in the previous country reports, where it was pointed out that ENERGI 21 has given deep geothermal energy low priority in its strategic plan, which effects government short-term and long-term funding of geothermal. The new version of the ENERGI 21 document is under preparation. CGER has actively lobbied for deep geothermal energy to get a higher priority in the new version of the ENERGI 21 document.

In 2008, the Norwegian Parliament adopted the Climate Agreement to increase energy research, development and deployment (RD&D) by 600 million NOK (80 million Euro) for carbon capture storage and non-fossil based energy systems. Public funding for energy RD&D is among the highest in the world. To develop expertise and promote innovation in targeted energy R&D areas, eight centres for environmentally–friendly energy research (FME) were established in 2009. Each of the centres 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 in 2012 with a specific decision to establish a research centre (FME) in geothermal energy. Hopes rose again when the new government, elected in September 2013 declared in its programme to support the establishment of an FME for geothermal energy and thus to secure future funding for geothermal research in Norway. A call for new FME centres was launched at the end of 2014, and it is expected that there will a strong application for a Geothermal FME research centre.

There has been an increase in GSHP particularly 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 requirements are expected to cut the need for energy for heating purposes by around 25%. 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 required 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.

1.4 Industry status and market development

Please refer to IEA-GIA Annual reports from previous years for further details.

Viking Development Group was established in 2008 to function as an innovation house with emphasis on technology development within marine, offshore and energy sectors primarily, including sustainable technologies. Viking Development Group serves as an umbrella group and provides management for different technology development companies. Within the group Viking Heat Engines AS has developed an Organic Rankine Cycle technology, the CraftEngine, which can produce electricity from very low temperature heat sources at smaller scales, typically less than 1 MW_{el}. The main goal for Viking Heat Engines is to become the leading provider of low-temperature energy conversion technology, which will serve as a key tool to convert waste heat and renewable heat sources into economical and emission-free electricity.

The CraftEngine technology is an engine technology based on the Organic Rankine Cycle (ORC), that converts low-temperature heat (typically < 220 °C) into electricity. Its main designated applications are within waste heat recovery, geothermal power generation, solar thermal power and biomass combined heat and power. The development has been done in close collaboration with AVL (www.avl.com), a

Figure 2 CraftEngine by Viking Development Group

professional engine development company, to ensure industrial quality of the design. The main difference between the CraftEngine and other ORCs is that the CraftEngine is based on piston engine expander technology, which gives an unmatched operational flexibility. The CraftEngine has undergone several field tests from late 2013 and onwards, and based on the findings from the field test program, the design is now being finalized for commercial sales starting in 2016. The first design available commercially will be the CraftEngine PowerPack, with an electrical power output of about 40kW. Considerably larger engines are planned for development soon.

1.5 Research, development and demonstration/deployment

CGER hosted international conferences GeoEnergi 2011, 2013 and is planning a new conference in 2015 in Bergen in the first week of September. The conference will have the same format as the previous conferences with participation from international scientific guests, politicians and media. In the same week, CGER will also host the annual meeting of EERA Joint Geothermal Programme which is an umbrella organisation of European academic institutes and universities.

The research at the University of Bergen (UoB) within geothermal energy involves nine faculty members within applied mathematics, geology and geophysics. Currently three PhD students, one Postdoc and three master students work on research projects directly related to geothermal. The on-going externally funded research projects are:

- GeoStim (2014-2017) “Mathematical modeling and simulation of fracture opening in geothermal reservoirs”, funding: 7 MNOK (RCN, BKK, Statoil)
- ANIGMA (2015-2018), “An Integrated Geological and Mathematical Framework for the Characterization, Modeling and Simulation of Fractured Geothermal Reservoirs”, funding: 9.6 MNOK (RCN, Statoil)
- FracZone (2015-2017), “Improved simulation technology for flow and transport in fracture zones”, 2.8 MNOK (Statoil Vista program).

In addition, geothermal research is funded in-house by UoB. The university also has fundamental research activities in geology, geophysics, physics and applied mathematics that have strong relevance for geothermal energy.

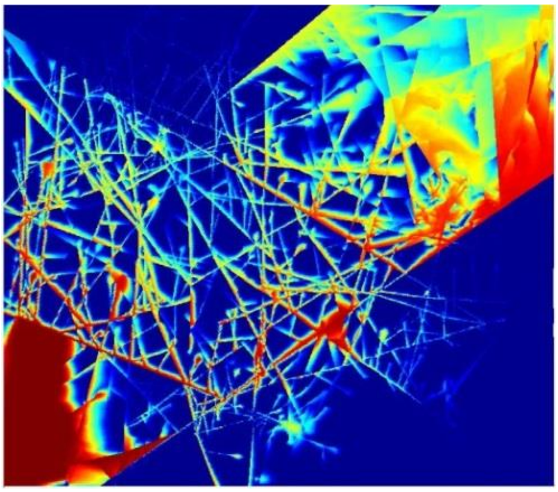

Figure 3 Simulation of heat extraction in a fractured reservoir (UoB, 2014)**.**

A research project led by mining company “Store Norske” is investigating the possibilities for geothermal energy utilization on Svalbard as a means to reduce carbon emissions. Fibre optic temperature measurement technology is being tested to provide high quality data from boreholes in permafrost areas. Finite element basin models (IFE) and Comsol Multiphysics models (CMR) describing the temperature distribution of the subsurface are being developed. Preliminary results indicate that heat flow values are above 70 mW/m^2. There are also indications of hot spot areas with significantly higher heat flow values.

The Research Council of Norway is also funding a geothermal project in the NorthWestern 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. The project is coordinated by the Norwegian Geotechnical Institute (NGI).

1.6 Geothermal Education

CGER has continued to run workshops on topics which are relevant to geothermal energy for its members. The Annual General Meeting was held in March in the industrial high-tech town Kongsberg (close to Oslo), where some companies have plans to invest in geothermal energy projects.

The University of Bergen has geothermal energy as one of the possible specializations in its Master programme in Energy, which was launched in 2012. Several PhD students are also working on geothermal energy research at the University of Bergen and University of Tromsø.

1.7 Future outlook

Shallow geothermal energy (heat pumps) is widely used in Norway. However, deep geothermal energy is a relatively new concept for the Norwegian establishment, particularly for the public, politicians, funding agencies, press (media), industry and also research organizations.

CGER continues to promote geothermal energy in Norway so that it becomes more well-known and accepted as an important component in the renewable energy mix. As part of this, CGER will organize a major geothermal conference GeoEnergi 2015 in Autumn 2015 which is a follow up of the successful conferences GeoEnergi 2011 and 2013.

CGER is an active member of the EGEC (European Geothermal Energy Council) thus gaining access to a valuable network of international geothermal organizations. In addition, several CGER partners are members in the following international organizations and consequently disseminate the results amongst their members.

Table 2 Organizations that CGER partners belong to

International geothermal organizations
EERA JP Energy Storage
EERA JP Geothermal Energy
IEA Energy Storage IA
IEA Geothermal Energy IA
Norwegian geothermal organizations
CMR, IFE, SINTEF
IFE, IRIS, SINTEF, UiB/CMR/UNI
NGI
IFE

Several CGER partners are also taking part in EU research programmes related to geothermal energy in FP7 and have submitted research proposals in the EU Horizon 2020 programme.

1.8 References

IEA Energy Policies of IEA Countries, Norway 2011 Review OECD/IEA (2011)

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1.9 Author

Jiri Muller,
Institute for Energy Technology,
P.O. Box, 40,
2027 Kjeller,
Norway
Email: Jiri@ife.no

To Find Out More

If you are interested in learning more about the IEA Geothermal Programme, or you wish to join the IEA-GIA:

Contact:

IEA-GIA Secretary
c/o GNS Science
Wairakei Research Centre
Private Bag 2000
Taupo 3352
NEW ZEALAND

Tel: +64-7-374 8211
Email: iea-giasec@gns.cri.nz

OR

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