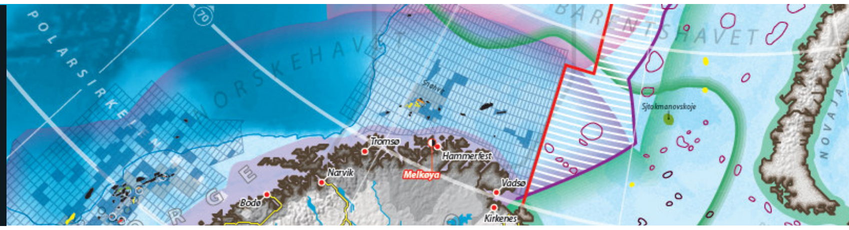

OceanFutures

FOCUS NORTH

Electricity Production

Prepared by the research company Ocean Futures, Oslo for the Norwegian Atlantic Committee

Introduction

The North has a great, natural need for electrical power and heat given the region's cold climate and its long, dark winters. At the same time, the North has great potential for energy generation given its hydrocarbon resources, rivers and favorable wind conditions.

Electricity production in Norway

Nearly all of the electricity produced in Norway is generated by hydropower. In 2005, Norway produced 127,000 gigawatt-hours (GWh) of electricity, of which 99 percent was generated by hydropower, 0.7 percent by thermal (oil, gas or coal) power, and 0.3 percent from wind power. Domestic energy use in 2005 was 125,000 GWh.

Norway is a net exporter of electricity. In 2005, it imported 8,500 GWh, but exported 10,000 GWh. The country has good transmission capacity with Sweden and Denmark (3,350 MW and 1,000 MW respectively), but limited capacity with Finland and Russia (100MW and 50 MW). Table 1 summarizes power exchange to and from Norway in 2004.

Electricity production and use in northern Norway

The total Norwegian energy production in 2005 was 127,000 GWh. Nordland county produced the most energy, accounting for 15.1 percent of the country's total production, while Troms county produced 2.4 percent and Finnmark county 1.3 percent.

The three northern counties have considerable hydropower potential, estimated at 33,000 GWh. Nearly three-quarters of this capacity is in Nordland county, as shown in Table 2.

Total power use in Norway was 125,000 GWh in 2005. Of this, the three northern counties accounted for 12.5 percent. Industrial and commercial enterprises are the greatest energy consumers in Nordland and Troms (72 percent and 57 percent, respectively), while household users are the greatest consumers in Finnmark (55 percent).

Fact Box 1 – Energy terms

Energy is defined as the ability to do work. The base unit for the effect of energy is the watt. The following terms and abbreviations are commonly used:

1 W = 1 watt
1 kW = 1 kilowatt = 1,000 W
1 MW = 1 megawatt = 1,000 kW = 1 million W

Another measure is the effect over time. The most common term is to measure the number of watts per hour:

1 kWh = 1 kilowatt-hour = 1,000 Wh
1 MWh = 1 megawatt-hour = 1,000 kWh
1 GWh = 1 gigawatt-hour = 1 million kWh
1 TWh = 1 terawatt-hour = 1 billion kWh

1 MWh is about the amount of energy needed to warm an electrically-heated house for one week in the winter.

1 TWh corresponds to the amount of electricity used by a city of 50,000 inhabitants for one year.

The average theoretical energy content of different fuel types is as follows:

1 ton oil equivalent = 11,800 kWh
1 cubic meter of natural gas = 10 kWh
1 barrel of crude oil (160 litres) = 1,600 kWh
1 cord of firewood (2.4 cubic meters) = 3,600 kWh

Table 1 – Energy import & export by Norway, 2004

Country	Import by Norway (GWh)	Export by Norway (GWh)
Sweden	11,204	2,260
Denmark	3,784	1,484
Finland	159	96
Russia	188	0
Total	15,335	3,840

Table 2 – Hydropower potential in northern Norway

County	Potential (GWh)	Developed	Available for development
Nordland	24,100	60%	25%
Troms	5,400	49%	14%
Finnmark	3,200	48%	14%
Total	32,700	57%	22%

Household energy use in Norway is greatest in the three northernmost counties due to the colder climate. Finnmark tops the list, with domestic energy consumption 32 percent higher than the national average of 7,400 kWh per person.

Svalbard obtains its power from coal-fired power plants located in Longyearbyen and the Russian settlement at Barentsburg. Both plants use locally mined coal. The plant at Longyearbyen produced 43,000 MWh of electricity and 57,000 MWh of thermal energy in 2004.

Wind power in northern Norway

The Norwegian coast has some of the best conditions in Europe for wind power: large, open areas together with high, stable winds. There is also good synergy on an annual basis between wind power and hydropower. The wind is strongest and the production potential greatest in the winter. In this period, precipitation falls mostly as snow, lowering hydropower potential.

The total theoretical wind power potential along the Norwegian coast is estimated to be 1.2 million GWh per year. Nearly a third of this potential is in Finnmark (370,000 GWh per year).

Despite this promising potential, Norway generates today less than 500 GWh per year from wind power. Increasing wind power is a clear political objective, and the Norwegian parliament has set as a goal for wind power to produce 3,000 GWh per year by 2010.

As of October 2005, two wind parks were in operation in northern Norway: Havøygavlen in Finnmark, and Sandhaugen in Troms and Nordland. A third—the Kjøllefjord wind park—is under construction in Finnmark. Six more projects have been granted concessions in the North, and another nine proposals are currently under review.

Norway's Water Resources and Energy Directorate expects Norwegian energy use to increase by 12,000 GWh by 2020—a 10 percent increase over current consumption. They also expect energy production to increase by 15,000 GWh (12 percent) during the same period, and that nearly half of this increase will come from wind power.

Limiting factors for wind power development

Potential does not necessarily equate to viability. Several factors can limit the viability of wind power and will determine the actual extent of its development.

Fact Box 2 – Offshore wind power in deep water

Offshore wind parks are found in several places, such as Denmark. These are typically located relatively close to land in shallow water. The Norwegian company Sway AS is working to develop technology for offshore wind parks in deep water, far from land.

Out to sea, wind conditions are generally very good. Wind parks can be placed out of sight from land, and adverse effects associated with noise, aesthetics, and other environmental factors will thus be substantially reduced. Furthermore, they can be placed off the coast of areas where the transmission network is relatively good, thus avoiding problems with bottlenecks in the network. However, offshore wind parks must be adapted to be compatible with existing activities, such as fishing and shipping.

Sway AS is working with two windmill models. One is a tower structure mounted on the seabed, suitable for depths up to 45 meters. The other is a floating tower anchored to the seabed, designed for depths from 100 to 400 meters. The floating model is particularly well-suited for use along the Norwegian coast.

The potential generating capacity for offshore wind power in Norway is estimated to be 600 GW. Depending upon what type of windmill is used and where it is located, Sway expects them to generate electricity at a cost of 1.9 to 3.6 euro cents per kilowatt-hour, making them quite competitive in price.

Economic factors

The cost of generating electricity by wind power is about 4 euro cents per kilowatt-hour, making wind power unprofitable given current market prices. To circumvent this obstacle and encourage wind power development, the Norwegian government pays 25 percent of the investment costs for building new wind parks.

However, the unit price is driven primarily by wind conditions, not construction costs, which tend to vary little from place to place. If wind conditions are favourable, generating costs can fall.

Technical factors

The transmission network to and from most wind power areas along the Norwegian coast is not designed to carry large amounts of energy. A large-scale expansion of transmission lines must thus occur in parallel with any significant development of wind power. In addition, the Norwegian Ministry of Defence has opposed wind power in northern Norway, claiming it will adversely affect their radar facilities.

Aesthetic factors

The debate over wind power has largely focused on the aesthetic consequences of planned facilities. Local residents, the tourist industry and others believe windmills will dominate the landscape and diminish its visual worth, particularly in protected, recreational and important cultural areas.

Other environmental factors

Windmills may adversely affect wildlife. Birds can collide with the windmill blades, and windmills can disturb or frighten nesting birds. Although some recent studies suggest that the likelihood for collision or disturbance is small, some species have fled from the near vicinity of windmills.

Windmills emit noise under routine operation. Within 40 meters, noise levels are about 50 to 60 decibels. Health authorities recommend a minimum distance of 200 to 300 meters between windmills and neighbouring settlements.

Energy from the sea

Ocean waves, tides and currents contain great energy potential. Energy can be produced either by exploiting the height difference between high and low tide, or by using the flow of water caused by waves and tidal currents.

In northern Norway, the potential for tidal energy alone is estimated to be between 1,000 and 3,000 GWh per year. However, the technology for exploiting energy from the sea is still in a developmental stage.

There are two ongoing pilot projects involving tidal power in northern Norway. Hammerfest Energy is testing a turbine in Kvalsundet near Hammerfest. At full-scale, the project will consist of 20 turbines producing 32 GWh per year.

Statskraft has a pilot project outside Tromsø that involves placing four turbines in a narrow strait to exploit tidal currents. The test facility will be built during 2007 and is expected to produce 3 to 5 GWh per year.

Another pilot project is seeking to exploit the energy of ocean waves. Fred. Olsen Energy is building a series of four wave energy platforms, each of which has a generating capacity of 2.5 MW. The goal is to produce power for as little as 2.6 euro cents per kilowatt-hour.

Electricity production in Russia

Russia has the largest electrical sector in Europe and the fourth largest in the world. It consists of about 440 thermal and hydroelectric power plants, and 31 nuclear reactors. Russia has an electrical production capacity of 206 GW and produced 952,000 GWh in 2005. Thermal power (i.e., gas-, oil- and coal-fired plants) accounted for 63 percent of production, hydropower 21 percent, and nuclear 16 percent.

Russia is divided into seven power districts. The districts are meant to balance demand, production and distribution so that each district is self-sufficient and independent of the others. Connections between the districts remain weak, and transmission capacity between them is limited.

Electricity production and use in northwest Russia

The regional provinces in northwest Russia fall within two different power districts. St. Petersburg and the provinces of Murmansk, Karelia, Pskov and Novgorod belong to the Northwest Power District, while the provinces of Arkhangelsk, Komi, Vologda and a number of others to the south belong to the Central Power District.

The Northwest Power District produces in the order of 50,000 GWh of power per year. Of this, 41 percent is generated by nuclear power, 33 percent by thermal and 18 percent by hydropower.

The Central Power District produces in the order of 200,000 GWh of power per year. Of this 60 percent is generated by thermal power, while 28 percent comes from nuclear power. The Komi Republic, known for its large reserves of oil, gas and coal, is a major producer and a net exporter within this power district. Arkhangelsk, on the other hand, has the largest deficit of generating capacity and is a net importer of electricity.

Murmansk county is by far the largest energy producer in northwest Russia. It produces in the order of 17,300 GWh per year, which is more than Arkhangelsk, Karelia and Komi combined. All together, these four regions produce some 32,000 GWh and consume about 24,000 GWh of energy per year. Murmansk accounts for nearly half of the region’s consumption—about 11,000 GWh per year—most of which is used by industry.

Kola Nuclear Power Plant

The Kola Nuclear Power Plant is located at Poliarny Zori south of Murmansk. It consists of four 440 MW pressurized water reactors built between 1973 and 1984. Together, these reactors produce in the order of 10,000 GWh of power per year. About 60 percent of this is used within Murmansk county, while the remaining 40 percent is exported, primarily to Karelia and Finland.

The two oldest reactors, built in 1973 and 1974, are of a model developed in the 1960s (model VVER-440/230), while the two youngest reactors are of a model from the 1980s (model VVER-440/213). Neither model satisfies western safety standards. Among other things, they lack a safety containment to prevent the spread of radioactivity in the event of an accident. Several international programmes, including Norway's Action Plan for Nuclear Safety, have provided technical assistance to improve operational safety of Kola's reactors.

The Kola reactors were originally designed for an operational lifetime of 30 years. The Russian Atomic Energy Agency granted a 15-year extension after Kola completed a renovation programme. The extension was highly controversial and has been criticized both inside and outside Russia.

What can replace nuclear power on the Kola Peninsula?

The Kola nuclear reactors are scheduled for closure and decommissioning between 2011 and 2020. Because electricity from Kola plays a pivotal role in fuelling heavy industrial activity in Murmansk county and the entire northwest power district, maintaining stability of supply is a top priority. A debate has already begun on how to replace Kola's power generating capacity. Several alternatives have been proposed.

New nuclear power plant

A new nuclear power plant can naturally replace the old one. Despite the high construction costs for nuclear plants, this appears to be the favoured alternative among Russian energy officials. Whether it is a viable alternative depends largely on economic factors and whether a replacement plant can be operational before the old one is closed.

Natural gas

Large reserves of natural gas have been found on the Russian continental shelf in the Barents, Pechora and Kara Seas. The Shtokman gas field, for example, is located 550 km from the Kola Peninsula and has extractable resources of 3,200 billion cubic meters of gas. Replacing the Kola nuclear power plant with a gas-fired plant is a viable option given Russia's plans to develop the Shtokman field. However, it is uncertain whether gas production will begin before the first reactors are expected to close, which could lead to a large deficit in power generation.

Hydropower

Hydropower already accounts for a large share of the production capacity in Murmansk county. Various sources estimate the potential for further hydropower development in the region at 4,000 GWh per year, which represents 40 percent of the Kola nuclear power plant's current production.

Wind power

A recent wind atlas of the Kola Peninsula estimates the wind power potential along the coast at 125,000 GWh. Wind conditions are considered very stable and favourable for wind power.

Developing wind power along the Kola Peninsula faces similar problems as in Norway: a limited, undersized transmission network along the coast, and relatively high construction costs. Nevertheless, some potential wind power sites are near large infrastructure centres, making them better candidates for development than others.

Fact Box 3– Floating nuclear power stations

Providing power and heat to remote settlements in the Russian North and Far East is a considerable challenge given the difficulty of connecting them to a central power grid. One idea that has long been under consideration is to build a nuclear power station on a barge that can be towed to wherever it is needed.

In September 2005, the Russian Atomic Energy Agency submitted concrete plans for a pilot project to build a floating reactor. It will be built at the Severodvinsk naval shipyard near Arkhangelsk. Construction is planned to begin in 2006.

The power station is based on experience from nuclear-powered icebreakers. It will have two KLT-405 reactors and use highly-enriched uranium for fuel. The plant will be capable of meeting the energy needs of a city of 200,000 inhabitants.

Besides meeting its own energy needs, Russia is also interested in leasing the floating power stations to others. Several countries have shown interest, including Indonesia, Malaysia and China.

The concept of floating nuclear power plants has been met with scepticism and criticism, not least from environmental groups. Besides the traditional objections to nuclear power, critics also point out the vulnerability of portable power plants to terrorist attack, especially in the relatively unstable regions of Southeast Asia.

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