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NATURAL GAS IN NORWAY AND THE MID-NORDIC GAS PIPELINE STUDY

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Abstract

Norway is a major supplier of natural gas to the European Union, with the 47 BCM exported in 2000 representing more than 15% of the market share. Russia and Algeria are the two other major non-EU suppliers. Consumption of natural gas in Norway is limited to offshore power generation (3.5 BCM) and on-land methanol production and gas processing (1 BCM). Natural gas consumption is well established in Denmark, Sweden and Finland, amounting to approximately 4 BCM, 1 BCM and 4 BCM, respectively. Transport of natural gas from offshore Mid-Norway, through Mid-Sweden and under the Sea of Bothnia to the west coast of Finland, is being studied by Stamgass AS, a development company owned by power companies in Norway, Sweden and Finland.

Introduction

Natural gas is gaining ground throughout Western Europe and the 21st century is already being called the Methane Age. In the United Kingdom and Continental Europe natural gas is displacing the use of coal for power generation and is the favoured fuel in new power stations. Natural gas is gaining ground because of favourable supply conditions, lower costs and lesser environmental impact, compared to other fossil fuels. The Nordic Countries are increasingly drawn into the Methane Age along with the rest of Western Europe.

The use of natural gas in Finland dates back to 1974; the use of natural gas in Denmark dates back to 1984; the use of natural gas in Sweden dates back to 1985. However, the use of natural gas in Norway dates back to only 1996, lagging Finland by 22 years and Denmark by 12 years. Finland imports natural gas from Russia while Denmark produces natural gas for own consumption and for Sweden. Clearly, the development of the natural gas industry in the continental Nordic Countries has been quite different.

The Nordic Countries are gradually adjusting to developments in energy policy and markets conditions in the European Union countries. The adjustments mean that changes are taking place in the energy sectors in the Nordic Countries. One example of such an adjustment is the interest of Finland to import natural gas from Norway, to supplement the import of natural gas from Russia. Because there is no natural gas pipeline between the two countries; the question arises where to build such a pipeline? A natural gas pipeline from Mid-Norway, through Mid-Sweden to the west coast of Finland, represents an attractive option (Stamgass 2001).

The Mid-Nordic Gas Pipeline was originally proposed by NTNU (Norwegian University of Science and Technology) and subsequently carried forward by Stamgass AS in Trondheim. The pipeline is currently being studied for a group of power companies in Norway (TrønderEnergi AS), Sweden (Graninge AB and Jämtkraft AB) and Finland (Pohjolan Voima Oy).

Norway and European Union

The energy situation in Norway is characterised by the abundance to two forms of energy: hydroelectric power and petroleum resources. The former stands for the bulk of domestic energy use while the latter stands for the bulk of energy export. Most of the hydroelectricity potential in Norway has been harnessed, and the official petroleum resources are reported to have a reserves/production (R/P) ratio of 35 and 141 for oil and gas, respectively (Ministry of Petroleum and Energy 2001a). The R/P ratio shows how many years the current rate of production can be maintained, based on the known reserves and resources.

The general view in Norway is that the days of major new hydroelectric power plants are over. Also, that the production oil will start to decrease within a few years, while the production of natural gas will expand. However, the official R/P ratios for oil may be conservative and Norway will likely continue to find oil further north. Exploration for oil and gas in new areas has moved from the North Sea to the Norwegian Sea and to the Barents Sea. The main areas entering production in recent years are in the Norwegian Sea offshore Mid-Norway and Trondheim, in an area called Haltenbanken. Mid-Norway has already become a major oil and natural gas production region in Norway.

The installed power of hydroelectric plants in Norway 2000 was 27,570 MW. This capacity has remained about the same the last decade. The normal annual energy production in the hydroelectric power plants is 118 TWh. In 2000, which was as wet year, a new production record of 143 TWh was achieved (Ministry of Petroleum and Energy, 2001b).

In 2000, Norway was the sixth largest producer of oil in the world behind Saudi Arabia, USA, Russia, Iran and Mexico, producing 3.31 million barrels per day (BP 2001). In 2000, Norway was the third largest exporter of petroleum in the world behind Saudi Arabia and Russia, exporting 3.08 million barrels per day. The term petroleum means oil and natural gas and petroleum liquids. Measured in oil equivalents (1000 standard cubic metres natural gas are equivalent to 1 standard cubic metre of oil equivalent), natural gas represents about 20% of the total petroleum exports of Norway.

The consumption of natural gas in the European Union (EU) and Norway in 2000 was 343 BCM (BP 2001), equivalent to 3430 TWh-thermal. The unit BCM stands for Billion Cubic Metre. The largest consumer was the UK with 86 BCM. The consumption of natural gas in Europe outside the European Union and Norway was 70 BCM not including Russia. The production of natural gas in the European Union was 197 BCM for which the UK stood for 97 BCM and the Netherlands 52 BCM. Natural gas production in Norway in 2000 and delivered to EU was about 47 BCM. In the EU and Norway production of natural gas in 2000 was therefore 245 BCM. The 98 BCM difference in EU and Norway consumption and production were delivered primarily by Russia and Algeria.

Natural Gas in Norway

Associated gas and non-associated gas are two kinds of natural gas produced. Associated gas is the gas dissolved in oil at reservoir conditions and comes out of solution when pressure is released and oil flows to the surface (two-phase flow). At the surface on a production platform, the associated gas is separated from the oil and cleaned, and then compressed for pipeline transport. Non-associated gas is the gas found in gas-dominated reservoirs. It stays as gas when it flows from the reservoir to the surface (single-phase flow) and is then cleaned and compressed for pipeline transport. Other reservoir conditions and production situations exist, but will not be discussed here.

Associated gas produced in Norway has three "destinations." First, the gas is used in power generation to drive compressors, pumps and other equipment on an offshore production platform. Second, the gas is injected into the reservoir to maintain oil production by pressure support. The gas is injected into the gas cap at the top of the reservoir. If the gas cap did not exist before the start-up of oil production from greater depth, the gas cap will be created by the gas injection. Third, the gas is cleaned, compressed and transported by pipeline to a receiving terminal (in Norway or Continental Europe). Non-associated gas produced in Norway has two "destinations," namely power generation and pipeline transport.

The volumes of natural gas injected (reinjected) offshore Norway each year are apparently not reported by the Ministry of Petroleum and Energy (2001a). On a particular production platform the volumes injected change greatly during the lifetime of the installation. The volumes injected offshore Norway are much less but still considerable in comparison to the volumes exported annually.

All of the oil and gas production in Norway is offshore. Most of the oil is loaded offshore and transported by tank ship to refineries near and far. Some of the oil is piped directly to two terminals (Sture and Mongstad, west of Bergen). The gas is transported by pipeline to land-based receiving terminals for processing before further transport to Continental Europe. In a few instance the gas is processed offshore and transported directly to the UK and the Netherlands.

The oil and gas fields offshore Norway are licensed to oil companies. Each field license is divided in such a way that several oil companies have a percentage. One of the oil companies is nominated the operator of the field on behalf of the licensees. The Ministry of Petroleum and Energy decides what companies get license percentages in a particular field and what company becomes the field’s operator, based on bids submitted by the companies in a public offering process. The offshore pipelines in Norway are owned by the oil companies according to their percentage ownership in the fields producing the natural gas transported in a given pipeline.

Detailed information about the Norwegian petroleum industry is provided by the Ministry of Petroleum and Energy (2001a). The history of natural gas developments in Norway is presented by Arneson (1998) in an interesting perspective.

There are three major receiving terminals in Norway, at Kårstø north of Stavanger, at Kollsnes west of Bergen and Tjeldbergodden some distance west of Trondheim. The Kårstø terminal is the oldest and largest and processes natural gas and gas condensate. The Kollsnes terminal processes natural gas from the very large Troll-field (non-associated gas field). The Tjeldbergodden terminal receives natural gas from the Heidrun field and is the site of an

important methanol plant. Natural gas to Continental Europe is compressed and transported from Kårstø and Kollsnes.

The Norwegian Petroleum Directorate (NPD) keeps statistics for the consumption and flaring of natural gas offshore (Hult 2001). Flaring is the burning of gas on drilling platforms when testing new wells, and on production platforms outside normal process operations (for example, process start-up and emergency shut-down). In 1999 the consumption was 2.65 BCM and the flaring was 0.66 BCM, in total 3.31 BCM. The natural gas consumption for Norway in 1999 was reported 3.2 BCM and in 2000 it was reported 3.5 BCM in BP's Statistical Review of World Energy (BP 2001). The NPD reports 0.29 BCM in natural gas consumption in 2000 at Kårstø, Kollsnes and Sture, and 0.0016 BCM in flaring (at Kollsnes). The consumption reported by BP (2001) is presumably limited to the offshore use of natural gas (consumption and flaring).

Long-term data from NPD (Hult 2001) show that while the consumption of natural gas offshore has increase, the flaring of natural gas has remained fairly constant. It seems reasonable, therefore, to assume that offshore flaring in 2000 was about the same as reported for 1999. The consumption and flaring of natural gas offshore needs to be monitored in Norway because of a special carbon dioxide tax. All natural gas burned offshore (consumption and flaring) is subject to a carbon dioxide tax of 0.72 NOK per standard cubic metre (in 2000 it was 0.70 NOK per standard cubic metre). The use of natural gas on-land in Norway is not subject to the carbon dioxide tax. The tax is comparable to the landing price of natural gas in Europe. The landing price is the price paid for the natural gas where the ownership changes hand.

In Mid-Norway, natural gas is transported 245 km from the Heidrun field to the Tjeldberodden receiving terminal and methanol plant (annual production capacity 830,000 tonne). The methanol plant and other production facilities (LNG, nitrogen, oxygen, argon, bioprotein) at Tjeldbergodden used about 0.7 BCM of natural gas annually. LNG stands for liquefied natural gas. Waste heat is also used at Tjeldbergodden. Near the Kårstø terminal north of Stavanger, modest volumes (0.04 BCM) of natural gas are distributed and used primarily for industrial purposes. The total consumption (including flaring) of natural gas offshore and on-shore in Norway 2000 was about 4.5 BCM.

Natural Gas in Finland, Sweden and Denmark

All the natural gas consumed in Finland is imported from Russia. The gas enters Finland near the city of Imatra, some 3500 km from the fields in Western Siberia (Gasum 2001). The natural gas network in Finland consists of 943 km of high-pressure transmission pipelines and around 1000 km of distribution pipelines. In 2000, about 3.9 BCM of natural gas passed through the network, equivalent to 11 percent of Finland's total energy requirement. Almost three-quarters of the natural gas imported to Finland is used in combined heat and power (CHP) generation. The established consumption of natural gas in Finland is expected to increase from the current 4 BCM to about 6.2 BCM in 2010 (Tebodin and Arthur D. Little 1998). Established consumption refers to already developed markets, not new consumption.

The natural gas consumed in Sweden is imported from Denmark. The gas enters Sweden south of Malmö and is transported in an approximately 300 km long high-pressure pipeline up the west coast to Göteborg. Along the pipeline the natural gas is distributed to consumers; the low-pressure distribution net is about 3500 km long. About 0.85 BCM of natural gas is

consumed in Sweden annually. About 40% are used in CHP, about 40% in industry and 20% for direct heating (Pellijeff 2000, Vattenfall Naturgass 2001). The natural gas consumed corresponds to about 2% of the energy used in Sweden. The potential total market in the pipeline-region (west coast of Sweden) is estimated 1.5 BCM. The Stockholm-region is estimated to have a potential of 3 BCM, of which 2 BCM for CHP and 1 BCM for industry. Several plans are being studied to supply natural gas to Stockholm.

The natural gas consumed in Denmark is produced in the Danish North Sea. The gas is piped the 200-250 km to shore at Nybro on the west coast of Jylland, and from there to sites in the north and south of Denmak and Copenhagen. The production in 2000 was 7.3 BCM, according to BP (2001), and 4.4 BCM went to consumption. According to Ingwersen (2000), about 4 BCM are distributed to about 300,000 customers in Denmark. The remaining gas is transported to Sweden (nominally 1 BCM) and Germany (nominally 2.5 BCM). Recently, an agreement was signed for about 2 BCM per year to Poland for 8 years (DONG 2001).

The role of natural gas to reduce carbon dioxide emissions in the Nordic Countries has been studied under the auspices of the Nordic Council of Ministers (Rambøll and ÅF-Energikonsult 1997).

Mid-Nordic Gas Pipeline Study

The role of natural gas in the European Union (EU) energy policy can be expressed in terms of three objectives: competitiveness, security of supply and environment (Burgos 1998). The competitiveness is pursued through the EU Gas Directive and the Trans-European Energy Networks (TEN) programme (European Commission 1997). The security of supply is pursued through the TEN programme, external relations and co-operation. The Environmental objectives are pursued through fuel switching to less carbon dioxide emitting fuels, reduction of methane leakages and improved gas technologies. More specifically, the TEN programme has internal energy market, economic and social cohesion and security of energy supplies as objectives, and connection of isolated gas grids, introduction of gas into new regions and interconnections with non-EU countries as priorities.

In the Nordic Countries, the TEN programme has funded the Nordic Gas Grid study (Sund and Grevink 1998, Burgos 1998) and the Baltic Gas Interconnector study (Nyman 2000). The TEN programme is currently funding 50% of the Mid-Nordic Gas Pipeline (MNGP) study, where the power company Pohjolan Voima Oy (PVO) of Finland is the main partner. The MNGP study formally covers the pipeline from the Norwegian-Swedish border to the West Coast of Finland.

The Mid-Nordic Gas Pipeline study is based on Finland's need for natural gas from Norway, to achieve the three main objectives of EU's energy policy. The petroleum resources offshore Mid-Norway are plentiful and natural gas can readily be fed into a pipeline to Finland. However, before that happens, a lot of work has to be carried out by companies in Norway, Sweden and Finland. The Mid-Nordic Gas Pipeline offers unique possibilities to companies in Mid-Sweden, primarily in the region between Östersund and Sundsvall. There is a modest potential for natural gas utilisation in Mid-Sweden and a dedicated pipeline would not be cost effective; it is because of the large gas volumes needed in Finland that Mid-Sweden will get access to natural gas.

The natural gas network in Finland is in the south, and here is no pipeline network on the west coast. On the west coast, however, PVO operates several coal-fired power stations: in Vaasa, Kristinankaupunki and Pori. These power stations can readily be converted from burning coal to burning natural gas; that is, re-powered. PVO (Isotalo 2001) has estimated that after re-powering the stations in Vaasa and Kristinankaupunki will each need 0.9 BCM per year and the two Pori stations 2.2 BCM. This re-powering potential of 4 BCM can be realised in a short time, contributing significantly to early-income for the Mid-Nordic Gas Pipeline. The re-powering potential comes in addition to the estimated increase in the established natural gas consumption in Finland from 4 BCM in 2000 to 6.2 BCM in 2010. It is expected that the availability of Norwegian natural gas in Finland will also lead to renewed growth in consumption. Therefore, the need for new natural gas supply to Finland is expected to be greater than the 6.2 BCM already identified.

One standard cubic meter of natural gas contains about 10 kWh of thermal energy (Ministry of Petroleum and Energy 2001a). The conversion efficiency achievable in combined-cycle natural gas driven power plant is about 60%. Therefore, the 6.2 BCM identified as the new market potential of natural gas in Finland, corresponds to about 37.2 TWh of electricity. For comparison, electricity produced in Sweden, Norway, Finland and Iceland in 2000 was about 145 TWh, 120 TWh, 80 TWh (Stamgass 2001) and 7.7 TWh (Orkustofnun 2001), respectively.

An important consideration in the re-powering of coal-fired to gas-fired power plants, is the reduction in carbon dioxide emissions. Typically, the burning of natural gas will produce 0.2 kg of carbon dioxide per kWh thermal, while coal will produce 0.33 kg per kWh thermal (Stamgass 2001). The conversion from coal-fired to gas-fired power generation, therefore, will reduce the carbon dioxide emissions by about 40%. A conversion to natural gas will also reduce nitrous oxides emissions and practically eliminate sulphur and particle emissions. According to the Kyoto agreement of 1997, Finland needs to achieve its 1990 emission levels in the time frame 2008 to 2012.

The Mid-Nordic Gas Pipeline study needs to be considered in the context of other natural gas development activities on-going in Mid-Norway. The company Industrikraft Midt-Norge DA (IMN) is planning a 800 MW (2x400 MW) gas-fired power plant at Skogn, deep in the Trondheim Fjord (Industikraft Midt-Norge 2000). Skogn is the location of a large paper mill and can be supplied with natural gas through a 160 km subsea pipeline from Tjeldbergodden. The first unit of the IMN plant is schedule for start-up on October 1, 2004; the second unit about two years later. The 800 MW power plant will require 1.1 BCM of natural gas when fully operational, and will produce 5.2 TWh of electricity and 1.0 TWh of process steam and waste heat.

The 160 km pipeline from Tjeldbergodden to Skogn needs to have sufficient capacity (diameter) for the IMN power plant and natural gas to Sweden and Finland through the Mid-Nordic Gas Pipeline. The IMN plant will receive natural gas through the existing Haltenpipe, currently supplying 0.7 BCM to the methanol and other plants at Tjeldbergodden. The current capacity of Haltenpipe is about 2.2 BCM. Clearly, a new subsea pipeline is required from Tjeldbergodden to an offshore production platform, to supply natural gas to the Mid-Nordic Gas Pipeline. Such a pipeline will be 150-200 km long.

The Mid-Nordic Gas Pipeline study is on-going and will be completed in early-2002. Assuming that the results will be favourable, formal negotiations for the supply of natural gas

can start in 2002, detailed engineering design in 2004, construction in 2006 and completed in 2008-2009, for example. The investment costs of the Mid-Nordic Gas Pipeline are being estimated in on-going activities. The following rough cost estimates have been used for the different part of the pipeline: Haltenbanken offshore to Tjeldbergodden 1 billion NOK, Tjeldbergodden to Skogn 1 billion NOK, Skogn in Norway to Sundsvall in Sweden 5 billion NOK, across the Sea of Bothnia 1 billion NOK. Investments in Finland are roughly estimated 1 billion NOK for pipelines and 1 billion NOK for re-powering.

Concluding Remarks

Natural gas is the fastest growing segment of the energy industry in Europe and world-wide; in Europe the growth was 3.3% and world-wide it was 4.8% from 1999 to 2000 (BP 2001). The European Commission has taken steps to facilitate further development of the natural gas market through the Gas Directive (liberalisation) and the Trans-European Energy Networks programme. Europe receives natural gas from three major production regions of natural gas: Algeria in the south, Russia in the west and Norway in the north. Natural gas from Norway to Finland represents all aspects of the EU energy policy in terms of competitiveness, security of supply and environmental protection.

Denmark, Finland and Sweden have established natural gas markets on-land, with annual nominal volumes of about 4 BCM, 4 BCM and 1 BCM, respectively. Norway does not have an established natural gas market on-land, but uses about 3 BCM offshore for power generation and about 1 BCM on-land for gas processing and chemical manufacture. However, Norway is planning to build several natural gas fired power plants, including 400 MW on Kårstø, 400 MW at Kollsnes and 800 MW at Skogn. The company Naturkraft AS is planning the Kårstø and Kollsnes power plants (Naturkraft 2001). Modest land-based uses are planned in the Bergen-region and the Trondheim-region. The use of natural gas in busses and ferries has started.

The production cost of electricity in a 400 MW gas-fired power plant in Norway is estimated 0.17 NOK/kWh (Aas 2001), compared to 0.23 NOK/kWh, 0.30 NOK/kWh and 0.35 NOK/kWh for new hydro-power, wind-power and coal-fired plants, respectively. The natural gas and coal production costs are without carbon tax. The costs are for Norwegian conditions and it should be noted that the further natural gas has to be transported, the higher the production cost of electricity. A central purpose of the Mid-Nordic Gas Pipeline study is to estimate the investment costs to determine the cost of transporting natural gas from offshore Mid-Norway to the west coast of Finland.

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