

Renewable Energy in the North

This chapter focuses on renewable power production in the BIN area. The BIN area is a substantial provider of renewable energy to Norway, Finland, Sweden and the Nordic power market. The power production from the BIN area is dominated by hydropower, with a growing wind production. We will look into renewable power production, transmission structure and market conditions. We will also comment shortly on the development of nuclear power in Sweden and Finland. Nuclear power production is not renewable, but this energy source is an important part of the energy market in these BIN countries, and Finland is currently building its sixth reactor in Hanhikivi 1 in Northern Ostrobothnia. The next editions of the production chapter in the BIN report will focus on mineral production, forestry, paper and pulp production, which are large industries in the BIN area.

Climate change has in recent years evolved into one of the core political issues both in Europe and worldwide. In December 2015, 195 countries adopted the first universal, legally binding, global climate deal at the Paris Climate Conference (COP21). Policies that aim at reducing greenhouse gas emissions by 40 % by 2030 (relative to 1990) have been implemented in the European Union. The development of renewable energy sources is regarded an important lever to reduce energy-related greenhouse gas emissions. Currently, in several countries, the expansion of renewable energy and other measures to reduce greenhouse gas emissions are primarily policy-driven. Regulations affect consumption and production costs, but also the competitiveness of companies and overall economic growth. Changes in energy consumption, such as electrification in transportation and energy-efficiency measures in power intensive industries, are factors that are policy driven. The growth in new power-intensive industries, such as data processing and block chain technology, affect energy consumption and energy policies of the BIN area and its respective countries.

Results suggest that:

- The BIN area is a substantial provider of renewable energy to the BIN countries and the Nordic Power market. The BIN area has three counties with a surplus of renewable energy, and in 2014 the surplus in these regions were 10,7 TWh in Västertotten, 7,1 TWh in Norrbotten and 5,6 TWh in Nordland in Norway . These regions are also increasing their renewable energy production
- Renewable energy production in the BIN area in 2014 by source;
 - Hydropower 50 783 GWh
 - Thermal power 8 289 GWh (including heat and power production combined)
 - Wind power 5 244 GWh
- Within the BIN area, several new wind power plants are under construction, enhancing the BIN area's position as an important renewable region in the North.
- The BIN counties in Finland are reliable on energy import. The planned Hanhikivi 1 nuclear power plant in Northern Ostrobothnia will change the energy balance in Finland.
- The BIN area is attractive for establishing new power-intensive industries

The BIN area is a part of an emerging European market

The BIN area is a part of the Nordic power market. The Nordic countries deregulated their power markets in the early 1990s and brought their individual markets together into a common Nordic market. Estonia, Latvia and Lithuania joined the Nord Pool¹ market in 2010-2013. The term deregulation means that the state is no longer running the power market, and free competition was introduced. This process was undertaken in order to create a more efficient energy market, with the exchange of power between countries and increased security of supply. Available power capacity can be used more efficiently in a large region compared to in a small one, and integrated markets enhance productivity and improve efficiency.

Now that transmission capacity and coupling is in place between the Nordic countries, the European continent and the Baltics, the power market covers large parts of Europe. This means that power from many different energy sources such as hydro, thermal, nuclear, wind and solar sources – enters the grid. This ensures a more 'liquid'

market, where large volumes are traded daily, and a more secure power supply.

The main trends influencing the Nordic power market today is a closer European market orientation and integration, increasing amounts of intermittent generation, more centralized regulation, and changes in the consumption of energy. We see a trend where the renewable energy demand is rising rapidly among large corporations worldwide. The number of companies that have set renewable energy or sustainability targets is increasing. RE100 currently lists over 88 multinational and influential companies that have committed to 100 % renewable electricity. Ikea, Apple, the BMW Group, Google and H&M are among the RE100s companies². In order to achieve this, they must match 100 % of the electricity used across their global operations with electricity produced from renewable sources, either sourced from the market or self-produced.

The development offers possibilities for the BIN area, both as host for new power-intensive industries and as a location for new renewable energy production. The BIN area is a large provider of renewable

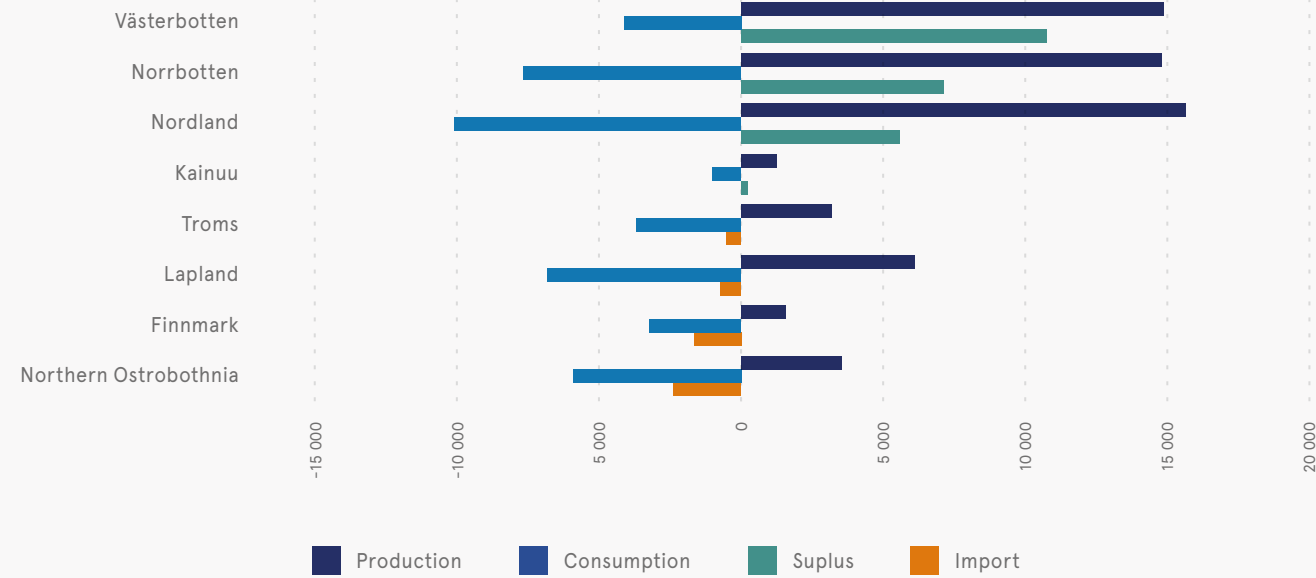


Øvre Forsland hydro power plant
Photo: Helgeland Kraft AS

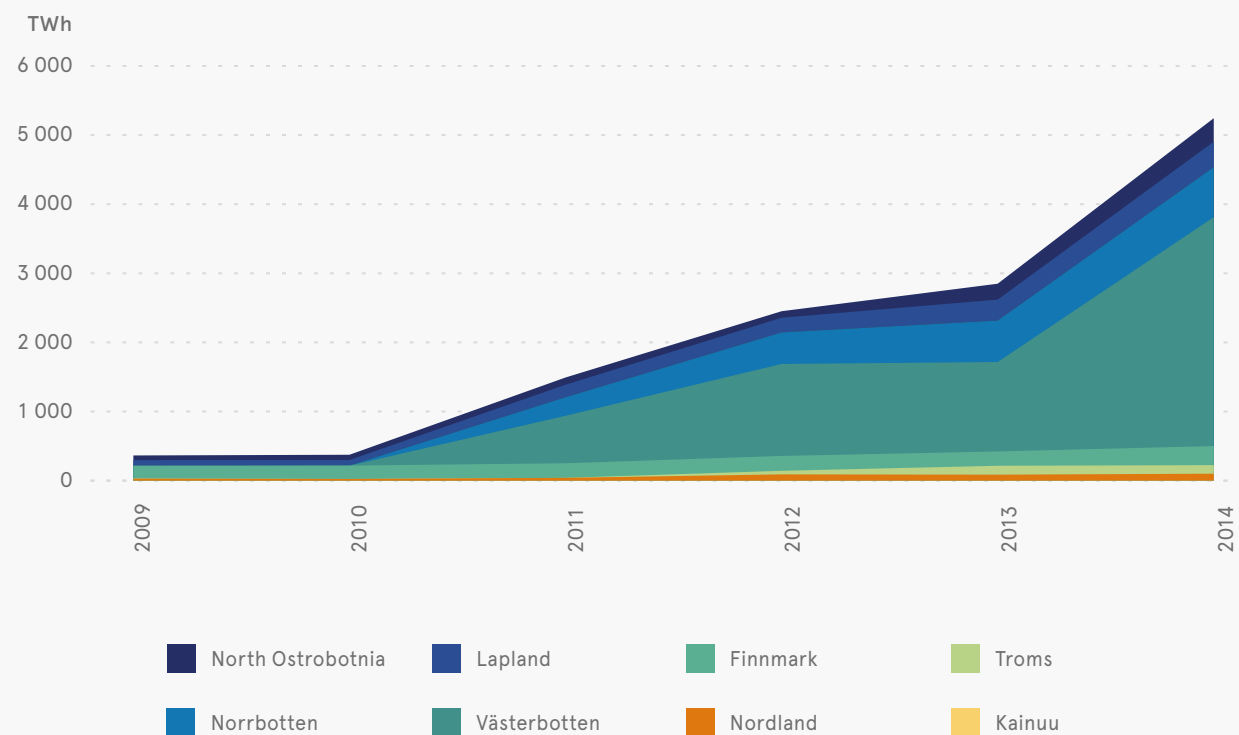
¹ Nord Pool is owned by the Nordic transmission system operators (TSOs) Statnett SF, Svenska kraftnät, Fingrid Oy, Energinet and the Baltic transmission system operators Elering, Litgrid and Augstsprieguma tikls.

² www.there100.org/companies.

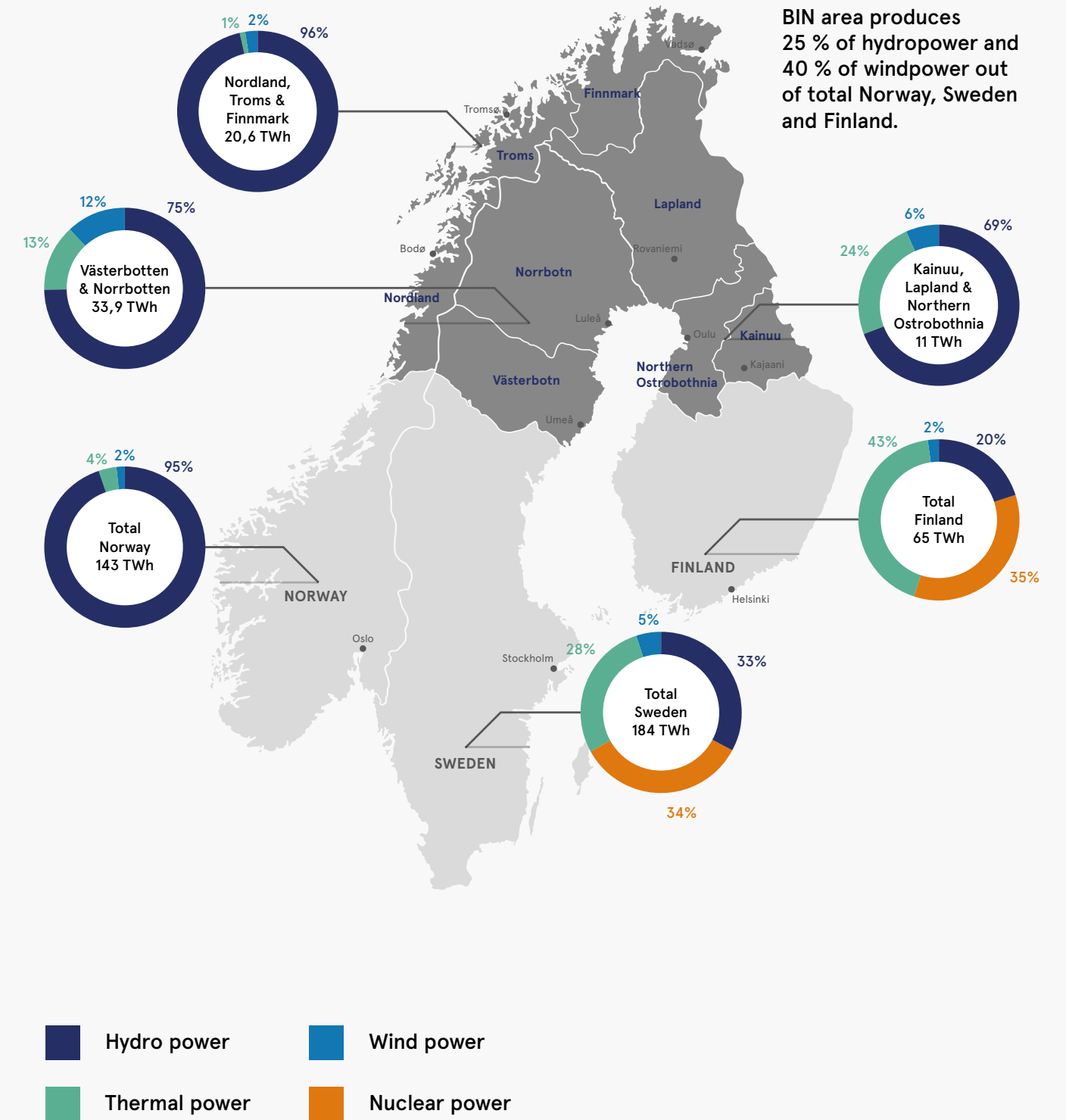
Electricity production and consumption in the BIN area, 2014



Growth in wind power production in the BIN area, 2009-2014



Map of power production in the BIN area at the county level, 2014



energy, and has regions with power surplus. The BIN area also has a potential of further growth in renewable energy production, and an increasing share of foreign capital is realising renewable projects such as wind power plants in the BIN countries³. The combination of a cold climate, high level of digital infrastructure, accumulated human capital and political stable governance makes the BIN area highly attractive to new power-intensive industries establishments.

For instance, Facebook established their first European data centre in Norrbotten's largest town Luleå. After careful due diligence and consideration of more than a hundred different possible areas in Europe, Facebook outlines two factors for choosing Luleå: cold climate and stable renewable energy supply. The winter in Norrbotten averages -20C. According to Facebook, the freezing air from outside that is pumped into the building is one of the factors that enables this warehouse in Luleå to be the most energy-efficient computing facility ever built. The other main factor was the electricity supply and cost. Norrbotten and Västerbotten are the counties where a large part of Sweden's hydropower production is generated. These two regions alone represented 41 % of Sweden's hydropower production in 2014. Västerbotten is the largest wind power production county in the BIN area, where wind power production is growing. The decline in the steel, iron ore and pulp and paper industries in Sweden resulted in decreased energy consumption. As a result,

both Norrbotten and Västerbotten have a power surplus generated by hydropower. Facebook's data centre uses as much energy as the steel plant. The ripple effects of Facebook's establishment in Luleå are many, e.g. direct, indirect and induced impacts are estimated to generate 4,500 full-time workers (half of impacts accruing locally), other effects include the emergence of a new ecosystem for ICT⁴. In 2017, the Chinese tech company Canaan Creative also moves into Norrbotten. Canaan is the first Chinese company within this sector to open a data center in Europe. These examples demonstrate a growing potential for the BIN area to attract power intensive industries.

Transmission capacity in the BIN area and the BIN Countries

The BIN areas electricity production and consumption are connected through a transmission system. The transition from a centralized to a more decentralized power system also affects the grid and transmission capacity. The national main grid owners are the Transmission System Operators (TSO)⁵, who are responsible for maintaining the balance in the respective nations' power system through a bilateral agreements. In 2010, the TSOs in Finland, Sweden and Norway initiated the Nordic Balance Settlement to establish a common Nordic end-user market for electricity. The TSOs operates the high-voltage grid and interconnections. The distribution system operators (DSO) are at regional and local level.

Table 1 – Interconnector capacity from and between the BIN countries⁶

Table 1 shows the cross-border transmission capacity from and between the BIN area and the BIN countries. The Nordic energy market is integrated with Europe through several new interconnectors. The European Commission has suggested a requirement that member countries should establish minimum 15 % bilateral transmission capacity of their installed production capacity. Regulation of the power flow up or down between the countries and regions is used when the consumption exceeds production, or vice versa. It enables the TSO to ensure stable frequency in the transmission grid. A large part of the grid in the BIN area, as well as for the rest of the BIN countries, was built about 60–120 years ago. Thus, there are now large ongoing investments in the grid, in order to secure power supply and meet the increasing demands of consumers. This affects the net tariffs for the consumers in the area. There is an ongoing political discussion on how to divide these costs between the areas with high production capacity and the areas of high electricity consumption. Net tariffs are stands for about half of the consumer's energy costs, but this varies between regions, grid companies and what grid level industries or businesses are connected to.

NORWAY		SWEDEN		FINLAND	
Sweden	3 600 MW	Norway	3 600 MW	Sweden	2 600 MW
Denmark	1 700 MW	Finland	2 600 MW	Russia	1 000 MW
Netherlands	700 MW	Denmark	360 MW	Norway	100 MW
Finland	100 MW	Germany	600 MW	Estonia	1 200 MW
Russia	50 MW	Lettland	570 MW		
Lapland		Lithuania	1 000 MW		

Under construction
 Statnett in Norway is currently building two new interconnectors. North Sea Link between Norway and the UK is a cooperation with British National Grid, the project is planned to be completed in 2021. NordLink is between Norway and Germany, built in cooperation with grid company TenneT and investment bank KfW, the project is planned to be completed in 2020. Both on 1 400 MW.

³ Wind power Ownership in Sweden: Business Models and Motives by Tore Wizelius 2014.

⁴ Source: Digital infrastructure and economic development: An impact assessment of Facebook's datacentre in Northern Sweden, captures the importance of large-scale data centres to the Swedish economy and the opportunity they provide. The Boston Consulting Group, Inc. 2014.

⁵ TSO's in the BIN countries are Statnett in Norway, Svenska Kraftnätt in Sweden, Fingrid in Finland and in Russia the TSO is Federal Grid Company.

Price areas and power flow in the BIN area

The electricity production is spread around the BIN countries, and a lot of the BIN areas' industry has been established close to power production. The cable grid has been developed based on this. Thus, there is capacity in the grid for power to be transported for consumption wherever there is a demand, but there are some bottlenecks in the BIN areas' transmission system today. The BIN nations need a system for handling this.

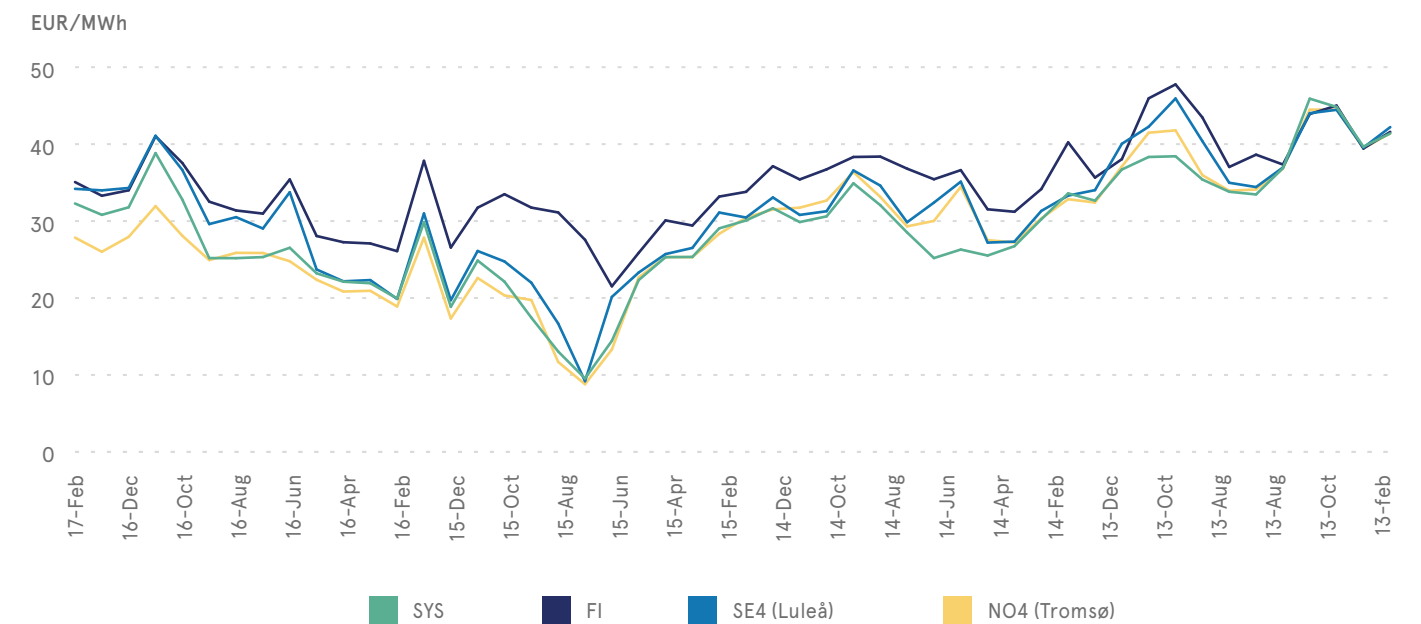
The authorities in the BIN countries have all chosen a market-based system for buying and selling power, and a market-based system for handling the bottlenecks that arise in the cable grid as a result of the power market; these are called el-spot areas (day-ahead market)⁸. Norway and Sweden are, furthermore, divided into market areas (price areas) that are used to handle larger capacity limits in the grid. Norway has five price areas, and the BIN region is area NO4, Tromsø. Sweden has four price areas and the BIN region is in SE1, Luleå. Finland has one price area. The price areas are

market areas for reporting power trading on the stock market. The energy price is a result of supply and demand on power reported on the stock market. As a consequence of this, the power and market situation of each area will determine which direction the power flows between the elspot areas.

In 2012, Sweden and Norway agreed on a common energy certificates market, which started in January 2012 and extends until 2035. The aim of this renewable subsidiary was to provide more renewable energy production. The subsidiary has been successful with regard to new renewable energy production, but has received criticism for holding renewable energy prices very low. The Norwegian ministry of oil and energy decided in 2016 that Norway will not continue the common Norwegian-Swedish market for electricity certificates after 2021. While Sweden has prolonged the certificate market until 2030. The energy authorities in the two countries have expressed their common opinion that there should be only one market for electricity certificates in the Nordic, should the market expand.

Figure 1 – Elspot prices in the BIN area, Q2.2013–Q2.2017, Source: Nordpool

Figure 1 shows the development in the monthly average elspot price in the BIN area. In addition to the system price (SYS), the three bidding areas in the BIN are shown. The Norwegian price area NO4 (Northern Norway) has limitations on the grid towards price area NO3, and this affects the prices in NO4. Nordland is one of the counties in Norway with the largest renewable energy production and has the largest annual surplus. Attracting new power-intensive industries in this area, as shown in Luleå, would increase the value creation from this natural resource greatly, through creating jobs in the regions where the power is produced and reducing the need for grid investments to export the electricity. In Sweden, the price in SE4 and the other three price areas are correlated.



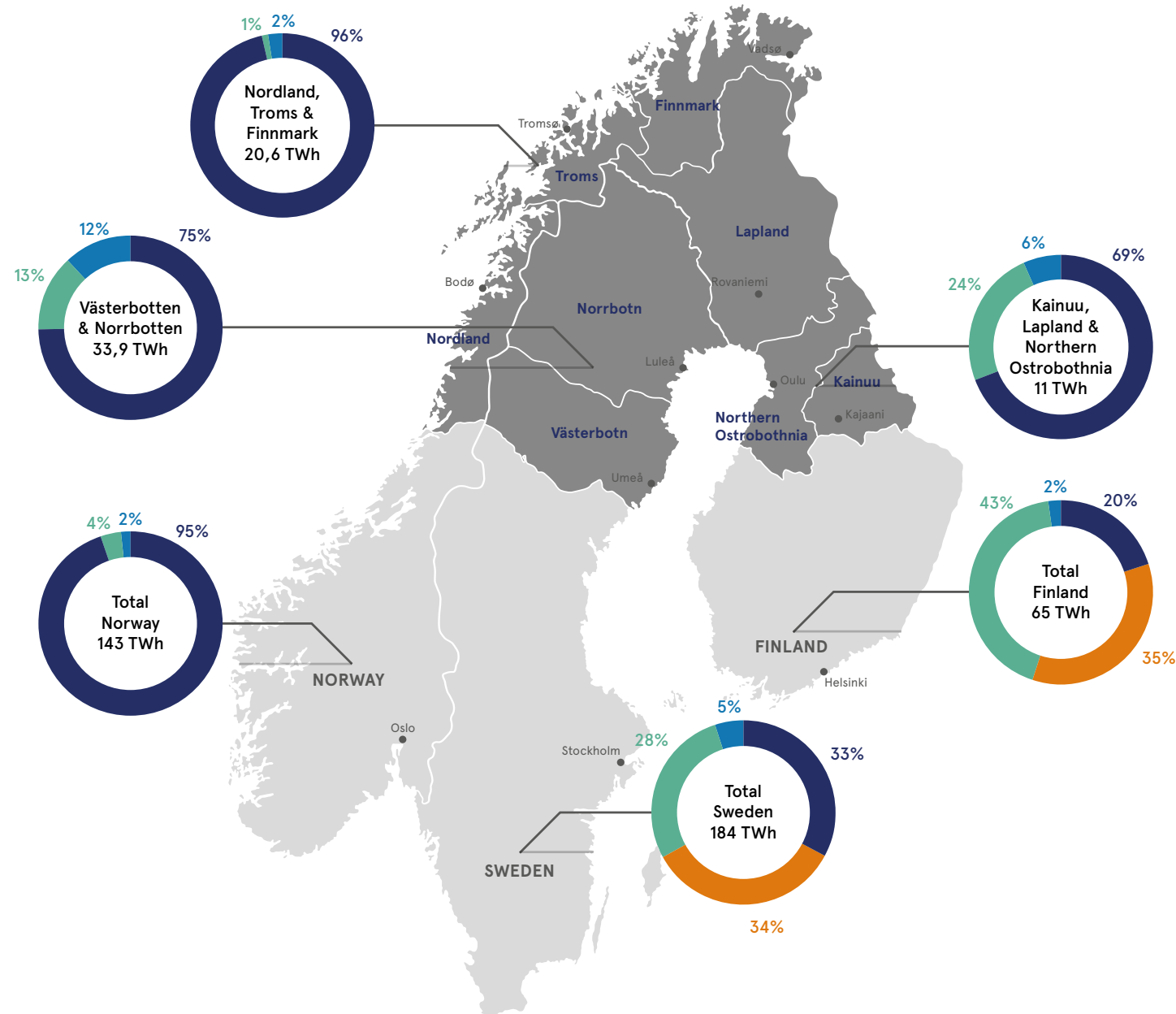
⁶ Source: Statnett, Svenska Kraftnätt and Fingrid.

⁷ Elspot refers to the spot market for physical power turnover on the Nordic power exchange Nord Pool. This is wholesale turnover of electricity. Usually, the Nordic power market is divided into six so-called elspot areas. Elbas is the intraday market.

Overview of electricity- and thermal power production in the BIN area

Figure 2 – Map of power production in the BIN area at the county level, 2014

Figure 2 demonstrates that the power system in the BIN area is a mixture of different generation sources: Hydro, thermal and wind power. Wind power is rapidly growing in the BIN area. Thermal power is a large source of energy in Sweden and Finland, but has not had the same development in Norway. The map shows the BIN region’s importance as a renewable energy provider to the Nordic energy market. The figures in the map give an overview of the energy sources in the BIN area and the BIN countries.



Hydropower

Figure 3 – Hydropower production in the BIN area and the BIN countries (excluding the BIN area), 2014

Figure 3 shows hydropower production in the BIN area and the BIN countries when extracting the production in the BIN area. Hydropower represents 96 % of the electricity production in Norway, 42 % in Sweden and 20 % in Finland. In 2014, more than 50 TWh hydropower energy was produced in the BIN region. Almost 25 % of the BIN countries’ total hydropower production was produced in the northern parts of these countries. The yearly hydropower production varies from year to year due to consumption and rainfall. Most all of the hydropower production in the BIN area is regulatory. Regulatory hydropower generation can easily be increased or decreased on very short notice. This functionality allows grid operators to match production with varying demand in real time. Thus, the hydropower production plants play an important part in operating the energy balance in the grid. A large part of Sweden’s hydropower production is generated in Norrbotten and Västerbotten counties. These two counties in Sweden represented 41 % of Sweden’s hydropower production in 2014. Norway is the world’s seventh largest hydropower producer with a normal yearly production of 136 TWh. In 2014, 13 % of this was generated in the North of Norway, the year before this number was 17 %. In Finland, the total hydropower production in 2014 was 13 TWh, and 58 % of this was produced in Northern Finland.

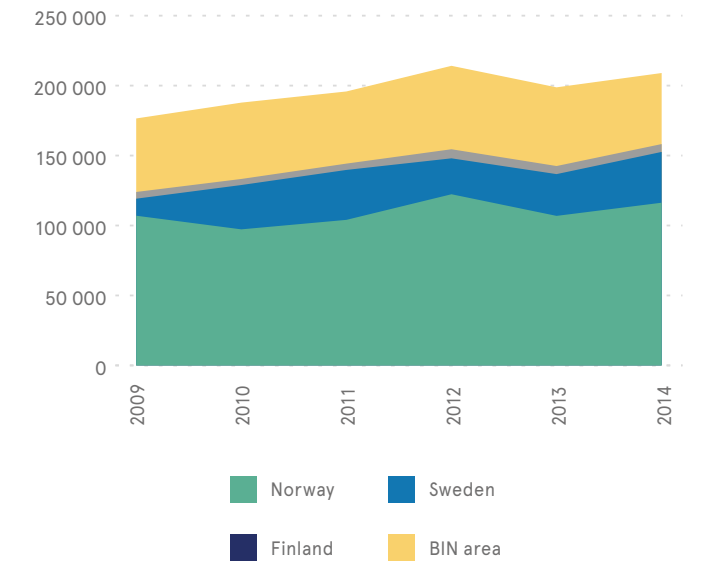
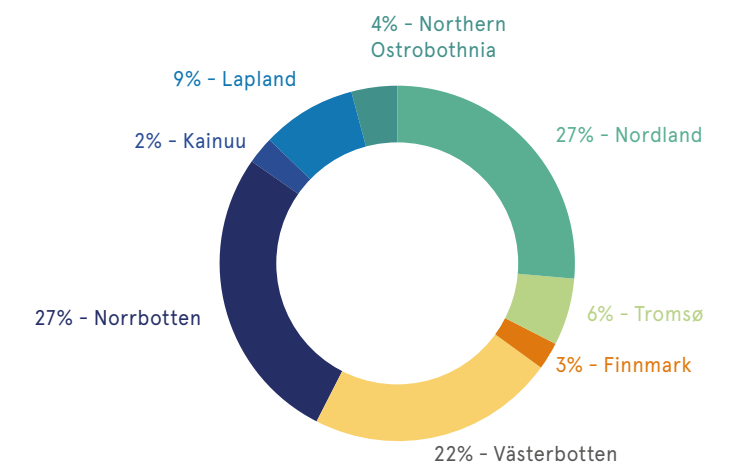


Figure 4 – Hydropower production at the BIN county level, 2014

Figure 4 shows the hydropower production in each of the BIN counties in 2014. Northern Sweden, with Norrbotten and Västerbotten, represents 25 TWh – which is 50 % of the hydropower production in the BIN area. In Norway, Nordland is the dominant renewable county and among Norway’s two largest hydropower producing counties. Lapland is the county in Finland with the largest hydropower production. Lapland County alone produces 50 % of Finland’s hydropower production. The hydropower production in the BIN area in 2014 was 52,7 TWh.



Windpower

Figure 5 – Wind power generation in the BIN area, 2009-2014
 Figure 5 shows that the wind power electricity production from the BIN area is rapidly increasing. Almost 40 % of the BIN countries' wind power production is in the BIN area. The noticeable effect of wind power production has increased strongly in the recent 6-7 years. The importance of wind power is increasing, as several wind power parks are under construction in the BIN area, e.g. in Västerbotten and Nordland.

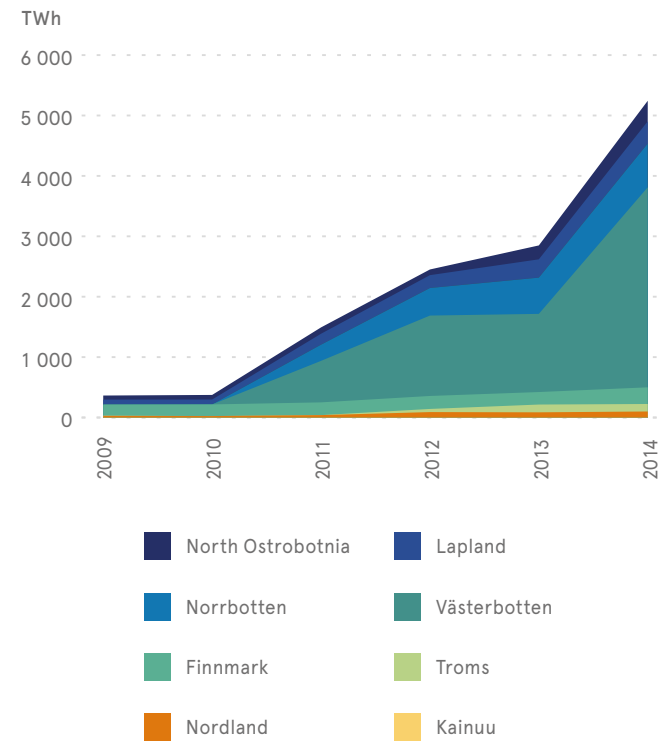
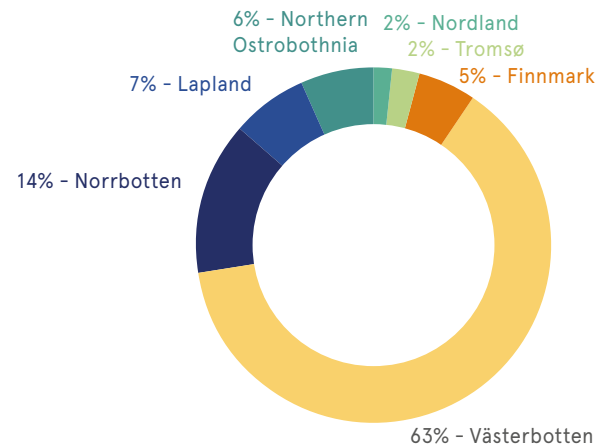


Figure 6 – Wind power generation at the BIN county level, 2014

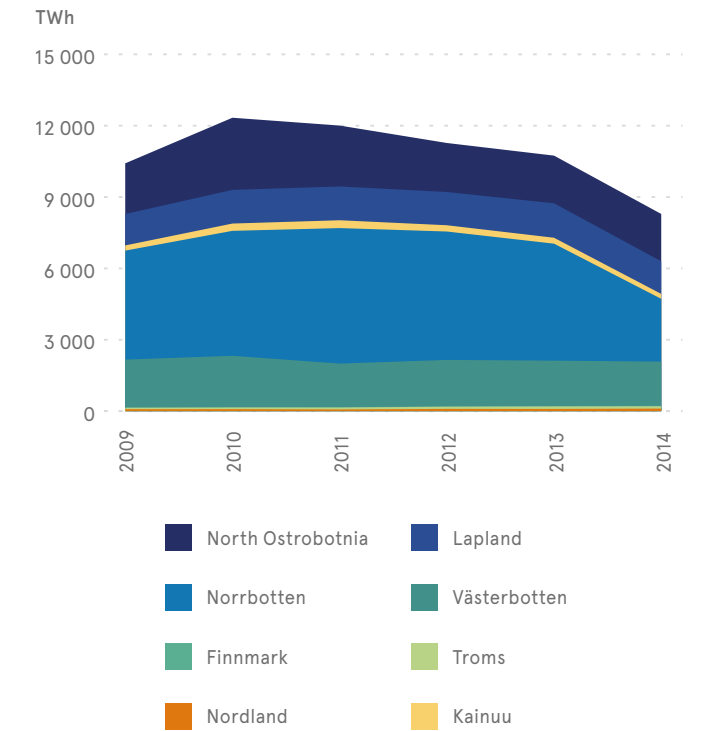
Figure 6 shows that Västerbotten⁸ is the largest wind power production county in the BIN area. In 2014, Västerbotten produced 63 % of wind power production in the BIN area and 33 % of Sweden's wind power production. Västerbotten county has a large potential for increased wind power production. Lapland and Northern Ostrobothnia produced 68 % of Finland's wind power capacity in 2014. The production was similar in these two counties. At the end of 2014, there were 260 wind turbine generators installed, with a combined capacity of 627 MW. They generated 1.3% of Finland's electricity consumption in 2014. Finland has the potential to increase wind power capacity considerably. The largest wind power potential in Finland is estimated to be along the Bothnia coast and in the Finnish Lapland. In Norway, Finnmark county has a large potential for onshore wind, in 2014 Finnmark produced 12 % of Norway's total wind production. In Nordland, two new wind parks, Ånstadblåheia wind park and Sørfjord wind park are in the early phases of construction, and a third one, Øyfellet in the south part of the county, recently received its permit. The three parks will together have a capacity of 470 MW installed, and if all are built according to plan, they will produce 1,710 GWh. The BIN area is expected to be the location for a great share of the expansion in wind power generation.



Thermal power

Figure 7 – Thermal power production including CHP in the BIN area, 2009-2014

Figure 7 shows the thermal power production in the BIN countries. This includes thermal power from combined heat and power production (CHP). Thermal power is a large source of energy in Sweden and Finland. Sweden has 62 % of the thermal power production in the BIN countries. District heating has its own distribution systems. In Sweden, district heating has undergone steady growth over the years and accounts for more than half of all heating for homes and other premises in Sweden⁹ now. CHP is what is produced when electricity and heat are produced at the same time. The heat that is produced when electricity is generated is utilized. According to the Swedish District Heating Association, 6 % of the electricity used in Sweden comes from CHP, which is less than elsewhere in the EU. In 2014, 10 % of the BIN countries' thermal power production was produced in the BIN area. The largest thermal power regions in the BIN area are Norrbotten with 32 % of the production¹⁰, Northern Ostrobothnia with 24 %, Västerbotten with 22 % and Lapland with 17 %. The decline in 2013 and 2014 in Norrbotten is due to reduced consumption by the industry during this period.



Solar power production

Solar power production is not yet a dominating energy production source in the BIN area. Swedish, Norwegian and Finnish researchers are cooperating to prove that solar power in the North is both possible and can be profitable¹¹. A solar power test plant is established in Piteå, and advanced computer simulations show that there is a solar power potential. In spite of the high number of sun hours, high latitudes pose some challenges for solar power in the BIN area. Nights are long in the winter, and in the summer, the sun's path across the sky varies a lot. New technology can potentially give Northern solar power plants the opportunity to generate energy regardless of high latitudes. The solar power plant in Piteå is expected to generate 28 MWh annually¹².

Nuclear power production

We include nuclear power in this overview, even though it is not a renewable energy source. It is an important part of electricity production in Sweden and Finland. Nuclear power is an important part of the Swedish, Finnish and Russian power systems; it represents as much as 41 % of the Swedish power production and 35 % of the Finnish power production. At present, there is no nuclear power production in the BIN area. In Northern Ostrobothnia, this will change, as Finland's sixth reactor in Hanhikivi 1 in Pyhäjoki outside Oulu and Raahen is under construction. Production is planned to commence during 2024, and the power plant will have an installed capacity of 1,200 MW electric power, which has been estimated to supply 10 % of Finland's energy demand, by 2024. The project is a cooperation between Finnish Fennovoima and Russian Rosatom Energy International.

⁹ Swedish District Heating Association

¹⁰ Regionfakta.com and Statistics Sweden

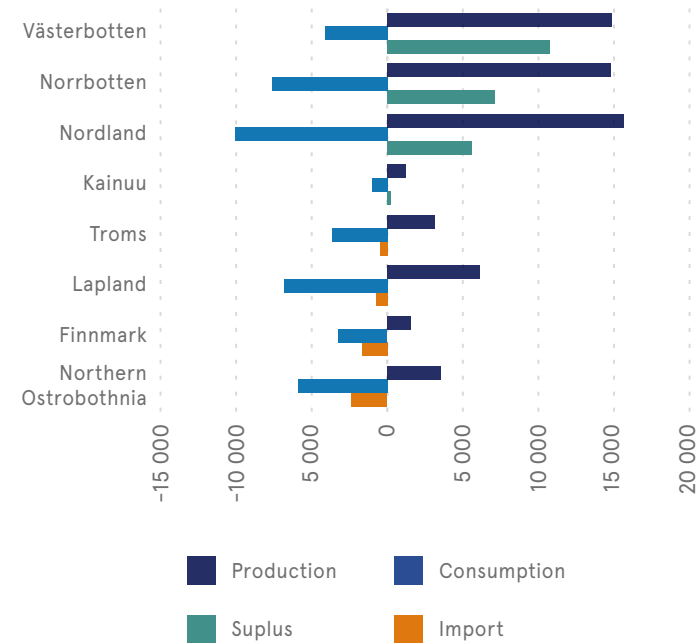
¹¹ Piteå in Norrbotten have more hours of sun in a year than any other town in Sweden. The Gulf of Bothnia is sunnier than Germany, the largest market for solar power in the world.

¹² This project is a cooperation between the Northern Research Institute (Norway), Kemi-Tornionlaakso Municipal Education and Training Consortium (Finland), Luleå Technical University (Sweden) and PiteEnergi AB (Sweden) and is supported by Nordic Energy Research.

Electricity production and consumption in the BIN area

Figure 8 – Electricity production and consumption in the BIN area, 2014

Figure 8 shows electricity production and consumption in the BIN counties in 2014. The BIN area has three counties with a surplus of renewable energy. In 2014, the surpluses in these regions were 10,7 TWh in Västerbotten, 7,1 TWh in Norrbotten and 5,6 TWh in Nordland in Norway¹³. The BIN counties in Finland, Northern Ostrobothnia and Lapland, have a higher electricity consumption than production. The planned Hanhikivi 1 nuclear power plant in Northern Ostrobothnia will change the energy balance in Finland.



Implications

According to RE100,¹⁴ the private sector accounts for around half of the world's electricity consumption. Currently, they list over 88 multinational and influential companies that have committed to 100 % renewable electricity, and this list of companies with renewable energy demand seems to be growing. These companies use this in marketing their products and branding their companies. Switching influential consumers' demand to renewables will accelerate the transformation of the global energy market and aid the transition to a low-carbon economy. For the BIN area, which is already a large provider of renewable energy, the question is how to make the most of value creation in the BIN area from this natural resource. Power-intensive industry entering the BIN area generates jobs and provides income in the form of taxes and other ripple effects. In addition, it reduces the need for grid investments when power is consumed close to power production.

For example, the Facebook data center in Luleå is estimated to generate a total of 9 billion SEK in full economic impact (direct, indirect and induced impact) and to engage 4,500 full-time workers over the course of ten years nationwide. About half of the economic benefits will accrue locally¹⁵. Furthermore, such establishment lay the foundations for the BIN area gaining a competitive advantage in attracting additional similar investments. The framework conditions are important in this process.

In November 2016, the European Commission presented a package of measures to keep the European Union competitive as the clean energy transition is changing global energy markets. Under the name "Clean Energy for all Europeans" the Commission wants the EU to lead the clean energy transition, not only adapt to it. This is the fourth inner market package; these regulations, therefore, affect the power system in the BIN region. There are three main goals in the Commission's proposals; putting energy efficiency first, achieving global leadership in renewable energies and providing a fair deal for consumers. The BIN area plays an important part in this, but the aim of the renewable regions of the BIN area is to utilize the power locally to increase local value production. Therefore, it is very important that the energy- and climate policies in the BIN countries should support energy production and consumption in the BIN area.

An important ongoing project with relevance for the BIN area's energy policies and the Nordic electricity market is taking place in cooperation with the EU Commission, the Agency for the Coopera-

tion of Energy Regulators (ACER), the Council of European Energy Regulators (CEER) and the European Network of Transmission System Operators for Electricity (ENTSO-E). The European Commission is proposing to increase these organs' legislative authority between the member countries.

For policy makers recommendations include:

- Promoting the BIN area as an attractive place for establishing power-intensive industries
- The work of implementing the elements of the European Energy Union¹⁶ should not work against local utilization of renewable energy. The BIN area provides the world markets with green power-intensive products. This is a great contribution to the clean energy transition, instead of just exporting the electricity. Framework conditions such as net tariffs and tax regime on renewable production are important parts of this.
- The BIN area has a strong ICT industry, especially Norrbotten and Northern Ostrobothnia. Policy makers should focus on increasing the synergies between access to natural resources and a strong ICT industry in the BIN area.
- There is an increase in European utilities who are investing in renewable projects in the BIN area, both directly in power plants and infrastructure projects, as well as through so-called Power Purchase Agreements (PPS) over a given amount of time

For the energy sector:

- Large changes in the Nordic power system presents challenges for the system operations, but also possibilities for increased value production.
- Implications from the BIN countries' Research Councils show that the energy sector in the BIN area has the possibility to increase their participation in research and development projects and programmes. Developing innovations and new technologies within renewable energy production and transportation are vital to securing cost levels with stable and secure supply of energy.

¹⁴ RE100 is a collaborative, global initiative of influential businesses committed to 100% renewable electricity, working to massively increase demand for - and delivery of - renewable energy

¹⁵ Source: Digital infrastructure and economic development: An impact assessment of Facebook's datacentre in Northern Sweden, captures the importance of large-scale data centres to the Swedish economy and the opportunity they provide. The Boston Consulting Group, Inc. 2014.

¹⁶ Norway is not part of the European Union, but a lot of the regulation under the European Energy Union will be implemented in Norway through the European Economic Area (EEA).