ENERGY POLICIES OF IEA COUNTRIES

Norway

2017 Review

International Energy Agency
Secure Sustainable Together

ENERGY POLICIES OF IEA COUNTRIES

Norway

2017 Review

International Energy Agency
Secure
Sustainable
Together

INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 29 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

Australia
Austria
Belgium
Canada
Czech Republic
Denmark
Estonia
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

International Energy Agency
Secure
Sustainable
Together

International Energy Agency
Website: ***www.iea.org***

PART I. POLICY ANALYSIS

PART II. SECTOR ANALYSIS

PART III. ENERGY TECHNOLOGY

PART IV. ANNEXES

LIST OF FIGURES AND TABLES

Figures

Tables

Executive summary

Norway continues to have a unique twin role as a major oil and gas producer and a strong global advocate of climate change mitigation. As one of the largest exporters of energy in the world, it contributes to the energy security of consuming countries. At the same time, as Norwegians highly value environmental sustainability, the country is taking climate policy very seriously.

Norway has set an ambitious target to reduce greenhouse gas (GHG) emissions by 40% of 1990 levels by 2030. Meeting the 2030 target will be challenging, because both the country's electricity supply and its energy use in buildings are already essentially carbon free. Norway is determined and, with its large oil and gas revenue, well placed to invest in developing new solutions for a low-carbon future.

Oil and gas

Oil and natural gas production has long been the largest sector in the Norwegian economy and will continue to generate significant wealth for the country as well as benefits for other countries. As a reliable and transparent supplier, Norway improves the energy security of many International Energy Agency (IEA) member countries. It has a consistent and predictable regulatory framework for exploration and production, and it manages both its oil and gas resources and revenue in a transparent and competent manner. The IEA acknowledges Norway's contribution to global energy security and regards its oil and gas resource and revenue management as commendable and a model for other countries to follow.

Oil production in Norway has stabilised at around 2 million barrels per day, 40% below the peak in 2001. Gas production has increased to a level of 120 billion cubic metres per year, which has led to larger exports. Investments in the transportation capacity might be necessary to promote new gas from the Barents Sea and to allow Norway to maintain its position as a major gas supplier to Europe. The IEA encourages the government to continue to facilitate investments in gas pipelines.

Norway's remaining oil and gas resources are considerable, as only one-third of the estimated discovered and undiscovered gas resources and half of the oil resources have been produced. In this context, the IEA welcomes the government's efforts to encourage increases in production and recovery. Environmental considerations are well integrated into the government policy on the management of oil and gas resources, and the IEA encourages the government to continue to develop innovative approaches to acreage management in an environmentally sound manner to stimulate exploration and production in both frontier and mature areas.

From a long-term perspective, the government should also consider ways for a transition in the country's economic model to prepare for an eventual reduction in revenues from fossil fuels.

Electricity system

Norway deserves to be commended for the continued reliable performance of the electricity sector in recent years. The country forms part of the regional Nordic wholesale market, which is widely regarded as the model for effective cross-border market integration. The Nordic market area is gradually becoming more integrated with other neighbouring market areas.

Norway has significant hydropower reservoir capacity (85 terawatt [TWh] in total) and several new cross-border connections are coming on line in the next few years. The combination of high levels of interconnection and its large hydropower fleet means Norway can provide the region with a significant source of low-cost, highly flexible, and zero-carbon generation. The IEA encourages Norway to use its hydropower capacity, the largest in Europe after Russia, to balance variations in demand and supply, increasingly with variable renewable sources, in the expanding regional market. This would increase the flexibility and efficiency in the integrated regional electricity market and, therefore, enhance European electricity security.

Low wholesale prices in the Nordic market area in recent years have reduced the profitability of power generators. Relatively high taxes on hydropower generators in Norway have had a similar impact, and this discourages investment in the maintenance and new facilities for hydropower. Norway and the other governments in the Nordic electricity market area should co-ordinate and harmonise their renewable energy subsidies and policies to avoid creating an oversupply of power that leads to wholesale prices too low to trigger investments in an otherwise profitable low-carbon electricity capacity. At the same time, they should also identify the best practices for taxation to avoid unnecessarily reducing the competitiveness of market-based low-carbon generation.

Although Norway is usually not a net exporter of electricity, it periodically relies on imports to meet peak demand. One critical question is whether and how this situation may evolve. Outlooks on electricity demand in Norway over the next few decades vary significantly. Increased interconnections would help to improve electricity security, but the country could also reduce this uncertainty by explicitly focusing its energy efficiency and demand-side management efforts on measures that reduce or shift peak load. Doing so would enhance the security of supply and also reduce the system costs.

Limiting carbon dioxide emissions

Norway has devoted considerable attention to environmental sustainability, and climate change mitigation enjoys a broad popular and political support. The country has a target to reduce emissions by 30% from 1990 to 2020. Norway's Nationally Determined Contribution under the United Nations Framework Convention on Climate Change is 40% from 1990 to 2030, a target that it pursues in joint fulfilment with the

European Union. Norway has also pledged to become carbon neutral (taking into account its contribution to emissions reductions abroad) by 2030. By 2050, the stated objective is for Norway to become a low-emission society, although the exact meaning of this concept remains to be defined. With its strong commitment to global climate change mitigation, Norway has set a fine example for other countries.

In many ways, Norway already is a lower-carbon economy than most others because of the historical predominance of hydropower. The widespread use of electricity, especially for heating, means that energy use in buildings has essentially already been decarbonised. Oil and gas production, manufacturing, and transport are the focus areas for further cuts in energy-related GHG emissions. Around 50% of Norway's emissions are already covered by the EU Emissions Trading Scheme (EU-ETS). Combined, the carbon dioxide (CO_2) tax and EU-ETS cover around 80% of the GHG emissions in the country.

Having fewer options for GHG mitigation tends to increase the mitigation cost per tonne avoided, which, in turn, explains why the government also relies on international carbon credits as a measure to meet climate targets. When it defines the 2050 target of becoming a low-emission society, the government should also clarify the expected role of international carbon credits, particularly because the supply of such credits is set to decline in global efforts to reduce emissions significantly by 2050.

Long-term improvements in energy efficiency in buildings are guaranteed by a strict building code. Norway has a long tradition of energy requirements for buildings – the 1949 building regulations included requirements for insulation that encompassed the thermal efficiency of walls, floors, and roofs. The current structure of the energy performance requirements was introduced in 2007. The requirements have been progressively tightened and the latest tightening, in 2016, placed energy performance requirements at passive house levels – a welcome move. What is more, the government aims to introduce a near-zero energy use standard by 2020. In 2016, the parliament also tasked the government to reach an absolute savings target of 10 TWh in existing buildings by 2030. The government also banned fossil fuel heating systems from new buildings in 2016 and is considering ways to ban fossil fuel use for all space heating from 2020 on.

In the transport sector, Norway's incentives for the uptake of electric vehicles (EVs) have been strong by international comparison; they include exemptions from toll road charges and various taxes, free access to public parking, and funding for infrastructure developments. Norway's long-going support for zero-emission vehicles has triggered an impressive growth in the number of EVs and made the country a world leader in EV deployment. From the perspective of climate change mitigation, EVs are an attractive option, especially for a country in which electricity is basically emission free. The cost-effectiveness of the various incentives has, however, been questioned, and the government should consider prioritising the expansion and electrification of public transport instead of further encouraging private EV ownership.

In general, the IEA encourages the government to prioritise policies and measures that reduce GHG emissions based on their long-term cost-effectiveness (Norwegian kroner per tonne of CO_2 avoided). The long-term approach is relevant here, because in the required transition to a low-carbon energy system, the need to change the economic structure may cost more today, but save money in the long run.

After the parliament's 2008 climate agreement, government funding for energy research, development, and demonstration (RD&D) increased rapidly and has remained at an exceptionally high level over the years since, which makes Norway one of the leading countries in public spending on energy RD&D per gross domestic product. This very positive state of affairs reflects a political commitment to respond to the new energy challenges. The IEA applauds the government for maintaining this high level of funding and encourages it to continue to do so.

Norway's strong focus on energy RD&D is very welcome. The country has been a global leader in carbon capture and storage (CCS) for the past two decades. The state-of-the-art projects of Sleipner and Snøhvit and the large-scale testing facilities at Mongstad are a testimony to this. Of particular interest will be how Norway sets up its planned next wave of full-scale CCS deployment. If Norway continues its current effort, the country is in the best position to overcome future barriers to large-scale CCS deployment domestically and to influence CCS development globally.

Key recommendations

The government of Norway should:

- Stimulate further increases in oil and gas production from safe and environmentally sustainable operations and consider measures to prepare for a future with lower oil and gas revenues.
- Continue to support further harmonisation and integration within the Nordic electricity market, facilitate an increase in cross-border connections and demand-side measures to this end, and take measures to encourage market-based investments in low-carbon power generation.
- Develop a strategy to meet the 2030 and 2050 climate change targets.

Figure 1.1 Map of Norway

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

1. General energy policy

Key data
(2015 estimated)

TPES: 29.6 Mtoe (hydro 40.0%, oil 36.8%, natural gas 18.2%, biofuels and waste 5.4%, coal 2.8%, wind 0.7%, heat 0.3%, net electricity imports -4.3%), +10.4% since 2005

TPES per capita: 5.7 toe (IEA average, 4.4 toe)

TPES per GDP: 96.3 toe/USD million PPP (IEA average, 111 toe/USD million PPP)

Energy production: 208.1 Mtoe (natural gas 49.1%, oil 44.0%, hydro 5.7%, biofuel and waste 0.7%, coal 0.4%, wind 0.1%), -7.3% since 2005

TFC: 20.5 Mtoe (industry and non-energy use 40.2%, transport 23.9%, residential 18.9%, commercial including agriculture 17.0%)

Currency (2015): EUR 1 = NOK 8.94; USD 1 = NOK 8.06

Country overview

The kingdom of Norway has a mainland area of 324 000 square kilometres (km^2) bordered on the east by Sweden and, within the Arctic Circle, by Finland and The Russian Federation. This includes some 50 000 islands that lie off a long, indented coastline along the North Sea, the Norwegian Sea, and the Barents Sea in the Arctic Ocean. Norway also exercises sovereignty over Svalbard, an Arctic archipelago of 61 000 km^2 almost 1 000 km north of the mainland. The climate is considerably milder than at similar latitudes elsewhere, because of the warm waters of the Gulf Stream. About two-thirds of Norway is mountainous and the mountains divide the country in both north-south and east-west directions.

The population of Norway was 5.2 million in January 2016; an increase of 12.4% since 2006, mainly because of immigration (SSB, 2016). After Iceland, Norway is the least densely populated country in Europe, with 14 inhabitants per square kilometre. In 2015, 80% of the population lived in urban settlements, compared with 50% in 1960 (World Bank, 2016).

Norway is one of the richest countries in the world. Among the Organisation for Economic Co-operation and Development (OECD) countries, it ranked fourth in gross domestic product (GDP) per capita, at USD 62 075 (US dollars) purchasing power parity (PPP) in 2015, after Luxembourg and Ireland and it almost tied with Switzerland (OECD, 2016a). According to Statistisk sentralbyrå (SSB) (Statistics Norway), the country's nominal GDP in 2016 was NOK 3.1 trillion (Norwegian kroner) and the unemployment rate was 4.4% in December 2016, relatively low by international comparison. The petroleum sector is the backbone of the Norwegian economy. In 2015, the sector generated 15% of GDP and 40% of exports. The services sector contributes around 60% of GDP, industry (including oil and gas) close to 40% and fishing, forestry and agriculture 2%. (OECD, 2016b; SSB, 2016).

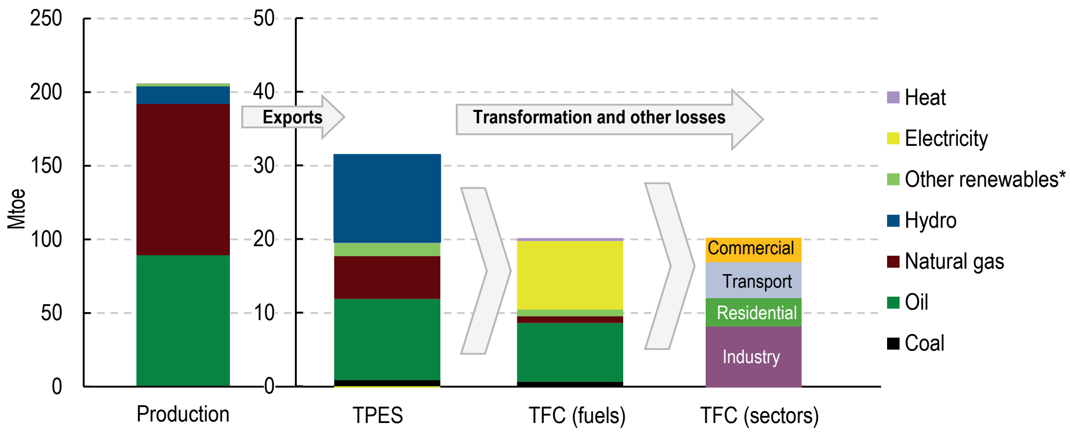
Norway is a constitutional monarchy, with a full parliamentary democracy. Executive power is vested formally in the king, but is exercised through the government headed by the prime minister. Legislative power is held by the Storting (the Norwegian parliament). A right-wing coalition of the Conservative Party and the Progress Party has governed the country since autumn 2013. The next general election is scheduled for September 2017.

As a member of the European Economic Area (EEA), Norway shares internal market legislation with the European Union and has therefore implemented several European Union directives and regulations related to energy.

Supply and demand

Unlike most other International Energy Agency (IEA) member countries, Norway does not depend on imports for its energy supply. Its large domestic oil and gas production makes the country not only self-sufficient in energy supply, but also a major exporter of energy (Figure 1.2). Vast resources of hydropower further enable an almost completely renewable electricity generation system. Access to cheap and clean hydropower has also led to a high consumption of electricity in many sectors.

Figure 1.2 Overview of energy production, TPES, and TFC, 2015



* Other renewables are biofuels and waste, and wind energy.

Notes: To be able to visualise the large production and the domestic supply and consumption, the scale is 5:1 between the first chart and the three others. Mtoe = million tonnes of oil-equivalent; TFC = total final consumption;[1] TPES = total primary energy supply.[2]

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

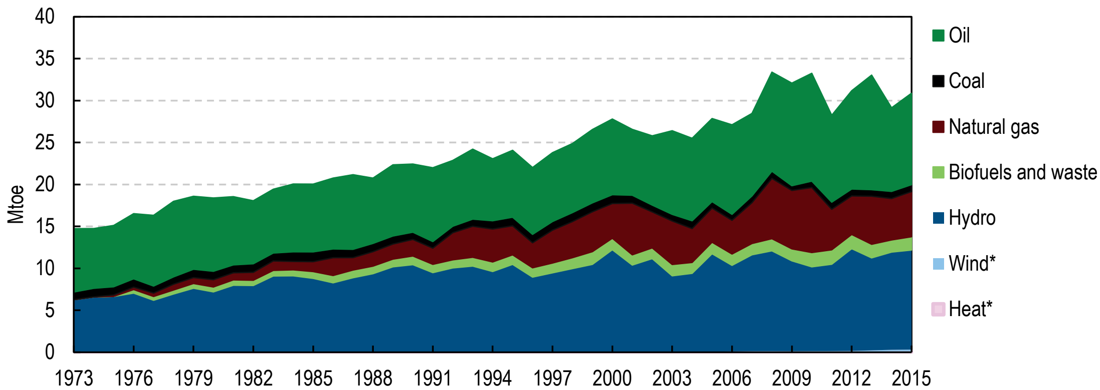
[1] TFC is the final consumption by end users, i.e. in the form of electricity, heat, gas, oil products, etc. TFC includes energy use as raw materials (non-energy use), but excludes fuels used in electricity and heat generation and other energy industries (transformations), such as refining.

[2] TPES is defined as production + imports - exports - international marine bunkers - international aviation bunkers ± stock changes. This equals the total supply of energy that is consumed domestically, either in energy transformation or in final use. For Norway, this includes electricity exports of 1.3 Mtoe, which are counted as a negative contribution to the TPES.

Supply

Norway's TPES has increased by 10% over the past ten years to 29.6 Mtoe in 2015. The trend has been increasing for several decades (Figure 1.3). Natural gas is mainly used in oil and gas extraction, and, as this industry has developed, the share of natural gas in the TPES has increased, without affecting the TFC of energy. Biofuels and waste are primarily used as a fuel for district heating. Wind power has increased significantly, with a fourfold growth since 2005, but it still accounts for only a very small share of the TPES.

Figure 1.3 TPES, 1973-2015



* Negligible.

Notes: Electricity exports (which contribute negatively to the TPES) are not shown in the chart.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Norway has the fifth-lowest share of fossil fuels in the TPES among the IEA member countries, and the second highest share of renewable energy sources (RES) after Sweden (Figure 1.4). Large hydropower resources enable Norway to have low levels of fossil fuel consumption even though there is no nuclear power in the energy supply.

Oil and gas exploration began in Norway in the 1960s, and the country has become a major energy producer. Total production was 208 Mtoe in 2015, which is the fourth largest among the IEA member countries, after three significantly larger countries.[3] Production has declined by 12% from a peak in 2002, but has been stable at around 200 Mtoe in recent years (Figure 1.5).

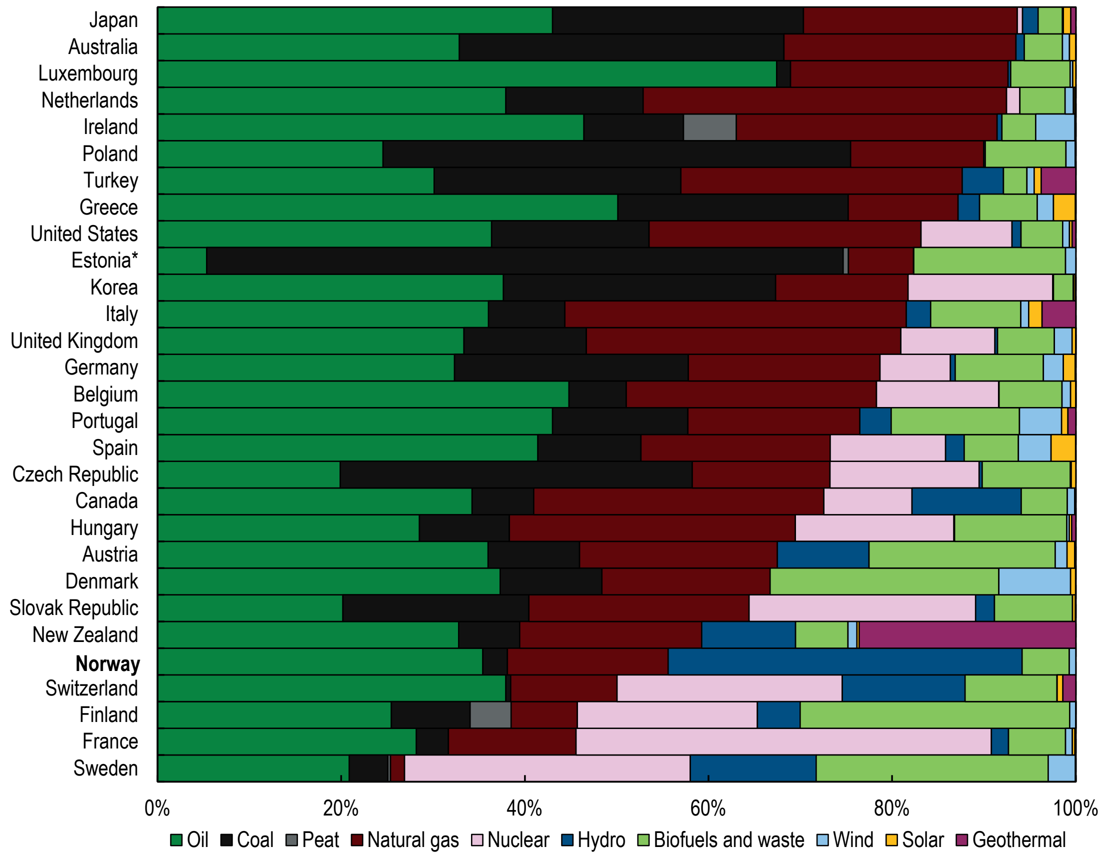
The production of oil grew significantly in the 1990s and peaked at 3.4 million barrels per day (164 Mtoe) in 2001. In the following decade, oil production declined before it stabilised at a level of around 90 Mtoe (around 2 million barrels per day) in recent years. Oil production is expected to remain at current levels at least until the early 2020s. The decline in oil production has also been compensated largely by the increased production of natural gas, which has exceeded oil production in Norway since 2012. Natural gas production has increased by 36% in the past decade, and accounted for almost half of the total production in 2015.

Hydropower accounts for around 6% of the total energy production (but 40% of TPES) and has been a stable source of electricity generation for many decades. Energy

[3] United States, Canada, and Australia.

production from wind and from biofuels and waste has increased, but accounts for a very small share of the total production.

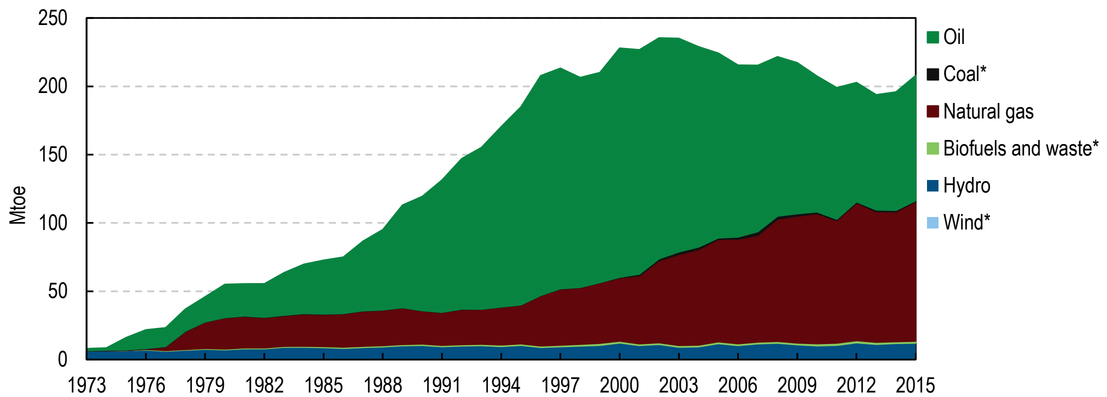
Figure 1.4 Breakdown of the TPES in IEA member countries, 2015



* Estonia's coal represents oil shale.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Figure 1.5 Energy production by source, 1973-2015



* Negligible.

Note: Data are provisional for 2015.

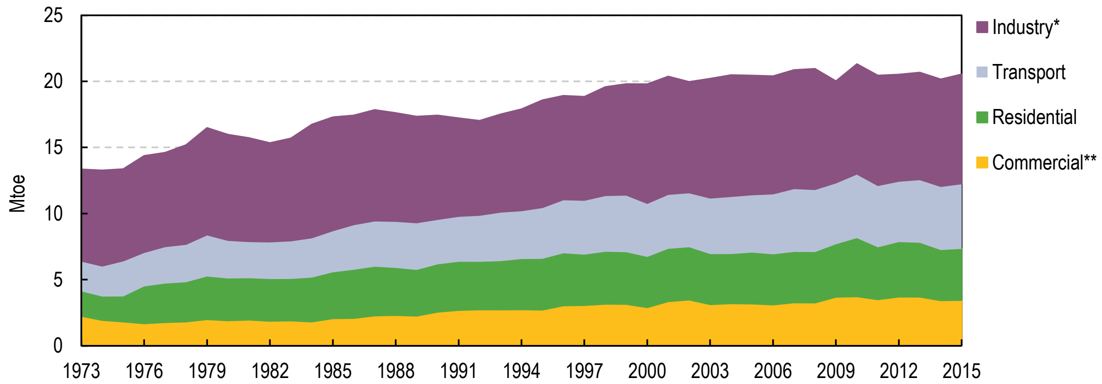
Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Demand

Norway's TFC of energy has been relatively stable at around 20 Mtoe over the past 15 years (Figure 1.6). Industry accounts for 40% of the TFC and is the largest consuming sector, followed by the transport sector (24%), residential sector (19%), and commercial sector (17%).

The TFC fell in 2009 because of lower industry consumption after the financial crisis, but picked up again in 2010 when the industry consumption recovered and a cold winter led to an increased demand in the residential sector.

Figure 1.6 TFC by sector, 1973-2014



* Industry includes non-energy use.

** Commercial includes commercial and public services, agriculture, fishing, and forestry.

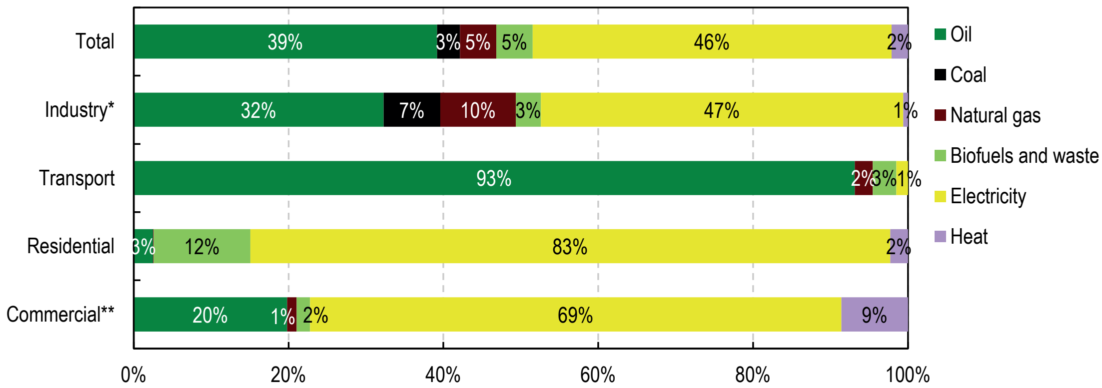
Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Electricity accounts for almost half of the TFC (46% of the total in 2015), and it is the most consumed energy source in all the sectors except in transport, which continues to be dominated by oil (Figure 1.7). Even in transport, the growing use of electric vehicles (EVs) is limiting the use of diesel and gasoline, a trend that is set to grow. The residential sector stands out with a very high share of electricity, which is the major source of heating in buildings.

Oil is the second-largest energy source in the TFC (39% of that total in 2015). It is used mainly as a transport fuel, but also as a raw material for the chemical industries. Natural gas constitutes a small share in the TFC (5%) compared with that in the TPES, as most gas is used in oil and gas production and is not part of the final consumption.

District heating is consumed in commercial and residential buildings. Even though it has doubled over the past decade, heat consumption still accounts for only around 2% of the TFC.

Figure 1.7 Fuel share of the TFC by sector, 2015



* "Industry" includes non-energy use.

** "Commercial" includes commercial and public services, agriculture, fishing, and forestry.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Institutions

The Ministry of Petroleum and Energy (MPE) holds the overall responsibility for the management of petroleum resources on the Norwegian continental shelf. This includes to ensure that the petroleum activities are carried out in accordance with the guidelines given by the parliament and the government. In addition, the Ministry has a particular responsibility to supervise the state-owned corporations (Petoro AS [Petoro] and Gassco AS), as well as the oil company in which the state holds a majority interest, Statoil ASA.

The MPE ensures the sound management, in both economic and environmental terms, of water and hydropower resources and other domestic energy sources. The MPE acts for the government as owner of Statnett FS (Statnett) – the electricity transmission system operator (TSO) – and Enova SF (Enova) (see below). The Norges Vassdrags- og Energidirektorat (Norwegian Water Resources and Energy Directorate [NVE]) is the subordinate agency of the MPE responsible for the management of the energy and water resources on mainland Norway. Norway's power supply sector is subject to legislation, which includes licensing, supervision, control, and other regulations.

The Ministry of Labour and Government Administration has the overall responsibility for the working environment in the petroleum sector, as well as for emergency responses and safety aspects of the industry.

The Ministry of Climate and Environment has a particular responsibility to carry out the environmental policies of the government.

The Ministry of Transport and Communications has the overall responsibility for energy use for transport purposes

The Norwegian Petroleum Directorate (NPD) is administratively subordinate to the MPE. The NPD plays a key role in petroleum resource management, and is an advisory body for the MPE. The NPD has responsibilities related to the exploration for and production of petroleum deposits on the NCS, which include statuary powers and to make decisions based on the rules and regulations that govern the petroleum activities.

The Petroleum Safety Authority Norway (PSA) was established on 1 January 2004 through a division of the NPD. The PSA is responsible for the safety, emergency response and working environment in the petroleum sector. It has taken over (from the Directorate for Civil Protection and Emergency Planning and the Directorate of Labour) the responsibility to regulate and supervise land-based facilities that relate to the petroleum industry. Administratively, the PSA is subordinate to the Ministry of Labour and Government Administration. The PSA shares premises with the NPD in Stavanger.

Petoro is a state-owned limited company that manages the state's direct financial interest (SDFI) on the NCS on behalf of the state. The company's main responsibilities are to manage the SDFI assets held by the state in joint ventures, monitor Statoil's marketing and sales of the petroleum produced from the SDFI and the financial management of the SDFI, including the keeping of accounts.

Gassco AS is a state-owned company that operates the transport network for natural gas (Gassled) from the NCS. Gassco has no ownership interest in Gassled. Gassco AS handles this operatorship in a manner that is neutral for all owners and users. The company is also an advisor to the MPE on gas transport issues.

The state enterprise Gassnova SF (Gassnova) helps find solutions to ensure that the technology for the capture, transport, and storage of carbon dioxide (CO_2) can be implemented and become an effective climate measure. Gassnova advices the authorities on carbon capture and storage (CCS) and, together with Research Council Norway (RCN), it administers the CLIMIT programme, through which it grants financial support to develop, demonstrate, and pilot CCS technologies.

Gassnova also manages the state's interest in the CO_2 Technology Centre Mongstad, which was set up to test and qualify technology for CO_2 capture. Moreover, Gassnova has experience from planning full-scale CCS projects and plays an important role in the government's current work to realise a commercial-scale CCS project. It is also active in international dissemination of its CCS experience (see chapter 6).

The Norwegian Water Resources and Energy Directorate (NVE), which reports to the MPE, is responsible for managing domestic energy resources, and is also the national regulatory authority for the electricity sector. The NVE is also responsible for managing Norway's water resources and for central government functions as regards flood and avalanche and/or landslide risk reduction. The NVE is involved in research and development and international development co-operation, and is the national hydrology expert body.

Statnett was founded in 1992. Statnett is the state-owned enterprise responsible for building and operating the central grid. The enterprise is the TSO for the central grid and owns more than 90% of it. Statnett is responsible for both short- and long-term system co-ordination, which entails the responsibility to ensure an instantaneous power balance, and to facilitate a satisfactory quality of supply throughout the country.

Enova is a state-owned enterprise established in 2001. Its goal is to help reduce greenhouse gas (GHG) emissions and increase the security of energy supply. Enova contributes to stable market changes for energy and climate solutions (e.g. charging stations for EVs, renewable energy solutions, and energy efficiency measures) and supports the development and deployment of more energy- and climate-efficient technologies. It pursues a strategy to maximise the impact of clean technology solutions in the market by encouraging technologies with a great overall potential during the process of their market implementation. Enova's main instruments are investment aid, conditional loans, and advisory services. Enova has an annual budget of more than NOK 2.6 billion (EUR 290 million [Euro]).

Key policies

Oil and gas production

The government's main objective for the oil and gas sector is to ensure long-term value creation through sound resource management on the NCS. The activities are to be safe and clean and take place in coexistence with other users of the Norwegian waters.

The oil and gas activity is important to maintain high employment and create wealth in Norway. It is a key sector of the Norwegian economy and has contributed significantly to industrial development and the advancement of the Norwegian welfare society. A large part of the oil and gas revenue goes to the state in the form of taxes, dividends, and fees, and contributes to the state's strong financial position. The state's oil and gas revenue is channelled to the Government Pension Fund Global, which, with around NOK 7 500 billion (around USD 900 billion) in assets, is the largest sovereign wealth fund in the world.

Norwegian oil and gas exports help ensure the security of supply in many IEA countries. The recovery rates for offshore oil resources are high. Oil and gas are produced in an environment-friendly manner with low emissions of GHGs. Through various policy actions, the government's aim is for Norway to remain a world leader in this sector.

Domestic energy supply

The government's priorities for Norway's domestic energy supply sector, which excludes the export-oriented oil and gas production, are outlined in the April 2016 White Paper Power for Change – an energy policy towards 2030 (MPE, 2016). The White Paper presents an energy policy that intends to improve the security of supply and promote industrial development and more-efficient and climate-friendly energy use. It has the following four priority areas:

1. Enhanced security of supply

Norway is by far the most electricity-intensive IEA member country. It uses twice as much electricity in its TFC as the IEA member countries on average (46% TFC vs. 22% TFC in 2015). Security of energy supply in Norway is primarily a question of electricity security.

Both production-side and demand-side flexibility help maintain the security of electricity supply, as do hydropower storage in reservoirs (up to 85 terawatt hours [TWh], half of the total in Europe) and cross-border trade in electricity in the Nordic market area.

The government views a smoothly functioning electricity market as critical for electricity security – as far as possible, market-based solutions should be used to operate the electricity system and trading electricity. As stated in the White Paper (MPE, 2016), effective markets give the right price signals for the production, transmission, and consumption of electricity and promote the sound use of resources and innovation, as well as the security of supply.

The government aims to ensure that Norway has a robust electricity grid, and that investments towards this end are made in time. It also promotes the use of new technologies and new market solutions, such as advanced metering systems and smart grids, to improve the security of supply.

Stronger co-operation with other Nordic countries (with which Norway shares a common electricity market) is also sought. This includes both the security of supply and a common approach to European Union energy policy, which, through the EEA agreement, influences how Norway's energy supply system can be organised.

2. Efficient production of renewables

Norway has significant resources for hydropower, mostly publicly owned, and the government aims to enable their profitable use. The efforts to develop and use new technologies for renewable energy will continue. As wholesale prices in the Nordic electricity market have been low and are expected to remain so given the stable demand but increasing supply, the government considers a stronger integration with other energy markets as important to maintain the value of the Norwegian renewable energy assets. Therefore, it aims to increase interconnections with other market areas and will change the regulatory framework to end the monopoly of the state-owned TSO Statnett in owning and operating them. After 2020, the government will not introduce new targets under the joint electricity certificate system with Sweden. The licensing process will also be made more efficient. The government also seeks a long-term development of profitable wind power in Norway, both on and offshore.

3. More efficient and climate-friendly use of energy

The government wishes to change the focus from the support of mature production technologies towards innovation and the development of new energy and climate solutions. Enova, the national agency for the support of green energy and energy efficiency, is the main instrument for this. Enova's overarching aims are to reduce GHG emissions, strengthen the security of energy supply, and develop technologies that, in the long term, will help to reduce emissions. Since 2015, Enova has also worked to reduce the emissions from transport. The development of new energy and climate technologies in the industrial sector will continue to be a main area of Enova's work.

Although improvements in energy efficiency to reduce GHG emissions help less in low-carbon Norway than in countries with a higher-carbon energy supply, the government has set a national objective to reduce the energy intensity of the economy (TFC/GDP) by 30% to 2030. The government is also working to propose a ban on fossil fuels for space heating in 2020. For the longer term, it will also develop a strategy for the use of hydrogen.

4. Economic growth and value creation through efficient use of profitable renewable resources

Low-cost hydropower has been the basis of Norway's industrial development and the country hosts several electricity-intensive industries. The government will ensure that electricity markets function well so that profitable renewable energy resources can be used efficiently. Flexible hydropower generation and the widespread use of electricity are seen as Norway's competitive advantages, and their development will be facilitated. Cross-border connection to the United Kingdom and Germany are expected to help increase the profitability of power generation in Norway. The access of industrial electricity users to a predictable long-term supply will be helped.

Future value creation from renewable energy depends on the capacity for innovation and knowledge development. The government aims to ensure that the whole innovation chain functions smoothly, with seamless interaction between the main public entities – Innovation Norway, the RCN, Enova and Gassnova. Future energy research, development, and demonstration (RD&D) will build on the strategy "Energy 21", which is jointly developed by the industry, research institutions, and public authorities.

Limiting energy-related CO_2 emissions

The Norwegian power sector is nearly emission free and based on RES. The government will facilitate the transition from fossil fuels to renewable energy in areas in which energy consumption results in GHG emissions, such as transport, industry, oil and gas extraction, and heating.

The polluter-pays-principle is a cornerstone of the Norwegian policy framework on climate change. Cross-sectoral economic policy instruments (e.g. CO_2 tax) are the basis for decentralised, cost-effective, and informed actions. Today, more than 80% of Norwegian GHG emissions are covered by taxes and/or the EU Emissions Trading Scheme (EU-ETS).

In addition to carbon-pricing instruments, the government supports research on and innovation in climate-friendly technologies to encourage developing emissions reduction solutions when the markets have not provided them. In particular, Norway is a global leader in CCS research, development, demonstration, and deployment.

Assessment

Oil and gas sector

Norway's significant energy resources give it a large competitive advantage, especially compared with other OECD economies. It is one of the leading oil and gas producers and exporters in the world and the sector accounted for 12% of the country's GDP and 37% of its total exports in 2016.

The oil and gas industry is the largest economical sector in terms of value added, government revenues (based on a strong energy taxation policy), and employment, with around 200 000 people employed, directly or indirectly. The main objective of the government is to maintain long-term management and economic value creation of the NCS within an environmentally friendly framework.

Norway's exemplary policy in the oil and gas sector is the result of a predictable and cautious management of the resources. Norway is a model for many countries in this respect. Every year a licensing round is held for mature exploration acreage and every two years a numbered round for frontier acreage. Since the last in-depth review in 2011, Norway opened the Barents Sea southeast for petroleum activity in 2013. In May 2016, in the 23rd licensing round, ten licenses were awarded to 13 companies, including three production licences in the areas opened in 2013. One area mentioned by industry as potentially interesting, if political conditions are met in the future, is to consider a joint co-operation with Russia to explore resources in this area, and to share the costs of the infrastructure needed to develop new projects.

To date, only one-third of the gas resources and half of the oil resources have been produced in Norway, but the rate of production by field has been decreasing since 2006. This means that if the government wants to maintain the level of resources and revenues, it must promote the exploration and production of oil and gas and increase recovery further.

Although the main goal of the government is to continue to manage cautiously the oil and gas sector and to develop its resources step by step, Norway has also been impacted by the recent drop in commodity prices, by a slowdown in GDP growth, and the recent reduction in tax revenues. To maintain the competitiveness and the profitability of this sector, access to new acreage for exploration and production in the NCS is considered essential by both the MPE and industry – otherwise, the level of future production of resources will decline, which could create uncertainties regarding the security of supply in Europe. The IEA welcomes Norway's efforts to maintain the production and recovery of oil and gas resources. It appears necessary to continue to maintain a favourable fiscal framework for this industry to preserve the level of investments and continue to promote RD&D.

From a long-term perspective, the government should also consider charting the way towards the transition of its economy to cope with an eventual reduction in revenues from fossil fuels.

Electricity sector

Norway's power system is notable for the predominance of the hydropower sector, which accounts for around 95% of the total installed capacity. Norway's hydroelectric fleet also has a very large reservoir capacity (85 TWh). This significant source of flexibility is a resource the government wishes to exploit further in the future, especially given the future structural changes in adjacent European Union electricity markets, which include increased shares of variable renewables and the need for a more flexible backup capacity, as well as the possible shut down of nuclear reactors in Sweden. To develop cross-border interconnections and grids will reinforce the security of supply of the regional electricity system, although it may also expose Norway to more price volatility. From this perspective, therefore, the government should facilitate the ongoing decisions for new interconnectors. These have the potential to deliver a significant increase in capacity compared with the current levels, and offer access to new markets in the region and improve the flexibility of the system.

Norway should also tackle the challenge to maintain the sustainability of its hydropower system, especially to ensure that investments in maintenance are realised in due time and that the renewal of licenses does not erode economic viability. Industry also calls for a fairer taxation level of the hydropower sector.

Norway's electricity market has been deregulated since 1991 and it functions very well: it is considered a mature and liquid market, and is a model for many other countries. The Norwegian electricity sector legislation is largely harmonised with EU legislation. Market coupling with other countries has increased and further integration is welcomed by the Nordic TSOs, which underlines the growing complexity of the future management of the grid. A common Nordic balance settlement (NBS) is expected to be launched in 2017. NBS will reduce entry barriers in retail markets across the Nordic borders.

Limiting CO_2 emissions

Regarding climate change, Norway has a long history of ambitious climate policy and has a goal to reduce GHG emissions by 30% from 1990 to 2020. The overall national climate policy is set by the parliament and is broadly supported. In Norway, a comprehensive set of instruments has been developed over many years, such as a CO_2 tax introduced in 1991, the pollution control act, agreements with and voluntary measures in many industrial sectors, and increased support to RD&D to reduce emissions and develop environmental technologies. The government has also adjusted taxes to promote EVs further, and increased spending on public transport, such as railways.

In the future, the aim will be to continue to utilise international flexibility mechanisms to meet the GHG emission targets. Norway will fulfil its commitment to reduce emissions by at least 40% of the 1990 levels by 2030, even if there is no agreement on a joint fulfilment with the European Union. Norway had also declared its intention to become carbon neutral by 2050 provided enough countries fulfil their obligations as 2030 approaches. However, in June 2016 the parliament decided to move carbon neutrality forward to 2030 and aim for Norway to become a low-emission society by 2050. The government is considering how to implement this objective. Norway should also be congratulated for its financial support of many international climate initiatives, especially for its involvement in the United Nations Framework Convention on Climate Change process and the Paris Agreement.

In comparison with other OECD countries, Norway is already a low-carbon economy because of the predominance of its hydropower sector. However, the large use of electricity for domestic heating also means that there is less room to manoeuvre to decarbonise the economy. Primarily only the industrial sectors, oil and gas extraction, manufacturing, and transport still have potential to do so, which could become more challenging. Norway should continue to consider further measures to internalise the costs of CO_2 emissions from these sectors.

A quantitative national target for energy efficiency to reduce energy intensity (energy use/GDP) by 30% by 2030 has been set, stricter legislation as to new building requirements has been adopted, and currently a consultation to ban the use of fossil fuels to heat buildings and district heating systems is ongoing. With regards to the 2030 energy intensity target, it would be an improvement to investigate further how the different end-use sectors can and should contribute to reaching it.

The contribution of Enova's support programmes to develop more innovation and new energy and climate solutions must be underlined. With its institutional set-up, Enova is well positioned to deliver savings and drive innovation through market entry of new technologies. The government should continue to task Enova with the implementation of policies to promote more-efficient and climate-friendly energy use.

Finally, in recent years Norway has substantially increased public funding for energy-related RD&D and has become the leading IEA member country when measured in RD&D spending per GDP. RD&D is a government priority and numerous programmes have been set up. The programmes are guided by the MPE's national RD&D strategies Energi21 (including CCS) for the energy sector and OG 21 for the petroleum sector, and also with the objectives to improve innovation and the development of new technologies.

Recommendations

The government of Norway should:

- Continue to manage efficiently the exploration and production of its oil and gas resources in a safe and environmentally friendly manner in both mature and frontier areas.
- Continue to support further harmonisation and integration within the Nordic electricity market and to facilitate the development of new interconnections to strengthen the security of supply of the electricity system.
- Define more precisely a long-term strategy to achieve its climate change targets by sector, regularly monitor and assess the different policies and costs in a more co-ordinated manner, and involve all the relevant stakeholders in efforts to meet these objectives.
- Develop pathways for a transition to a future with lower fossil fuel revenues.

References

IEA (International Energy Agency) (2017), *World Energy Balances - 2017 Preliminary Edition (OECD Countries)*, OECD/IEA, Paris. www.iea.org/statistics/.

MPE (Ministry of Petroleum and Energy) (2016), *Kraft til endring — Energipolitikken mot 2030 (Power for Change – an Energy Policy towards 2030)*, Oslo, www.regjeringen.no/no/dokumenter/meld.-st.-25-20152016/id2482952/sec4

OECD (Organisation for Economic Development and Cooperation) (2016a), *Gross Domestic Product*, OECD, Paris, http://data.oecd.org/gdp/gross-domestic-product-gdp.htm.

OECD (2016b), *OECD Economic Surveys Norway*, OECD, Paris, www.keepeek.com/Digital-Asset-Management/oecd/economics/oecd-economic-surveys-norway-2016_eco_surveys-nor-2016-en#.WQmISsa1uUk.

SSB (Statistisk sentralbyrå) (2016), *Population and Population Changes*, Statistics Norway, Oslo, www.ssb.no/en/befolkning/statistikker/folkemengde.

World Bank (2016), *Population Density Urban Population*, World Bank, Washington, DC, http://data.worldbank.org/indicator/.

2. Climate change

Key data
(2014, 2015)

GHG emissions ex. LULUCF* (2014): 53.2 $MtCO_2$-eq, +2.4% since 1990 (UNFCCC, 2016)

GHG emissions with LULUCF* (2014): 27.7 $MtCO_2$-eq, -33% since 1990 (UNFCCC, 2016)

CO_2 emissions from fuel combustion (2015): 36.7 Mt, +34% since 1990

CO_2 emissions by fuel (2015): oil 58.9%, natural gas 30.6%, coal 7.9%, other 2.6%

CO_2 emissions by sector (2015): transport 38.9%, other energy industries 33.4%, manufacturing and construction 15.2%, commercial and other services 6.0%, heat and power generation 5.6%, residential 0.8%

Carbon emissions per GDP (2015): 0.12 tCO_2/USD 1 000 GDP PPP (IEA average, 0.25)

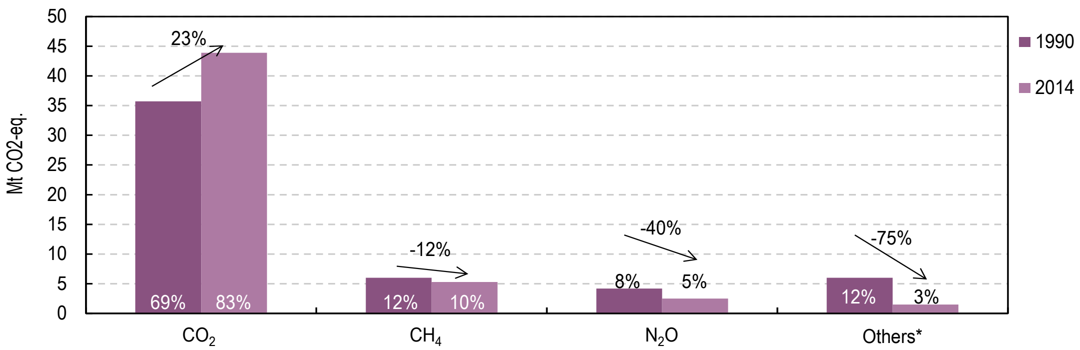
Carbon emissions per person (2015): 7.1 tCO_2 (IEA average, 9.9)

* land use, land-use change and forestry

Greenhouse gas emissions

Total emissions of greenhouse gases (GHGs) in Norway amounted to 53.2 million tonnes (Mt) carbon dioxide (CO_2)-equivalent ($MtCO_2$-eq) in 2014 (Figure 2.1). CO_2 was the major GHG. It accounted for 83% of the total GHG emissions in 2014, methane (CH_4) for 10% and nitrous oxide (N_2O) for 5%. The remainder, around 3%, consisted of perfluorocarbons (PFCs), sulphur hexafluoride (SF_6), and hydrofluorocarbons (HFCs).

Figure 2.1 GHG emissions by gas, 1990 and 2014



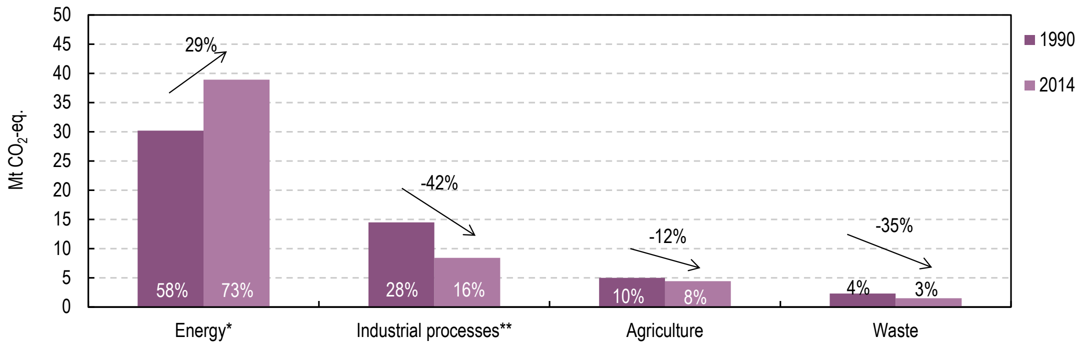
* Other gases includes HFCs, PFCs, and SF_6.

Note: Numbers in columns indicate the gas's share of the total greenhouse gas emissions.

Source: UNFCCC (2016), *Norway's National Inventory Submission 2016*.

By sector, by far the largest source of GHG emissions is fossil fuel combustion in the energy sector, including transport. It produced 73% of all the GHG emissions in 2014 (Figure 2.2).

Figure 2.2 GHG emissions by sector, 1990 and 2014



* Energy includes emissions from transport, manufacturing, and construction.

** Industrial processes include emissions from processes and product use (mainly metals, non-metallic minerals, and chemical industries).

Note: Numbers in (or above) the columns indicate the sectors' share of the total GHG emissions.

Source: UNFCCC (2016) *Norway's National Inventory Submission 2016*.

Energy-related CO_2 emissions

The following sections concern mainly CO_2 emissions from fuel combustion, which is the main source of GHG emissions. Emissions from the non-energy related sectors (Figure 2.2) and from other GHGs (Figure 2.1) are not included.

CO_2 emissions from fuel combustion in Norway were 36.7 Mt in 2015, 34% more than in 1990. Emissions had increased steadily along with economic growth, to 37.2 Mt in 1999. This was followed by a sharp decline and a gradual rebound. For the past decade, CO_2 emissions have plateaued. Since the record of 37.5 Mt in 2010, emissions had declined by 2% to 2015 (Figure 2.3).

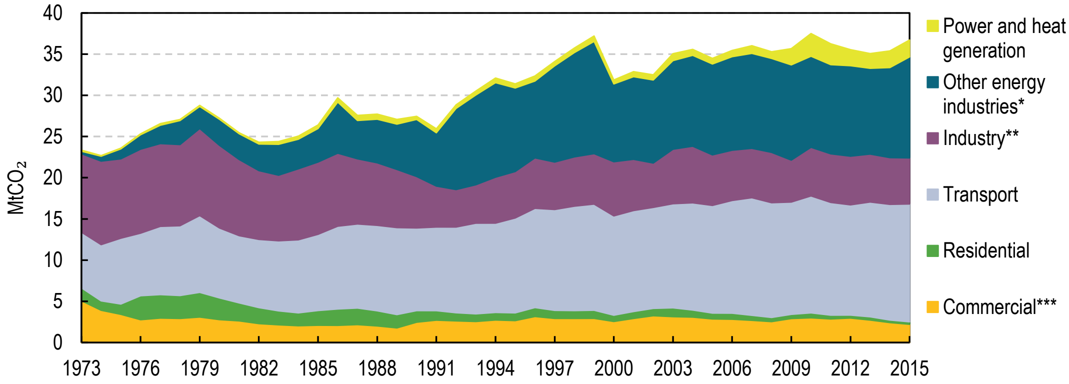
Sources of emissions

Emissions by sector

Transport is the largest CO_2-emitting sector, at around two-fifths (14 $MtCO_2$) of total emissions in 2015. Transport emissions have grown by 43% since 1990, as the number of vehicles and volume of transport have increased.

The second-largest CO_2-emitting sector was energy industries other than power and heat generation. This mainly covers oil and gas production and oil refineries, but also coal mining.

Figure 2.3 CO_2 emissions by sector, 1990-2015



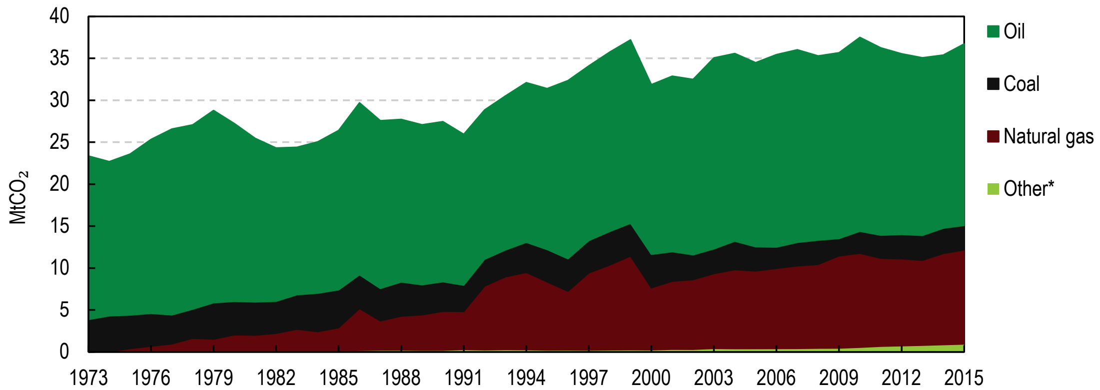
* Other energy industries include oil and gas production, refining, and coal mining.

** Industry includes manufacturing and construction.

*** "Commercial" includes commercial and public services, agriculture, forestry, and fishing.

Source: IEA (2017), *2017 Preliminary Edition of CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

Figure 2.4 CO_2 emissions by fuel, 1990-2015



* Negligible.

Source: IEA (2017), *2017 Preliminary Edition of CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

Emissions by fuel

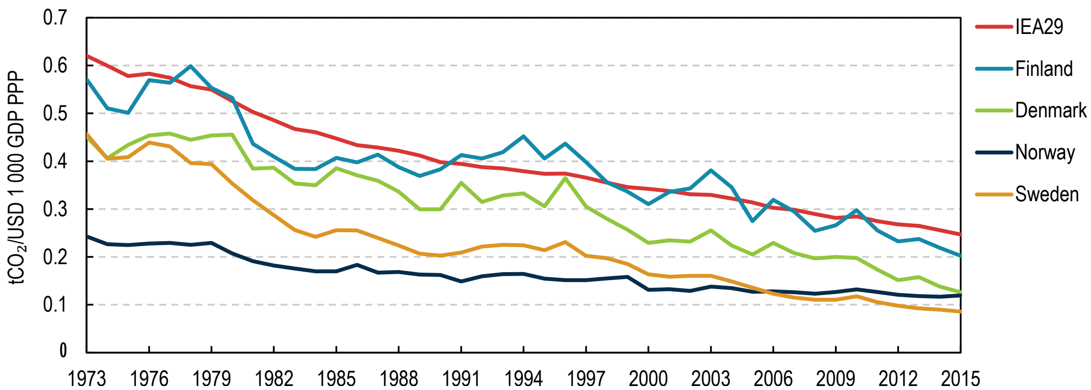
Oil is the largest source of CO_2 emissions, at 58.9% of the total in 2015, followed by natural gas (30.6%) (Figure 2.4). Oil is consumed mainly in the transport sector (57% of the total final oil consumption in 2015) and in industry (33%, including non-energy use). Around three-quarters of the natural gas are consumed in oil and gas production and the rest mostly as a raw material for methanol production. In a recent development, in 2016 the 420 MW gas-fired power plant at Kårstø was permanently shut down. Coal was the source of 7.9% of the total emissions in 2015. Since 2005, CO_2 emissions from oil use have decreased by 1.4% and those from coal by 1.0%, whereas those from natural gas use have increased by 21.3%, mostly because of increased gas production, both onshore and offshore.

Carbon intensity of the economy

Carbon intensity of the Norwegian economy has traditionally been low by international comparison and has continued to decrease over the past decades (Figure 2.5). Norway's carbon intensity, measured as CO_2 emissions per gross domestic product (GDP) adjusted for purchasing power parity (PPP) in 2010 US dollars (USD), amounted to 0.12 tCO_2/USD 1 000 GDP PPP in 2015 and was less than half of the International Energy Agency (IEA) average of 0.26 tCO_2/USD 1 000 GDP PPP. Norway has the fourth-lowest CO_2 intensity among the IEA member countries, after Switzerland, Sweden and France.

Since 1990, economic growth has been the main driver for CO_2 emissions, and it has been much faster than population growth. Over the same period, the CO_2 intensity of energy consumption has remained relatively stable. In 2014, Norway's energy-related CO_2 emissions per person amounted to 7.0 t, which was close to the IEA median and around one-third less than the IEA average of 10.1 t (Figure 2.6).

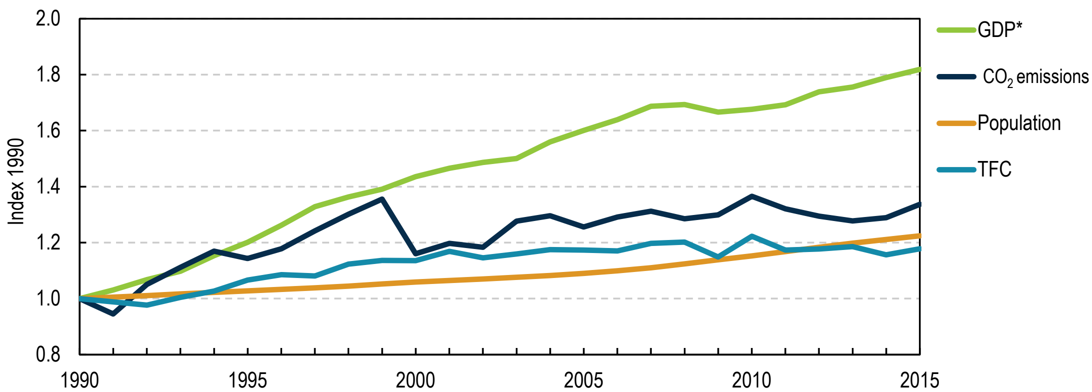
Figure 2.5 Energy related CO_2 emissions per unit of GDP in Norway and in other selected IEA member countries, 1973-2015



Note: IEA29 = the 29 members of the IEA.

Source: IEA (2017), *2017 Preliminary Edition of CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

Figure 2.6 CO_2 emissions and main drivers in Norway, 1990-2015



* Real GDP in 2010 prices and PPP.

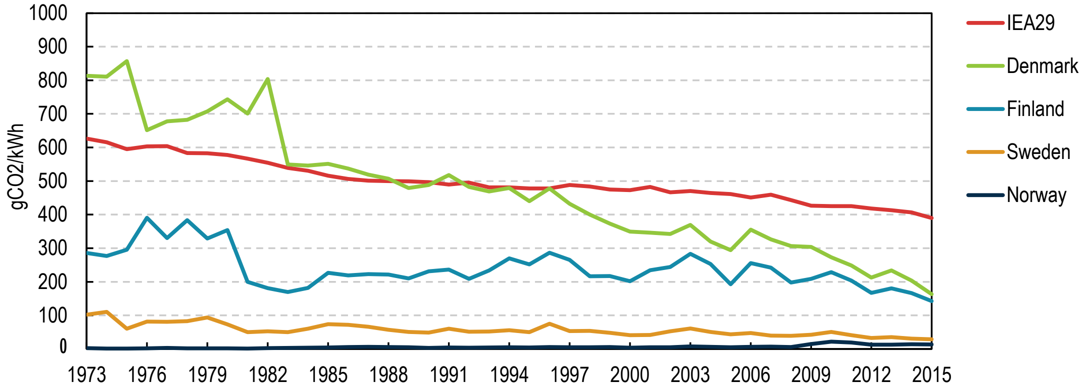
Source: IEA (2017), *2017 Preliminary Edition of CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

Carbon intensity of electricity generation

The carbon intensity of electricity generation in Norway's hydro-dominated power system has traditionally been the lowest among the IEA countries. In dry years, Norway imports electricity from elsewhere in the well-interconnected Nordic electricity market area, which overall has a low carbon intensity by international comparison (Figure 2.7). From 2011 to

2015, the CO_2 intensity of electricity generation in Norway averaged 14.4 grams of CO_2 per kilowatt hour (gCO_2/kWh).

Figure 2.7 CO_2 emissions per kWh of power and heat generated in Norway and in other selected IEA member countries, 1973-2015



Source: IEA (2017), *2017 Preliminary Edition of CO_2 Emissions from Fuel Combustion*, www.iea.org/statistics/.

Local air quality

Air quality in Norway is generally good and concentration levels for most air pollutants are below the EU limit values. Yet, in some parts of major urban areas the limit values for particulate matter (PM) and nitrogen oxides (NO_x) are exceeded, especially in winter.[1] Norway also has national legislation on limit values, and the limit values for PM are even stricter than the EU limit values. Overall, however, air pollution levels have been decreasing in recent years (EEA, 2014).

The main source of PM and NO_x in Norway is road transport, both through exhaust emissions and asphalt dust. Under Norway's National Transport Plan 2014-23, the transport sector is to be developed in an environmentally friendly way and public transport in urban areas will be encouraged.

Institutions

The overall national climate policy is decided by the Norwegian parliament (the Storting), and the government implements and administers the most important policies and measures, such as economic instruments and direct regulations. Most policies and measures in the area of climate policy are developed through interministerial processes before the political proposals are tabled. The Ministry of Climate and Environment has the overarching cross-sectoral responsibility for the co-ordination and implementation of the Norwegian climate policy. The other ministries are responsible for implementation in their respective sectors.

[1] As a party to the Agreement on the European Economic Area (EEA), Norway must comply with EU law on air pollution law. The EU limit values are laid down in the Directive 2008/50/EC on ambient air quality and cleaner air for Europe.

The Ministry of Climate and Environment is assisted by the Norwegian Environment Agency. The agency reports to the Ministry and implements government pollution and nature management policy, which includes climate and air-quality policy.

Local governments are responsible for implementing policies and measures at the local level, for example through waste management, local planning, and some transport measures.

Policies and measures

Targets

Norway has emissions reduction targets for 2020, 2030, and 2050.

By 2020, Norway aims to cut emissions of GHGs equivalent to 30% of the country's emissions in 1990. This will be done through a combination of domestic reductions and reductions in other countries, which include those achieved through Norway's participation in the EU Emissions Trading Scheme (EU-ETS). The use of international flexible mechanisms (notably the Clean Development Mechanism credits under the Kyoto Protocol) will also help reach Norway's 2020 target.

Under the Paris Agreement of the United Nations Framework Convention on Climate Change (UNFCCC), Norway's nationally determined contribution specifies a target to reduce emissions by at least 40% from the 1990 levels by 2030. The aim is to fulfil this target as a joint fulfilment with the European Union and its member states. Around half of Norway's emissions are already covered by the EU-ETS. In addition, a national target for emissions reductions will be set for sectors outside the EU-ETS. Norway has entered into a dialogue with the European Union on an agreement for the joint fulfilment of the 2030 target. If there is no agreement with the European Union, Norway will fulfil the commitment individually provided that it will have access to flexible mechanisms under the Paris Agreement and be credited for participation in the EU-ETS. The ambition level of at least a 40% reduction will remain the same.

Norway also aims to be carbon neutral by 2030, which it plans to achieve through the EU-ETS, international co-operation on emissions reductions, and emissions trading or project-based co-operation. Previously, it had set this target for 2050, but the parliament brought the date forward in summer 2016.

By 2050, Norway aims to become a low-emission society. The volume of domestic emissions reductions will depend on the ambition and actions of other countries. The government will also aim to balance the concerns over carbon leakage and the competitiveness of Norwegian industry with the need for more ambitious global climate policies and to avoid locking in infrastructure and systems that are incompatible with domestic and global climate targets. The government is currently working on a new climate change act that will legislate emissions reduction targets. The parliament has asked the government to legislate a target for 2050 that states a low-emission society has emissions levels of 80-95% below the 1990 levels.

Domestic measures

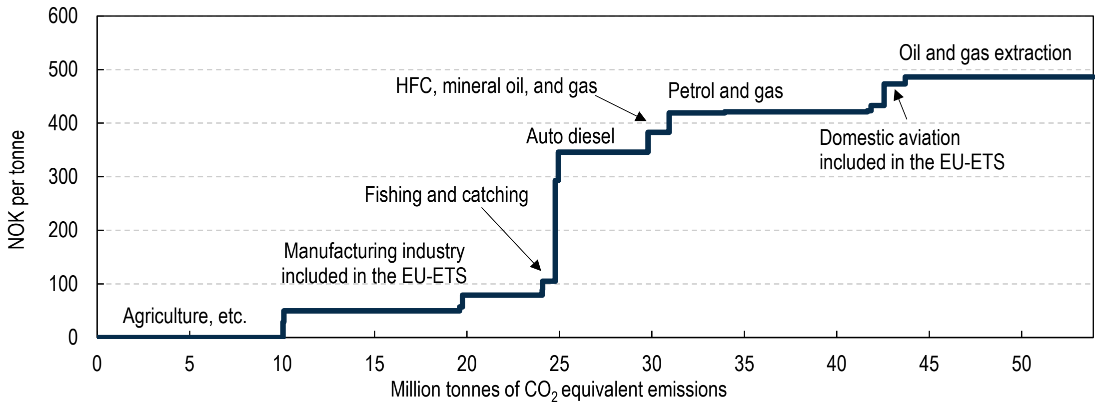
As explained in Norway's *Second Biennial Report under the Framework Convention on Climate Change*, the polluter-pays principle is a cornerstone of the Norwegian policy framework on climate change (GOV, 2015). Cross-sectoral economic policy instruments (e.g. CO_2 tax) are the basis for decentralised, cost-effective, and informed actions.

Norway's CO_2 tax was first introduced in 1991 in the offshore oil and gas sector, as well as in the transport and heating sectors. Mainland energy-intensive industries were, however, exempt from the tax because of the perceived threat of carbon leakage.

The tax rate varies by fuel type and sector. The CO_2 tax has encouraged the offshore oil and gas industry to reduce flaring and adopt carbon capture and storage (CCS) at the Sleipner and Snøhvit fields. Further measures include the electrification of some processes and an increased energy efficiency.

CO_2 taxes on transport and heating fuels have also helped to reduce emissions. In the transport sector, CO_2 emissions have been further reduced by introducing CO_2-based vehicle taxation to promote electric and other low-emission vehicles, and biofuels blending obligations (see chapters 3 and 7).

Figure 2.8 Price of GHG emissions by sector, 2016



Note: Price refers to tax level in Norwegian kroner (NOK) per tonne of CO_2 equivalents in 2016 and an EU-ETS allowance price of NOK 50 per tonne. Emissions data are for 2013.

Source: Ministry of Finance (2016), *The Norwegian tax system – main features and developments: Chapter 2 of the bill and draft resolution on taxes*, Oslo.

Today, more than 80% of Norwegian GHG emissions are covered by carbon taxes and/or the EU-ETS. Nevertheless, as elsewhere, carbon price levels across sectors remain far from uniform and efforts to reduce these disparities would help to ensure consistent and economic incentives to abate them (Figure 2.8).

In addition to carbon-pricing instruments, such as taxes and the ETS, the government has supported research on and innovation of climate-friendly technologies to help develop emissions reduction solutions where the markets have not provided them (see chapter 8).

According to government estimates, Norway's GHG emissions in 2010 would have been 12.6-15.2 $MtCO_2$-eq higher than observed if the climate policies and measures had not been implemented. GHG emissions would be 17.1-20.1 $MtCO_2$-eq higher in 2020 and 17.8-20.5 $MtCO_2$-eq higher in 2030 (GOV, 2015).

Further domestic emissions reduction is somewhat challenged by the widespread use of electricity, which is 94-98% generated from zero-carbon sources. Norway has the highest share of electricity in the total final consumption among the IEA member countries (46%), and space heating, for example, is heavily electrified. Through Enova SF (Enova), the government has ambitious programmes to increase renewable energy use and energy efficiency, but often they do not replace the use of fossil fuels (see chapters 3 and 7).

Emissions trading

The EU-ETS is currently in its third phase (2013-20) and around half of Norway's GHG emissions are covered by it. This EU-ETS phase is significantly different from previous phases. National allocation plans are no longer required and a single EU-wide ETS cap has been introduced. The cap is reduced by 1.74% per year from 2013 onwards, which results in a total cap for 2020 that is 21% below the 2005 emission levels from the sectors covered by the scheme.

More than 40% of the allowances will be auctioned and electricity generation no longer receives free allowances. For the sectors in which allowances are still given away for free, such as the manufacturing industry and heat sectors, harmonised allocation rules apply, based on EU-wide benchmarks of emission performance. A separate cap applies to the aviation sector. A market stability reserve of allowances will start to operate from 2019 to enable the supply of allowances to respond to changes in demand. In its proposal for a revised ETS from 2021 to 2030 (Phase IV), the European Commission has proposed to increase the linear reduction factor from 1.74% to 2.2% per year from 2021 onwards.

International emission credits

Norway supports the Clean Development Mechanism of the UNFCCC and has a programme to procure some 60 million Certified Emission Reductions (CERs) generated in the second commitment period of the Kyoto Protocol (2013-20). The government will procure carbon credits to help reach its domestic GHG emissions target of a 30% reduction by 2020 from 1990, but the final procurement target is yet to be determined.

The government has decided to acquire carbon credits from projects that face a risk of discontinuing their operations under the current low-carbon credit prices (vulnerable projects), or from new, as yet unregistered, projects. Credits will not be acquired from so-called industrial HFC projects or from coal-based energy production without CCS (GOV, 2015).

The expected deliveries from vulnerable projects that have been contracted were estimated at 31 million CERs (as of June 2016). A further 3.9 million CERs from new projects are expected to be delivered from the Carbon Partnership Facility and Prototype Carbon Fund (World Bank) and the Nordic Environment Finance Co-operation Carbon Fund. As of August 2016, contracts with an estimated delivery of some 10 million CERs have so far been agreed under a bilateral programme, and contracts with a further 6 million CERs were under negotiation in the second half of 2016.

Climate change vulnerability and adaptation

In May 2013, the Ministry of Climate and Environment published a White Paper on climate change adaptation in Norway. The White Paper focuses on the challenges associated with climate change and how Norway can become more resilient to it.

The Norwegian economy, environment, and society are all vulnerable to climate change. Projections indicate a warming in all parts of Norway and during all seasons. The annual mean temperature for Norway is estimated to increase by 3.4 (2.3-4.6) degrees Celsius by the year 2100. The growing season is projected to increase in large parts of the country. Annual and seasonal precipitation is also projected to increase. The annual runoff from the Norwegian mainland is estimated to rise, but regional differences can be expected. The snow season is projected to become shorter, and rainfall floods can be expected to increase. Higher temperatures and somewhat lower precipitation in the summer are projected to result in more serious summer droughts, particularly in southern Norway. Projections for the period 2071-2100 indicate that 90% of the country's glaciers may melt completely, and 30-40% of the total glaciated area may be gone by the year 2100. Climate change will also affect the oceans along the Norwegian coast. By 2100, the ocean surface temperature and sea level are expected to rise, and ocean acidification is expected to accelerate.

The Norwegian power supply is based primarily on hydropower. A higher precipitation caused by climate change will probably serve to increase power generation. At the same time, the expected increase in temperature will mean that Norway requires less heating, but more cooling (see chapter 6).

The authorities are responsible for creating the necessary framework for the country to adapt to a changing climate. This includes providing national statutes, regulations, and guidelines. The municipalities play an important role in climate change adaptation, as climate change impacts are manifested at the local level, where many adaptation actions are designed and implemented. Land-use planning is one of the core elements of this responsibility. In general, the government aims to incorporate climate change considerations into planning and decision-making processes in all areas and at all levels of society.

Since January 2014, the Norwegian Environment Agency has been the agency that supports the Ministry of Climate and Environment on climate change adaptation. It also co-ordinates the work of the central government on climate change adaptation.

Assessment

Norway has devoted considerable attention to environmental sustainability, and climate change mitigation enjoys broad popular and political support. The country has a target to reduce emissions by 30% from 1990 to 2020. In 2014, GHG emissions were roughly at the 1990 level, despite strong economic growth in the 1990-2014 period. The government plans to meet the target through a combination of domestic reductions, participation in the EU-ETS, and the use of international flexible mechanisms obtained through the government's procurement programme.

Norway's Nationally Determined Contribution under the UNFCCC is -40% from 1990 to 2030, a target for which it pursues joint fulfilment with the European Union. Norway has also pledged to become carbon neutral by 2030 (taking into account its contribution to emissions reductions abroad). By 2050, the stated objective is for Norway to become a low-emission society. The government is currently working on a climate change act to legislate its 2050 target. With its strong commitment to global climate change mitigation, Norway has set a fine example to other countries.

As to the -40% target for 2030, the negotiations with the European Union over a collective delivery (joint fulfilment) should be concluded as quickly as reasonably possible. To conclude the negotiations with the European Union is also a prerequisite for estimating the volume of international carbon credits Norway will need to purchase to meet its 2030 carbon neutrality goal. If an agreement with the European Union is not reached, the government will maintain the ambition to reduce emissions by at least 40% (compared with 1990) by 2030. This target will be conditional on the availability of flexible mechanisms under the Paris Agreement and on Norway's being credited for participating in the EU-ETS. If Norway does not conclude an agreement with the European Union, the government will consult the parliament at a later date to set a national target for the non-ETS sector. The question of how much of the emissions reductions should be carried out domestically remains a divisive one. Norway will probably have an ongoing reliance on some use of market mechanisms to meet the targets it has set, so it should seek early clarity on the post-2020 rules and position itself to secure credits early.

In many ways, Norway already is a lower-carbon economy than most others because of the historical predominance of hydropower. The widespread use of electricity, which includes for heating, means that energy use in buildings has essentially already been decarbonised. Oil and gas production, manufacturing, and transport are the focus areas for further cuts in energy-related GHG emissions. Fewer options for GHG mitigation tend to increase the mitigation cost per tonne avoided, and this, in turn, explains why the government also relies on international carbon credits as a measure to meet climate targets. When it defines the 2050 target to become a low-emission society, the government should also clarify the expected role of international carbon credits, in particular because the supply of such credits is set to decline in the global efforts to reduce emissions significantly by 2050.

Around 50% of Norway's emissions are already covered by the EU-ETS. Combined, the CO_2 tax and EU-ETS cover around 80% of GHG emissions in the country. Since the 2011 in-depth review, climate policies have been strengthened further through, among other things, increased tax rates on CO_2 in mineral products and on HFCs and PFCs in products. The government has also adjusted taxes to promote low- and zero-emission vehicles and increased spending on public transport, railways, and cycling/walking paths. The blending obligation for biofuels in road transport was increased to 5.5% in 2015. Funding for Enova has been increased. New energy requirements in the building code were introduced from 1 January 2016, and the government is working on a phase out of fossil fuels in buildings from 2020. The IEA encourages the government to prioritise policies and measures that reduce GHG emissions based on their long-term cost-effectiveness (NOK per tonne of CO_2 [NOK/tCO_2] avoided). The long-term approach is relevant here because, in the required transition to a low-carbon energy system, the need to change the economic structure may cost today, but will save money in the long run.

Recommendations

The government of Norway should:

- Work to conclude the negotiations with the European Union on a joint fulfilment of the 2030 target without undue delay.
- Prioritise policies and measures that reduce GHG emissions based on their long-term cost-effectiveness (NOK/tCO_2 avoided). Such assessments should consider costs and benefits over the full long-term energy transition, not just the short-term emission savings.
- Consider measures to enhance emission reductions and support low-carbon development of the oil and gas, manufacturing, and transport sectors, particularly where policy gaps exist.
- Implement measures to fulfil the commitments outlined in its White Paper on climate change adaptation and consider updating its national strategy to adapt to climate change based on the best available knowledge.
- Continue to work towards policy co-ordination of emissions reduction measures, which include the domestic carbon tax, EU-ETS, and renewable energy and energy efficiency measures.

References

EEA (European Environment Agency) (2014), *Air Pollution Fact Sheet 2014 Norway*, EEA, Copenhagen, www.eea.europa.eu/themes/air/.

GOV (Government of Norway) (2015), *Norway's Second Biennial Report under the Framework Convention on Climate Change*, Government of Norway, Oslo, https://unfccc.int/files/national_reports/biennial_reports_and_iar/submitted_biennial_reports/application/pdf/br2_norway.pdf.

IEA (International Energy Agency) (2017), *2017 Preliminary Edition of CO_2 Emissions from Fuel Combustion (OECD countries), OECD/IEA, Paris*, www.iea.org/statistics/.

Ministry of Finance (2016), *The Norwegian tax system – main features and developments: Chapter 2 of the bill and draft resolution on taxes*, Oslo. www.statsbudsjettet.no/upload/Statsbudsjett_2017/dokumenter/pdf/main_features_tax_system.pdf.

UNFCCC (United Nations Framework Convention on Climate Chsnge) (2016), *Norway's National Inventory Submission 2016*, http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php.

3. Energy efficiency

Key data
(2015)

Energy supply per capita: 5.7 toe (IEA average, 4.4), -11% since 2005

Energy intensity (TPES): 96.3 toe/USD million PPP (IEA average, 111), -3% since 2005

TFC: 20.5 Mtoe (electricity 46.4%, oil 39.2%, natural gas 4.7%, biofuels and waste 4.7%, coal 3.0%, heat 2.1%), +0.4% since 2005

Consumption by sector: Industry 40.3%, transport 24.0%, residential 18.9%, commercial and public services including agriculture, forestry, and fishing 16.8%.

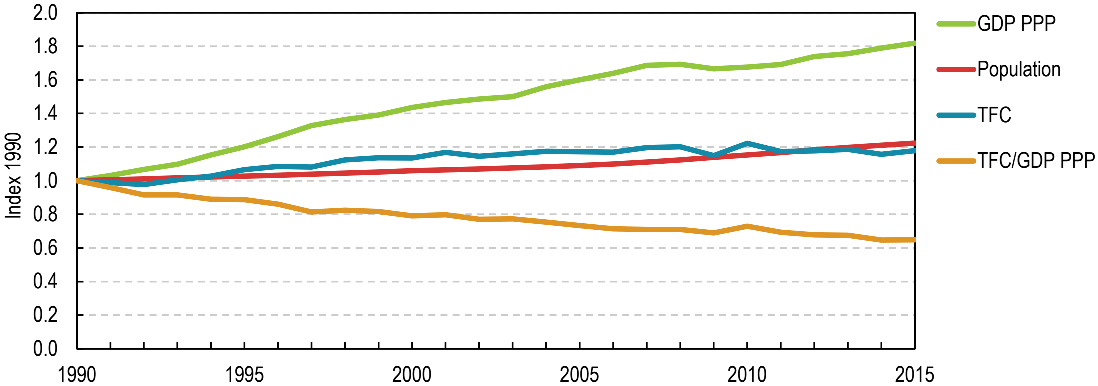
Currency (2015): EUR 1 = NOK 8.94; USD 1 = NOK 8.06

Overview

Norway's total final energy (TFC) consumption increased by 18% to 20.5 million tonnes of oil-equivalent (Mtoe) from 1990 to 2015. Over the same period, the Norwegian economy increased much more quickly, by 82% (Figure 3.1).

The growth in energy consumption varies significantly across sectors. In industry, the largest consumer, it increased by only 5% from 1990 to 2015, whereas in transport, the second-largest consumer, it grew by 45%, faster than in any other sector.

Figure 3.1 Energy consumption, population, and economic growth, 1990-2015



Note: GDP in real numbers for US dollars (USD) per purchasing power parity (PPP), in 2010 values.

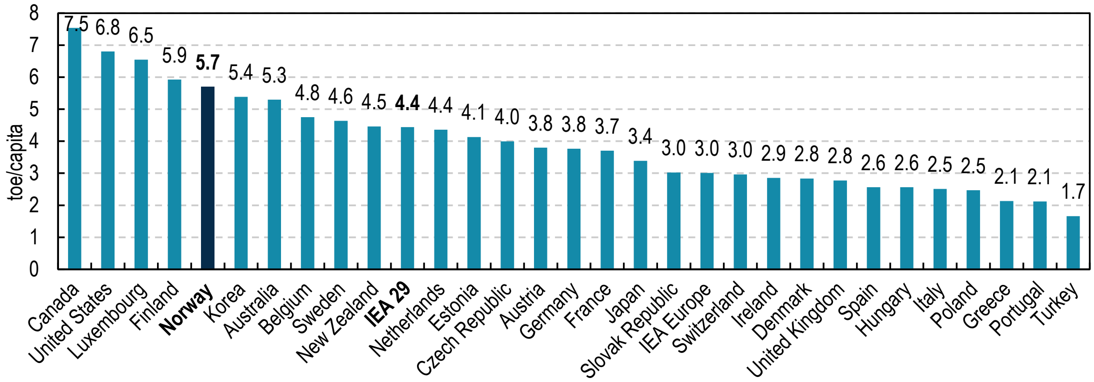
Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Energy intensity

Norway has the fifth-highest energy supply per capita among the International Energy Agency (IEA) member countries (Figure 3.2). It is a relatively cold country with a large energy consumption capacity for heating in winter, but also for electricity-intensive industries, such as aluminium production. Furthermore, it is a rich country with a high gross domestic product (GDP) per capita, which tends to increase the energy consumption. In terms of the energy intensity of the economy, Norway is in the lower half among the IEA member states (Figure 3.3).

Energy intensity has historically been low in Norway compared with neighbouring Scandinavian countries (Figure 3.4). The exception is Denmark, which has one of the lowest energy intensities among the IEA members. In recent years, energy efficiency improvements have been slow in Norway. The energy intensity fell by 3% between 2005 and 2015, compared with 9% in Finland and 20% in Denmark and 27% in Sweden.

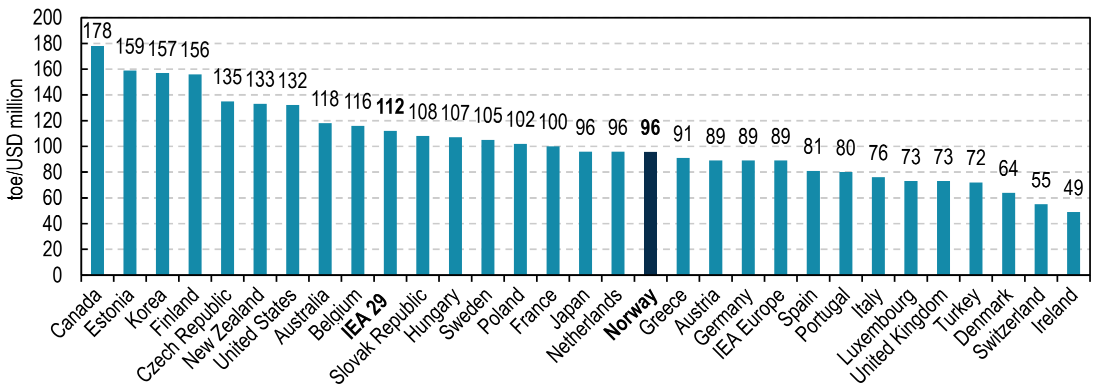
Figure 3.2 TPES per capita in IEA member countries, 2015



Note: TPES, total primary energy supply; IEA29, the 29 members of the IEA.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

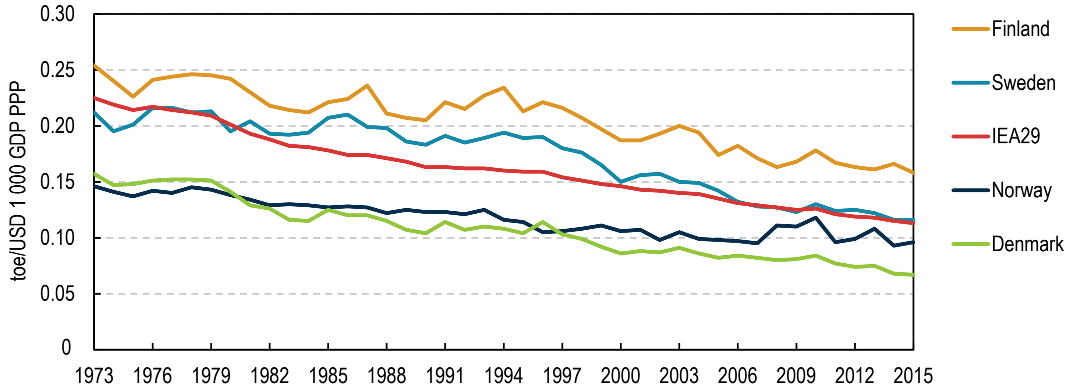
Figure 3.3 TPES per GDP in IEA member countries, 2015



Note: GDP in real numbers for US dollars (USD) per purchasing power parity (PPP), in 2010 values.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Figure 3.4 Energy intensity in Norway and in other selected IEA member countries, 1973-2015



Note: Energy intensity in terms of TPES per GDP PPP.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

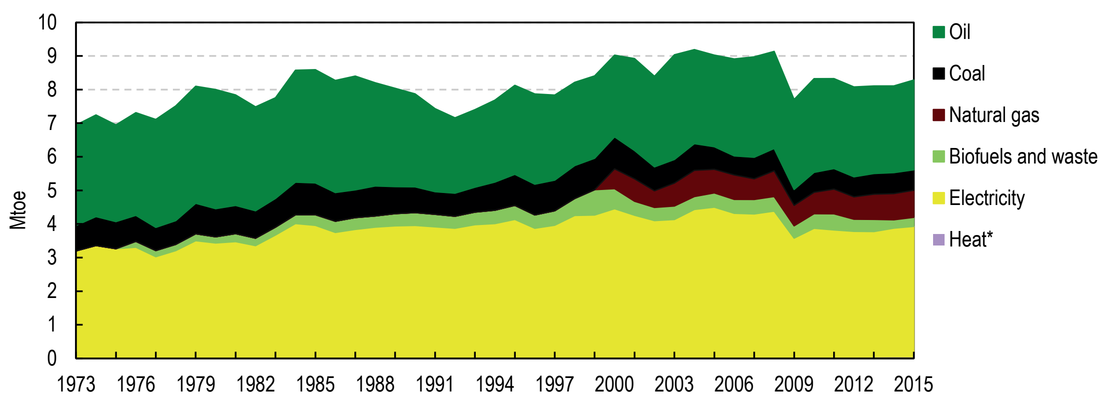
Energy consumption by sector

Industry

Industry is the largest energy-consuming sector, at 40% of the TFC in 2015. This includes fuels for non-energy use, mainly oil and natural gas used as feedstock in the process industries, which account for almost one-third of the total industry consumption. Energy consumption in industry fell in 2009 because of the financial crisis. Despite a recovery in 2010, consumption has declined by 9% since 2008.

Electricity is the dominant energy source, at almost half of the total energy consumption in industry (Figure 3.5). Oil accounted for one-third of the total consumption, and is mainly used for non-energy purposes. By industrial sector, metals and chemicals are the main energy consumers, at two-thirds of the total industry consumption (see Figure 3.6).

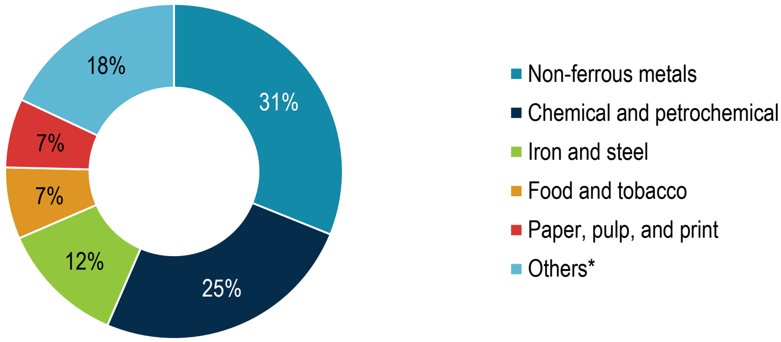
Figure 3.5 TFC in industry (including non-energy use) by source, 1973-2015



* Negligible.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Figure 3.6 Breakdown of the final energy consumption in industry by sector, 2015



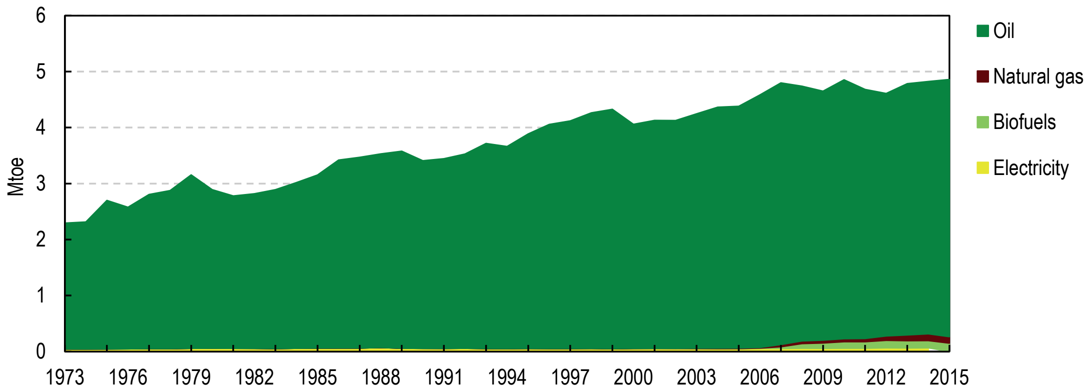
* Others include non-metallic minerals, construction, wood, machinery, mining, transport equipment, and textiles.
Note: Does not include non-energy use.
Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Transport

In 2015, transport consumed 4.9 Mtoe, at 24% of the TFC. In recent decades, energy use in transport has grown faster than in any other sector, and it increased by 13% from 2005 to 2015. Oil accounted for 93% of the energy consumption in the sector, with the rest supplied by biofuels, natural gas, and electricity (Figure 3.7).

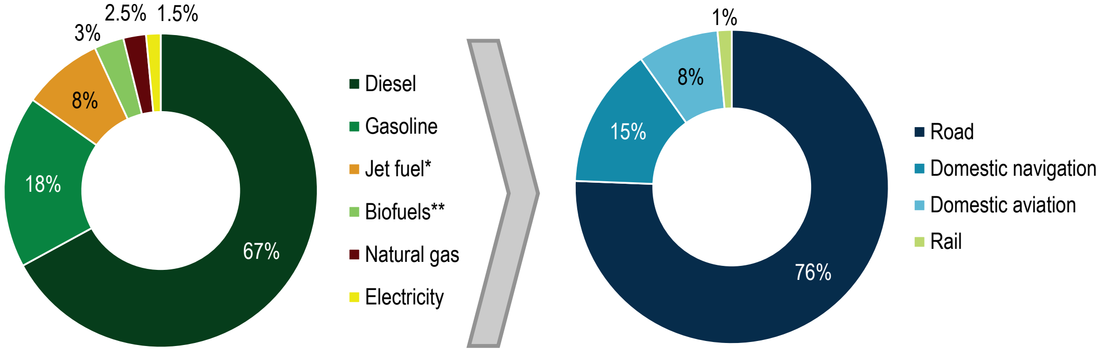
Diesel is the most consumed oil-based fuel, mainly used for road transport and domestic navigation (Figure 3.8). Road transport accounts for three-quarters of the total energy demand in the sector, followed by shipping and air travel. Domestic aviation has increased the fastest recently, by 60% over ten years. Despite a recent boom in electric vehicles (EVs) in Norway, electricity only accounts for 1.5% of the total energy consumption in transport, mostly in rail transport.

Figure 3.7 TFC in transport by source, 1973-2015



Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Figure 3.8 Breakdown of energy consumption in transport by fuel and sector, 2015



* Jet fuel is kerosene type jet fuel excluding bio.

** Biofuels consists of biodiesel, bio-gasoline, other liquid biofuels, and biogas.

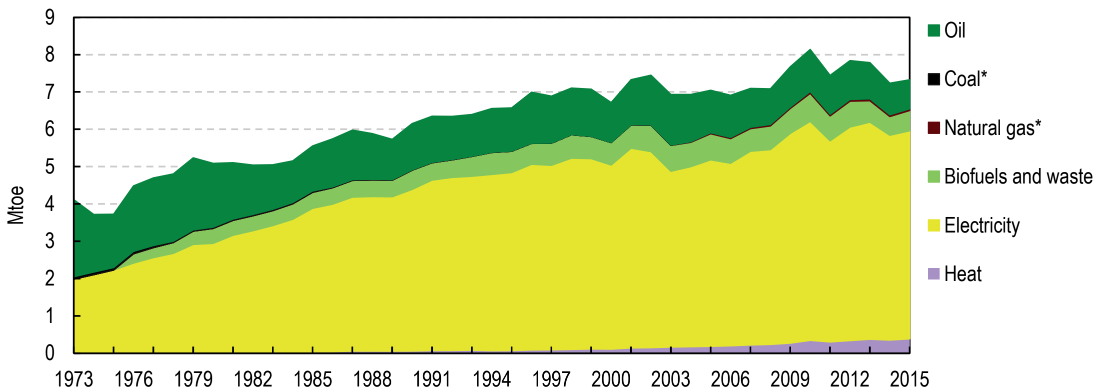
Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Residential and commercial sectors

In 2015, the residential and commercial[1] sectors consumed 7.3 Mtoe combined, or 36% of the TFC. Energy consumption in the residential sector increased slightly by 0.2% over the past decade, whereas commercial and public services grew by 9% over the same period. However, energy demand varies year-on-year according to heating needs (Figure 3.9).

Electricity accounts for three-quarters of the total energy consumption in the sectors. This is significantly higher than that in any other IEA member country and is largely explained by the widespread use of electric heating. Small volumes of residential and commercial energy demand are supplied by oil, biofuels, and district heating. The government is working on legislation to ban oil (and other fossil fuel) use for space heating from 2020 on.

Figure 3.9 TFC in the residential and commercial sectors by source, 1973-2015



* Negligible.

Note: The commercial sector includes agriculture, forestry, and fishing.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

[1] Commercial includes agriculture, forestry, and fishing.

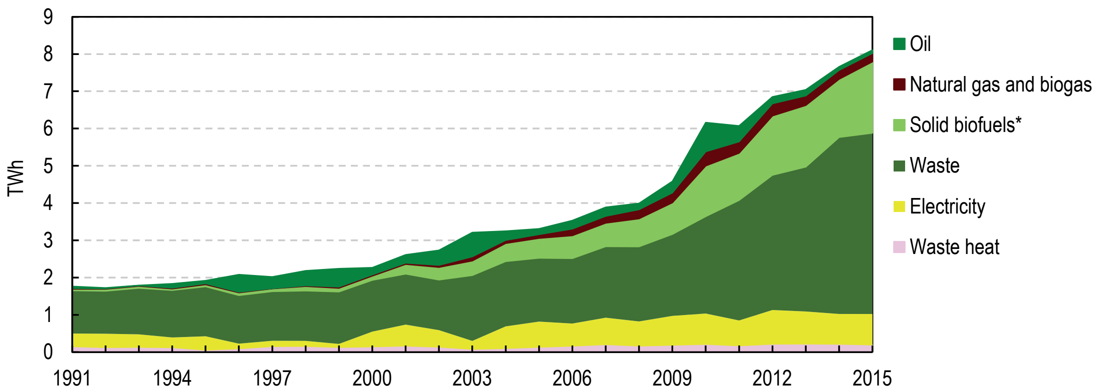
District heating

The total energy use in district heating production was 8.1 terawatt hours (TWh) in 2015. Municipal waste was the largest energy source, at 60% of the total, followed by biofuels at 24%, electricity at 10%, and small shares of fossil fuels and industrial waste heat (Figure 3.10). District heating production has increased by 145% over the past decade, with the largest growth in waste and biofuels.

The final district heating consumption was 4.8 TWh in 2015, equal to 60% of the total fuel input. The difference between energy input and delivered district heating is made up by conversion losses, heat used for electricity production in combined heat and power (CHP) plants, and distribution losses in the district heating network. Around one-third of the district heating is produced in CHP plants.

The commercial and public services sector is the largest consumer of district heating, at around 62% of final consumption (Figure 3.11), followed by the residential sector at 21% and the industry sector at 18%.

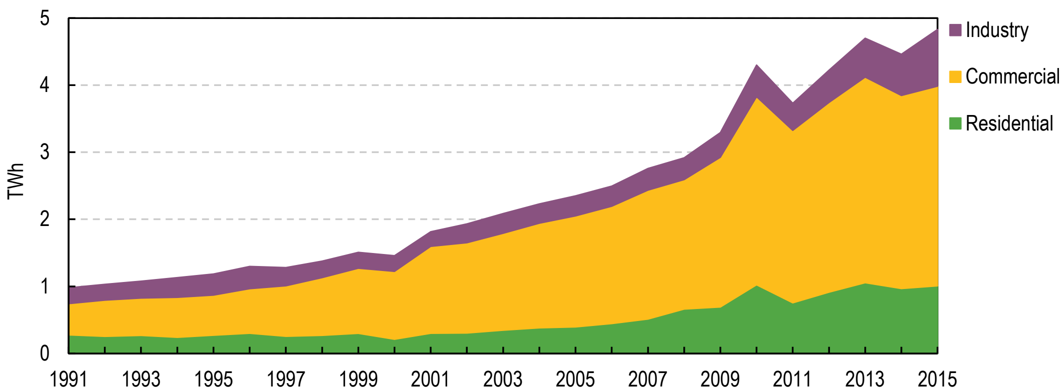
Figure 3.10 District heat production by energy source, 1991-2015



* Solid biofuels includes small shares of bio-oil.

Source: SSB (2016), *Statistikkbanken, Fjernvarme (District Heating)*, www.ssb.no/statistikkbanken.

Figure 3.11 District heat consumption by sector, 1991-2015



Source: SSB (2016), *Statistikkbanken, Fjernvarme (District Heating)*, www.ssb.no/statistikkbanken.

Institutions

The Ministry of Local Government and Modernisation is responsible for Norwegian housing policy, district and regional development, local government, and the administration of elections. The Housing and Building Department is responsible for implementing the government's housing and building policy. As part of the efforts to promote sustainable quality, security, and high aesthetic standards in the built environment, the department takes measures to reduce energy use and the use of building materials that are hazardous to health and the environment.

The National Office of Building Technology and Administration is the main agency that implements building policy. The office advises the Ministry of Local Government and Modernisation and other central government bodies on technical regulations and administrative provisions that relate to building policy measures.

The Norwegian State Housing Bank administers the government's programme to provide loans at a low interest rate for highly efficient buildings and efficiency upgrades.

The Ministry of Transport and Communications is responsible for energy efficiency policy in the transport sector.

The Ministry of Petroleum and Energy (MPE) is organised into four departments. The Energy and Water Resources Department is responsible for land-based energy generation, the administration of water resources, new renewable energy production, and energy efficiency and consumption. The main objective of the department is to ensure sound management, in both economic and environmental terms, of water and hydropower resources and other domestic energy sources.

Enova SF (Enova) is a public enterprise owned by the MPE. It aims to help reduce greenhouse gas (GHG) emissions, increase security of energy supply, and develop technology that, in the long run, also helps reduce GHG emissions. Enova supports investments in energy efficiency in all the sectors (see chapter 2).

Regional and local governments have responsibilities associated with planning and building permits.

Policies and measures

Targets

Norwegian policies related to energy efficiency were presented in the 2016 White Paper on energy policy to 2030, and the parliament's decisions on the proposal are the basis for the Norwegian efforts related to energy efficiency. The government has set a national target for energy efficiency. The goal is to reduce energy intensity (energy consumption/GDP) by 30% by 2030. In addition, the government is working to set a target of a 10 TWh reduction in energy consumption in 2030 in existing buildings from current levels, in line with the Norwegian Parliament's decision.

The government has not prepared a specific strategy or action plan on energy efficiency. Energy efficiency is considered as a tool to meet the energy policy objectives of the security of supply, environmental sustainability, and economic efficiency, but to meet these objectives, the government typically relies on measures that address them directly (e.g. limits on the carbon dioxide [CO_2] intensity of passenger cars or a ban on fossil fuels for space heating) or it relies on the price mechanism (e.g. through taxes, the EU Emissions Trading Scheme [EU-ETS], and wholesale electricity prices). The role of energy efficiency in mitigating climate change is also reduced by the high level of electrification and the almost zero-carbon supply of electricity.

The state enterprise Enova supports investments in energy efficiency in all the sectors and in renewable electricity and heat supplies. It also provides information and advice services, as well as targeted communication to both businesses and households.

Buildings

The building code is the main legal instrument to improve energy efficiency. It was revised in 2015 and the new requirements (passive house level) entered into force on 1 January 2016. Compared with the previous requirements, the 2016 ones are 26% stricter for dwellings and 38% stricter for office buildings.

New buildings and buildings subject to major refurbishments must meet limit values for either the total net energy need for space heating, cooling, and hot water or for individual building components. The latter option applies to residential buildings only.

The limit value for the total energy need is measured in kilowatt hours per square metre of heated floor area per year for nine different building categories. The limit values for individual building components are windows/doors (U-value ≤ 0.8), roofs (U-value ≤ 0.13), floors facing the ground or exterior (U-value ≤ 0.10), exterior walls (U-value ≤ 0.18) and air tightness (air change per hour at a 50 pascals [Pa] pressure difference ≤ 0.6), heat recovery, and other technical requirements.

Regardless of the option chosen, all new buildings must meet the minimum requirements for windows (U-value ≤ 1.2), roofs and floors that face free air (U-value ≤ 0.18), exterior walls (U-value ≤ 0.22), and air tightness (air change per hour at 50 Pa pressure difference ≤ 1.5).[2]

The parliament has agreed that the energy requirements in the technical building code TEK10 will be tightened further to next to zero energy use in 2020.

Restrictions on oil use for heating

The direct use of fossil fuels to heat buildings has decreased significantly in recent years, thanks to the highest taxes on heating oil among the IEA countries and to the support to use renewable energy instead.

The 2016 buildings energy requirements also banned the installation of fossil fuel heating in new buildings. In practice, this means oil heating and natural gas and coal are not used. Previously, from 2010 on, only installing oil heaters for baseload had been prohibited. The 2016 requirements also specify that buildings with more than 1 000 square metres (m^2) of heated usable floor area must have flexible heating solutions.

[2] The U-value represents the rate of heat loss, i.e. how much energy passes through 1 m^2 of a material by a difference of 1 K in temperature. It is measured in watts per degree Kelvin per square metre.

Furthermore, the parliament has asked the government to prepare legislation to ban the use of fossil fuels to heat new and existing residential buildings and as the base load in other buildings in 2020. The government is now working on how to design the ban for 2020.

Energy certification scheme

As from 1 July 2010, the energy certification scheme required buildings to have an energy certificate when built, leased, or sold. The objective of the scheme is to provide basic information about the energy performance of buildings and the possibilities for improvements. The energy certification scheme is part of the follow-up of the EU Directive on energy performance in buildings (Directive 2002/91/EC). The MPE is responsible for the scheme, which is executed by Enova.

Support for energy efficiency in buildings

Since 2006, Enova has managed a grant scheme in households to promote the deployment of mature, but currently not widely used, technologies for environmentally friendly heating and electricity savings. In 2015, this scheme was made rights based, so that there is a predefined set of measures for which costs will be refunded without the need to apply in advance.

Enova runs information and advisory activities that target businesses, municipalities, and households, including a free advisement service that provides guidance over the telephone, chat, or e-mail (Enova Svarer). In addition, the Norwegian State Housing Bank provides loans at low interest rates for highly efficient buildings and efficiency upgrades.

Transport

Private cars remain the dominant form of passenger travel in Norway (Table 3.1). From 1990 to 2014, traffic volume by passenger cars increased by 46% and railway use for passenger transport by 62%, whereas bus use declined by 3%. Over the same period, Norway's population grew by 22%. In 2014, Norway had 940 000 more passenger cars than in 1990, an increase of 58%. Passenger car density has risen from 380 in 1990 to 495 per 1 000 inhabitants in 2014, practically equal to the European Union 28 average of 491 (European Union, 2016).

Roads accounted for 78.9% of the total mainland freight in tonne kilometres in 2014, whereas the share of rail was 12.6% and of pipelines 8.5%. Road haulage volumes roughly doubled from 1990 to 2005 and have increased by 19% since then (European Union, 2016). However, freight by sea accounted for 46% of the total domestic freight in tonne kilometres in 2015. In particular, 83% of Norway's cross-border freight volume was carried by ship, according to the Institute of Transport Economics of Norway (ITE, 2016).

Table 3.1 Modal breakdown of passenger transport on land, 2014

Mode	Car	Buses and coaches	Train	Tram and metro
Share of passenger-km (%)	88.9	5.3	4.8	1.1

Source: European Union (2016), *EU Transport in Figures – Statistical Pocketbook 2016.*

Measures to promote a shift towards the use of alternative fuels are implemented primarily to reduce CO_2 emissions from the sector. The government sees an important role for sustainable biofuels (see chapter 7) in addition to electricity. A shift from fossil fuels to electricity in the transport sector also considerably improves the energy efficiency, as electric motors are more efficient than conventional combustion motors.

Norway has an ambitious national target to limit CO_2 emissions from new cars to an average of 85 grams CO_2 per kilometre (gCO_2/km) by 2020. The measures have already brought results, as from 2001 to 2016 the average CO_2 emissions from new passenger cars declined from more than 180 gCO_2/km to under 93 gCO_2/km.

Fossil fuel cars are taxed quite heavily through the motor vehicle purchase tax, which is linked to CO_2 emissions, and through the CO_2 tax and road usage tax on petrol, diesel, and liquid petroleum gas. The purchase tax for motor vehicles has three components: weight, CO_2 emissions, and nitrogen oxides emissions. The weight and CO_2 emission components are progressive. The CO_2 component makes it more attractive to buy cars with lower emissions. Cars with very low CO_2 emissions benefit from reduced taxes levied on weight. In general, cars with low emissions are also energy (fuel)-efficient cars.

The government also grants tax exemptions for EVs. In 2016, these became exempt from purchase (registration) tax and value added tax (VAT) (25% for conventional cars). EVs also benefit from a reduced annual motor vehicle tax and a 50% tax reduction on the private use of an electric company car compared with conventional cars. EVs are also not subject to the road usage tax. Furthermore, EVs have enjoyed extensive user benefits, such as free parking, free toll roads and free charging, although these benefits were reduced recently (see the section on e-mobility).

Transport policy in major urban areas in Norway is now being directed towards absorbing the growth in passenger transport by public transport, cycling, and walking. This means a modal shift from private cars to less energy-intensive and less-polluting transport. Urban environment agreements have been established to follow up on this work through a more comprehensive approach to urban policy. The government also grants considerable financial support for cities to invest in measures that promote public transport, walking, and cycling.

The government is also taking steps to mitigate the environmental impact of public transport outside cities, for example new state-owned ferries are required to use low-carbon emission or zero-carbon technologies. In addition, the government prioritises investments in the rail network, which is an energy-efficient low CO_2 alternative to road and air travel.

Industry

Energy-intensive industries are regulated under the EU-ETS which, in principle, encourages energy efficiency improvements, but the low CO_2 allowance prices in recent years have dampened that effect. The low CO_2 allowance prices are indirectly partly because of the high support for renewable energy in Europe. Support for renewable energy through the Norway-Sweden electricity certificate system, as well as support schemes in other European countries, also has a direct effect on the incentive to energy efficiency improvements by lowering the market price on electricity.

Another measure that indirectly promotes energy efficiency is the CO_2 tax, which was introduced in 1991 and covers mineral products, such as oil and natural gas.

Voluntary agreements with industry have also been used for years. The Programme for Energy Efficiency in Energy Intensive Industry is managed by the Norwegian Energy and Water Resource Directorate (NVE). Participants are entitled to an exemption from the electricity tax if they carry out identified and agreed energy efficiency initiatives. Participating companies must implement a standardised energy management system, identify measures, and carry out efficiency measures.

Enova has several programmes that promote energy management, energy efficiency, and climate measures, and demonstrate new technology in industry. Enova has a particular responsibility to support for new energy and climate technologies in industry and offers investment grants for full-scale demonstration projects that involve new technology under real-life operating conditions.

District heating

District heating is a small but growing source of energy in Norway, at around 5% of the energy consumption in the residential and commercial sectors. Waste incineration and biofuels are the most common fuels and the government supports the use of more renewable energy in district heating production.

District heating is regulated through the Energy Act from 1990 which requires district heating plants with an output greater than 10 megawatts to hold a licence from the NVE. Today, there are 94 licences for district heating production and distribution owned by around 60 concessionaires. All the major cities and many small and medium-sized towns have access to a district heating network.

The Energy Act regulates the price that may be charged for district heating. The price consists of a connection fee, a fixed yearly charge, and a charge for the heat that is consumed. The total price for district heating shall not exceed the price for electric heating in the same supply area (MPE, 1990).

Enova supports investment in the district heating and district cooling infrastructure through the Programme for District Heating (Enova, 2016). The programme aims to add new production capacity based on renewable energy or industrial waste heat, or to convert existing district heating production from fossil fuels to renewable energy sources (RES). Municipal waste incineration is categorised as a RES for district heating production.

Appliances

Norway implemented the voluntary labelling scheme Energy Star for office equipment in 2005. The Norwegian Energy Star regulation was revised in 2014 to implement the EU Energy Star Programme regulation EU 174/2013.

The EU Ecodesign Directive 2009/125/EC was transposed into national law in 2011. The related regulations for energy efficiency for different product groups are also implemented in Norway, with two exceptions: Ecodesign regulation 813/2013 for water heaters and hot water storage tanks and Ecodesign regulation 814/2013 for space heaters and combination heaters. Both are still under consideration.

Norway implemented the Energy Labelling Directive 2010/30/EU in 2013. The directive is a revision of the framework Directive 92/75/EC. The major changes in the revisions are a widened scope from "energy using" to "energy related" products, inclusion of non-household products, and the addition of three new energy efficiency classes, A+, A++, and A+++ on top of the original A to G scale. Norway has currently implemented all the EU regulations under the Energy Labelling Directive.

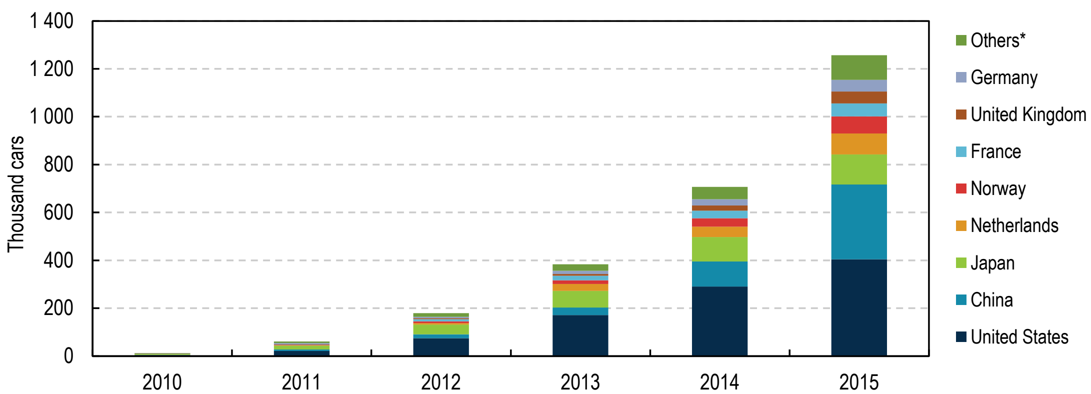
Case study: E-mobility

Norway is world leading in electric vehicle (EV) deployment. A strong policy support has made the price for EVs competitive with regular internal combustion engine (ICE) vehicles, and EV sales have increased rapidly as a result. Also, modes of transport other than passenger cars can be electrified, and digitalisation enables new transport solutions.

EV and infrastructure development

Progress in battery technology, which includes improved storage capacity and cost reductions, as well as strong policy support mechanisms have enabled a rapid growth in EVs in recent years. The global EV fleet grew by a hundredfold from 12.5 thousand in 2010 to 1.26 million in 2015 (Figure 3.12) and surpassed 2 million in 2016. The United States had the largest number of EVs with over 400 000 in 2015, followed by China, which tripled its EV fleet in one year to over 300 000. Norway had the fifth-largest EV fleet, and by far the highest share of EVs per capita.

Figure 3.12 Global EV fleet per country, 2010-15



* Others includes Canada, Sweden, Italy, India, Spain, Korea, and Portugal with more than 2 000 EVs, and another 25 countries with smaller shares.

Note: Both battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs) are included.

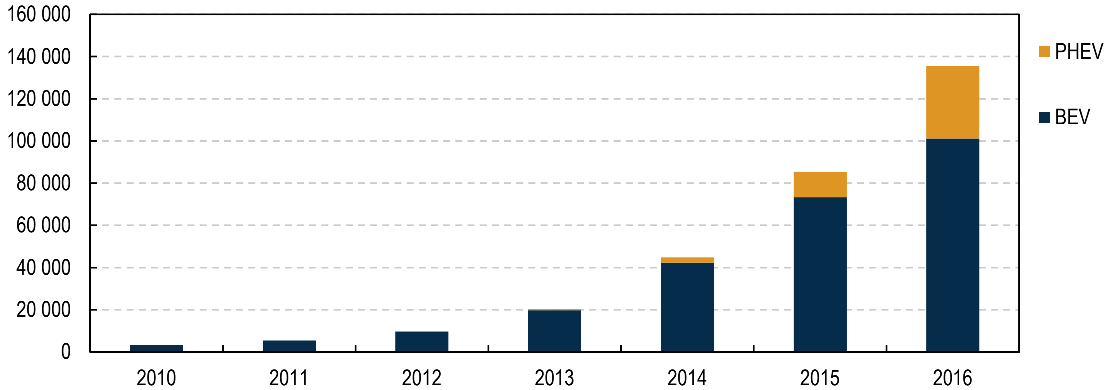
Source: IEA (2016), *Global EV Outlook 2016.*

Norway has increased its number of EVs by a factor of 25 in five years, from 5 400 cars in 2011 to 135 500 cars in 2016 (Figure 3.13). EVs accounted for 29% of all new cars sold in Norway in 2016,[3] which is an outstanding level globally. Second after Norway was Iceland with an EV market share of 6.3%, followed by the Netherlands at 6.0% and Sweden at 3.6% (EAFO, 2017b).

[3] This is preliminary 2016 data from EAFO (2017a).

Pure battery electric vehicles (BEVs) accounted for 75% of the total EV fleet in Norway in 2016. This is different to that of several other countries with a large EV deployment in which plug-in hybrid EVs (PHEVs) are more common, such as the Netherlands and Sweden. However, recently the PHEV share has been increasing in Norway, and in 2016 PHEVs accounted for over 40% of new EV registrations.

Figure 3.13 EV fleet development in Norway, 2010-16

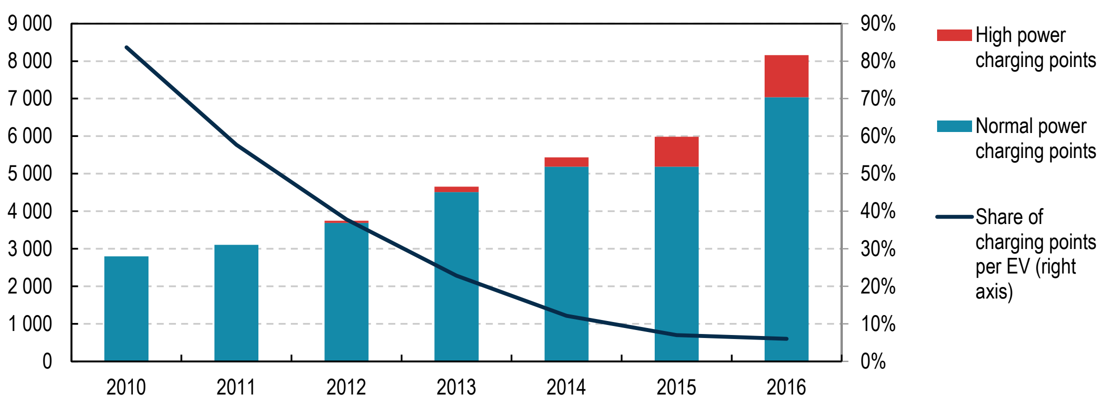


Source: Norsk elbilforening (2017a), *Electric Vehicle Fleet in Norway*, http://elbil.no/english/norwegian-ev-market/.

Access to the charging infrastructure is a challenge for EV deployment. Most EV charging is done overnight at home, but for longer trips EV drivers must be able to charge their cars in publicly available charging stations. The number of publicly available charging points in Norway has increased from around 3 000 in 2011 to around 8 000 in 2016 (Figure 3.14). The number of charging points is far below the corresponding increase in the number of EVs over the same period, and the rate of available public chargers per EV has declined significantly.

The EU directive for an alternative fuels infrastructure sets a recommendation of one charging point per ten EVs (EC, 2014). In 2016, Norway's share was only 0.6 chargers per 10 EVs. It is, however, difficult to define an optimal number of EV chargers, as this depends on local factors, such as traffic conditions, the capacity of the charging points and their precise locations. The important aspect is the availability of public charging possibilities to ensure that EV drivers and potential buyers have confidence in the technology.

Figure 3.14 Publicly available EV chargers in Norway, 2010-16



Source: EAFO (2017b), *Norway*, www.eafo.eu/content/norway.

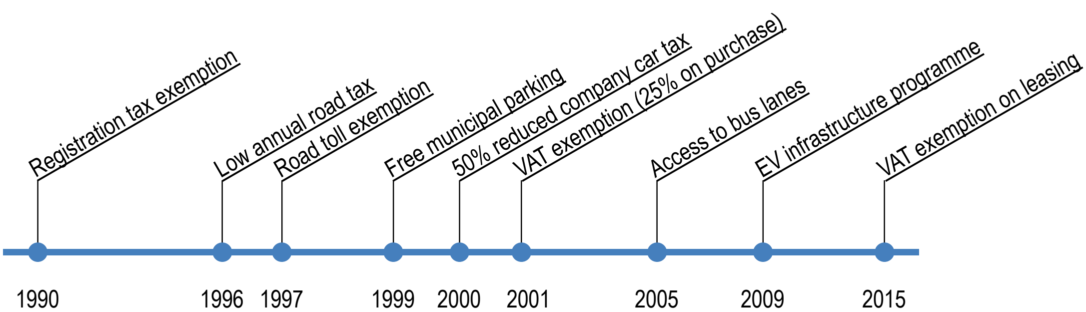
National and local policy

The Norwegian Parliament has set the target to limit CO_2 emissions from new cars to 85 gCO_2/km, on average, by 2020. This is lower than the EU target of 95 CO_2/km by 2021 (EC, 2017).

Over the past decades, Norway has adopted a comprehensive EV support system that includes both financial and non-financial incentives (Figure 3.15 and the transport policy section above). The support system has promoted BEVs more than PHEVs, which explains the BEV dominance in Norway. The VAT exemption is only valid for BEVs and not for PHEVs, and the purchase tax discount is smaller for PHEVs (Mock and Yang, 2014).

To encourage infrastructure development, a large share of charging stations installed in Norway has received government or municipal support. The government has launched a programme to finance the establishment of at least two fast charging stations every 50 km on all main roads in Norway by 2017 (Norsk elbilforening, 2017b). Oslo and other cities have a grant system to support charging stations in shared apartment buildings (NEVA, 2016).

Figure 3.15 EV-related support policy in Norway, 1990-2015



Source: Norsk elbilforening (2017b), *Norwegian EV Policy*, http://elbil.no/english/norwegian-ev-policy/.

The strong support policies for EVs have been effective in terms of rapid market growth. EVs are not necessarily directly replacing petrol or diesel cars, but are often bought as additional cars. However, the EV usually becomes the car used for most travel needs by the owner, and the ICE car is used mainly for long-distance travels (NEVA, 2016).

The cost of the strong fiscal policy measures was estimated in 2014 by the Institute for Transport Economics (Fridstrom and Ostli, 2014) in terms of cost per CO_2 emission abatement. The study concluded that the support systems are expensive for society during the early phase, but that the costs are reduced in the long term to NOK 400-2 500 (Norwegian kroner) per tonne CO_2 (USD 50-310 in 2015 exchange rates) (Fridstrom and Ostli, 2014). By June 2014, the EV policies had reduced state revenues by NOK 2.3 billion, according to the TOI study, and the total cost for EV tax exemptions increases further with the growth in EVs. In 2015, the yearly revenue loss was claimed to be NOK 4 billion (TU, 2015a). The VAT incentives are scheduled to remain until 2020 and then be revised. As to toll roads, ferries, and parking, the parliament has asked the government to establish a national binding rule to ensure that zero-emission vehicles should not pay more than 50% of the charges for conventional vehicles.

E-mobility in public transport and car-sharing services

EVs can help increase energy efficiency and reduce emissions from the transport sector, but issues with congestion on densely trafficked roads remain. Other e-mobility solutions, such as electrified public transport and electric car-sharing programmes, can improve the sustainability of transport further.

Public transport

Electrification of city buses has environmental benefits from the reduced local air pollution and noise levels. Norway's first electric bus line was introduced in Stavanger in 2015 (TU, 2015b) and bus lines in Oslo and Drammen are planned to be electrified in 2017 (BFK, 2016; Ruter, 2017). The city of Oslo has set a target of fossil free public transport in 2020, which will make electric buses more attractive (Oslo Kommune, 2016).

E-mobility is also being introduced in sectors other than road transport. The marine sector is relatively large in Norway, and all new state-owned ferries are required to use low- or zero-emission technologies. In 2015, the world's first electric passenger ferry was introduced on the E39 route over the Sogne fjord, and two more electric ferries have been ordered (TU, 2016).

Electric car-sharing services

An alternative to public transportation is car sharing through the use of car pools, taxi services, or other programmes. The benefit of low energy costs when using electricity instead of gasoline or diesel increases when cars are used more intensively by multiple people, which makes car sharing of EVs more cost-effective. Digitalisation further provides new ways to organise and enable car sharing through user-friendly mobile applications.

Car sharing programmes can be private or be supported by public initiatives. In Norway, several private car rental and car-sharing services offer EV rentals. One example is Move About, which runs an EV fleet of 70 cars in the Oslo area that can be rented on an hourly basis using a digital booking system. Move About subscribers can choose between a membership with only an hourly fee for the EV rental or one with a monthly fee and a 25% discount on the rental fee (Move About, 2017).

Assessment

Norway has a broad set of energy efficiency policies and measures. They include taxes, subsidies, tax exemptions, labelling, building regulations as well as public awareness campaigns. These appear to have been generally effective, as the country's final consumption of energy has remained relatively flat over the past decade, despite economic and population growth.

The government considers energy efficiency as a tool to meet the energy policy objectives of the security of supply, environmental sustainability, and economic efficiency, but it typically relies on measures that directly address them (e.g. limits on the CO_2 intensity of passenger cars or a ban on fossil fuels for space heating) or it relies on the price mechanism (e.g. through taxes, EU-ETS, and wholesale electricity prices). In 2016, however, the government announced a new energy efficiency target to improve the energy intensity of the economy by 30% by 2030. The IEA considers that Norway would benefit if it prepared and implemented an energy efficiency strategy that prioritises policies and measures based on cost-effectiveness.

Public interest in energy efficiency is often linked with economic considerations. A standard global example is the reaction to high and increasing oil prices. In Norway, electricity is low cost (particularly in relation to income levels) and low carbon by international comparison, which makes it harder to use energy efficiency to support the broader energy policy goals of the security of supply, economic growth, and environmental protection. Electricity accounts for close to half of the final energy consumption, and if the government wishes to see a more-efficient electricity use, it should consider a broad suite of mechanisms, which includes pricing, to provide additional incentives to domestic users to increase their energy efficiency.

Industry

The energy use of industry has decreased slightly over the past decade. Significant efficiency potentials have reportedly been identified in oil and gas production, and major investments have been triggered because of commitments by the industry to reduce GHG emissions. Nevertheless, whether efficiency in this sector could improve more quickly, particularly because of a potential strong impact on GHG emissions, should be analysed. The government could initiate further voluntary agreements with manufacturing industries, as well as with the oil and gas industry, and implement measures to improve the awareness as to the benefits of efficiency investments.

Buildings

Building codes are a key instrument to promote energy efficiency. Buildings have the longest service life of all energy-using products, spanning decades or even centuries; they account for about one-third of all the end-use energy in Norway. Therefore, strict building codes are a necessity to improve the overall energy efficiency.

In recent years, Norway has tightened its building codes progressively. The latest tightening, in 2016, placed energy performance requirements at passive house levels – a welcome move. What is more, the government aims to introduce a near-zero energy use standard by 2020. In 2016, the parliament also tasked the government to reach an absolute savings target of 10 TWh in existing buildings by 2030.

The renovation rate in the buildings sector is roughly 1.5% per year. To achieve the aspired reductions, the government could strengthen its existing programme (administered by the Norwegian State Housing Bank), which provides loans at low interest rate for highly efficient buildings and efficiency upgrades, and could introduce additional financial incentives for better insulation. Apart from financial incentives, building owners should be offered a wider range of advisory services, such as tailored concepts for phased renovations.

Further efficiency improvements in the building sector are expected from replacing the remaining fossil fuel heating systems (non-renewable energy use to heat buildings accounts for 20%). In autumn 2016, the government initiated a public hearing process on a possible ban of oil heating systems by the year 2020. To help reach the efficiency target for 2030, it will be important to replace the remaining fossil fuel heating systems by efficient low-carbon technologies, such as heat pumps.

Transport, including e-mobility

Energy efficiency measures in the sector are primarily designed to help reduce CO_2 emissions. Norway's long-going support for zero-emission vehicles has triggered an impressive growth in the number of EVs and made the country a world leader in EV deployment. A combination of high taxes for cars with ICEs, tax incentives, and non-fiscal benefits for EVs (e.g. free parking and the use of bus lanes) has led to an impressive diffusion of EVs and increased their number to more than 135 000.

Given the high uptake, however, the tax incentives have become expensive. Under the polluter-pays principle, the government can cover the subsidy costs with income from the high purchase tax on non-electric cars, but this system does not guarantee an efficient use of the tax income. It appears that the subsidy system has not been differentiated across car types (e.g. motor size and price) or by the type of buyer (e.g. first car or second car), and neither has its budget been capped. This has led to the largest subsidies being offered to the buyers of the most expensive cars, which raises questions about the cost-effectiveness of the system, although specific data are hard to find. Non-fiscal incentives, such as the right of EV drivers to use bus lanes, have also been questioned as they can have a negative impact on public transport as they increase congestion.

From the climate change mitigation perspective, EVs are an attractive option, especially in a country where electricity is basically emission free. They can also significantly improve energy efficiency. However, a heavy reliance on EVs to decarbonise the transport sector can lock in the private car as the dominant mode of transport (its share of passenger travel on land in 2014 was 89%). In this regard, the government should take a broader approach to e-mobility and closely monitor and follow-up on the consequences of different support mechanisms. To prioritise the expansion and electrification of public transport could bring stronger benefits than to encourage more private EV ownership. Furthermore, electrification can provide large efficiency improvements in the marine sector as well as in road transport.

Recommendations

The government of Norway should:

- Develop and implement a national energy efficiency strategy based on the past performance of measures and an analysis of the costs and benefits of efficiency measures in different sectors. Focus the strategy to maximise the impact of efficiency measures that reduce GHG emissions and that deliver positive system benefits (e.g. security of supply and peak demand).
- Determine the extent to which the different end-use sectors can contribute to reaching the overall energy intensity target for 2030.

- ☐ Design policies to replace existing fossil fuel heating systems with efficient low-carbon technologies.
- ☐ Develop a more diversified strategy to improve the efficiency in the transport sector, which should include measures on the modal split.
- ☐ Take a broader approach to e-mobility and expand public support policies to include electrification in public transport, car-sharing programmes, and other innovative e-mobility solutions, but still ensure the cost-effectiveness of measures on electric passenger cars.

References

BFK (Buskerud fylkeskommune) (2016), "Brakar kjøper elbusser av Ebusco", BFK, Dramen, www.bfk.no/Nyheter/Hovedsiden/Nyheter-2016/Brakar-kjoper-elbusser-av-Ebusco/.

EAFO (European Alternative Fuels Observatory) (2017a), *Norway*, EAFO, Brussels, www.eafo.eu/content/norway.

EAFO (2017b), *Top 5*, EAFO, Brussels, www.eafo.eu/top-5.

EC (European Commission) (2017), "Reducing CO_2 emissions from passenger cars", European Commission, Brussels, ec.europa.eu/clima/policies/transport/vehicles/cars_en.

EC (2014), "Clean fuels for transport: Member States now obliged to ensure minimum coverage of refuelling points for EU-wide mobility", European Commission, Brussels, europa.eu/rapid/press-release_IP-14-1053_en.htm.

Enova (2016), *Program Fjernvarme (District Heating Programme)*, Enova, Oslo, www.enova.no/finansiering/naring/programtekster/program-fjernvarme/245/1257/.

European Union (2016), *EU Transport in Figures – Statistical Pocketbook 2016*, European Union, Luxembourg, https://ec.europa.eu/transport/facts-fundings/statistics/pocketbook-2016_en.

Fridstrom L. and V. Ostli V. (2014), *Ressursøkonomisk Regnskap for Elektrifisering av Bilparken*, Institute for Transport Economics, Oslo.

IEA (International Energy Agency) (2017), *World Energy Balances - 2017 Preliminary Edition (OECD Countries)*, OECD/IEA, Paris. www.iea.org/statistics/.

IEA (2016), *Global EV Outlook 2016*, OECD/IEA, Paris, www.iea.org/publications/freepublications/publication/Global_EV_Outlook_2016.pdf

ITE (The Institute of Transport Economics) (2016), *Transport volumes in Norway 1945-2015. Summary.* Oslo. www.toi.no/getfile.php/Publikasjoner/T%C3%98I%20rapporter/2016/1544-2016/1544-2016_Summary.pdf.

Mock, P. and Z. Yang, Z. (2014), "Driving electrification – A global comparison of fiscal incentive policy for electric vehicles", International Council on Clean Transportation, Washington DC, www.theicct.org/sites/default/files/publications/ICCT_EV-fiscal-incentives_20140506.pdf.

Move About (2017), "Move About gjør det rimelig og enkelt å kjøre miljøvennlig", Move About, Oslo, www.moveabout.no/Hva-koster-det.

MPE (Ministry of Petroleum and Energy) (1990), "Act no. 50 of 29 June 1990: Act relating to the generation, conversion, transmission, trading, distribution and use of energy etc. (The Energy Act)", Oslo, www.regjeringen.no/globalassets/upload/oed/vedlegg/lover-og-reglement/act_no_50_of_29_june_1990.pdf

NEVA (Norwegian Electric Vehicle Association) (2016), "The Norwegian EV success continues", EVS29 Symposium Montréal, Québec, http://gammel.elbil.no/elbilforeningen/dokumentarkiv/finish/10-dokumenter/458-evs29-symposium-montreal-the-norwegian-ev-success-continues-paper

Norsk elbilforening (2017a), "Electric vehicle fleet in Norway", Norsk elbilforening, Oslo, http://elbil.no/english/norwegian-ev-market/.

Norsk elbilforening (2017b), "Norwegian EV policy", Norsk elbilforening, Oslo, http://elbil.no/english/norwegian-ev-policy/.

Oslo Kommune (2016), "Climate and Energy Strategy for Oslo", Oslo Kommune, Oslo, www.oslo.kommune.no/getfile.php/Innhold/Politikk%20og%20administrasjon/Etater%20og%20foretak/Klimaetaten/Dokumenter%20og%20rapporter/Climate%20and%20Energy%20Strategy%20for%20Oslo%20ENG.pdf.

Ruter (2017), "De første batterielektriske bussene på vei til Oslo", Ruter, Oslo, https://ruter.no/om-ruter/presse/pressemeldinger/de-forste-batterielektriske-bussene-pa-vei-til-oslo/.

SSB (Statistisk sentralbyrå) (2016), *Statistikkbanken, Fjernvarme*, Statistics Norway, Oslo, www.ssb.no/statistikkbanken.

TU (2016), "Storeslem for Siemens i Trondheim: Leverer elsystem til alle verdens elektriske ferger", TU, Oslo, www.tu.no/artikler/storeslem-for-siemens-leverer-batterier-til-alle-verdens-elektriske-ferger/350934.

TU (2015a), "Så mye taper staten på elbil-fordelene", TU, Oslo, www.tu.no/artikler/sa-mye-taper-staten-pa-elbil-fordelene/223844.

TU (2015b), "Her kjører Norges første elbusser i rutetrafikk", TU, Oslo, www.tu.no/artikler/her-kjorer-norges-forste-elbusser-i-rutetrafikk/222331.

Further reading

Aftenposten (2016), "Bilistene betaler 9 milliarder mindre i avgifter enn før regjeringsskiftet" ("Car owners pay NOK 9 billion less in fees compared to before the election"), Schibsted Media Group, Oslo, www.aftenposten.no/norge/politikk/Bilistene-betaler-9-milliarder-mindre-i-avgifter-enn-for-regjeringsskiftet-610552b.html.

IEA (2016), *Energy Efficiency Indicators 2016* (database), OECD/IEA, Paris, www.iea.org/statistics/.

Korneliussen K. (2016), "The Norwegian transport sector", presentation at the IEA In-depth country review, Norwegian Ministry of Transport and Communications, Oslo.

Ystmark Bjerkan K., T.E. Norbech, and M. Elvsaas Nordtomme (2016), Incentives for promoting battery electric vehicle (BEV) adoption in Norway, *Transportation Research D*, Vol. 43, Elsevier, Amsterdam, pp. 169–180, www.sciencedirect.com/science/article/pii/S1361920915002126.

4. Fossil fuels

Key data

(2015)

OIL

Crude oil production (including natural gas liquids): 88.0 Mt, -34% since 2005

Crude oil net exports: 63.8 Mt, -42.4% since 2005

Oil products net exports: 12.0 Mt

Share of oil: 36.8% of TPES and 0.02% of electricity generation

Consumption by sector: 10.9 Mtoe (oil in TPES) (transport 52.6%, industry 30.6%, commercial and public services, including agriculture and fishing 7.8%, other energy industries 7.8%, residential 1.1%, heat and power generation 0.2%)

NATURAL GAS

Production: 121.0 bcm, +39% since 2005

Net exports: 114.7 bcm, +39% since 2005

Share of natural gas: 18.2% of TPES and 1.8% of electricity generation

Consumption by sector: 6.3 bcm (5.4 Mtoe) (energy industries 74.8%, industry 15.1%, heat and power generation 7.1%, transport 2.2%, commercial and public services, including agriculture and fishing 0.8%, residential 0.1%)

COAL

Production: 1.1 Mt, -25% since 2005

Imports and exports: 0.7 Mt imported, 1.1 Mt exported

Share of coal: 2.8% of TPES and 0.1% of electricity generation

Consumption by sector: 0.8 Mt (0.8 Mtoe) (industry 79.5%, other energy industries 16.2%, heat and power generation 4.2%)

Currency (2015): EUR 1 = NOK 8.94; USD 1 = NOK 8.06

Upstream oil and gas sector

Norway is one of the leading oil and gas exporters in the world. In 2015, its net exports of were the fifth-largest, after the Russian Federation, Saudi Arabia, Canada, and Qatar. Its gas exports, at 115 billion cubic metres (bcm) per year, were the third-highest in the world and its net crude oil exports, at 1.3 million barrels per day (mb/d), the tenth-largest, according to preliminary International Energy Agency (IEA) data.

The oil and gas sector is the backbone of the Norwegian economy. In 2016, it generated 12% of the gross domestic product (GDP) and 37% of exports. It also accounted for 21% of investment in the country and provided 13% of government revenue, even with the sharp decline in oil and gas prices since 2014.

Resources and production

The government estimates the total discovered and undiscovered oil and gas resources on the Norwegian continental shelf (NCS) at 90 billion barrels (14.3 bcm) of oil equivalent at the end of 2016 (Table 4.1). Around 48% of this total has already been produced, mostly in the form of oil. The remaining resources contain more gas than oil and consist mostly of proved reserves and undiscovered resources, each at around two-fifths of the remaining resources.

The North Sea, where Norwegian oil and gas production started, has 51% of the remaining resources, and the Norwegian Sea contains 23% and the Barents Sea 26% of the total. The share of the Barents Sea region has increased from 7% in 2009, whereas the share of the North Sea has declined correspondingly.

The undiscovered resources are estimated at around 18 billion barrels of oil-equivalent. Around half of these are expected to be found in the Barents Sea and one-quarter each in the North Sea and the Norwegian Sea.

Finally, around one-fifth of the remaining resources is made up of contingent resources in fields and discoveries, as well as of resources to be added through possible future measures for improved recovery (Table 4.1).

At the end of 2016, Norway had 80 fields in production – 62 fields in the North Sea, 16 in the Norwegian Sea, and two in the Barents Sea. For 2017-21, the government expects the total petroleum production to remain at the 2012-16 level. Oil production has decreased by 40% since its peak in 2001 and is estimated to remain at around its current level of 2 mb/d for the coming years. Gas production is at a record level and is expected to remain at this over the next few years. In 2015, gas accounted for exactly half of total petroleum production.

The Norwegian Petroleum Directorate's (NPD) detailed production outlook to 2021, dating from autumn 2016, is relatively stable: 1.9-2.0 mb/d of liquids and around 114 bcm/year of gas. The outlook to 2030 is also relatively flat, but naturally includes more uncertainty (MPE/NPD, 2017). This depends on measures in the producing fields, on decisions as to which discoveries will be developed, and also on new discoveries made. International market developments and other factors will play a role in these decisions.

The decline in crude oil production has largely been compensated for by the increased production of natural gas and natural gas liquids (NGLs) (Figure 4.1). This has resulted in a rather stable level of oil and gas production, which is forecast to remain above 200 million cubic metres (mcm) of oil-equivalent per year until 2021.

Table 4.1 Norway's oil and gas resources, end 2016

	Resources, 31 Dec 2016					Changes from 31 Dec 2015				
Total recoverable potential	**Oil** (mcm)	**Gas** (bcm)	**NGL** (Mt)	**Cond** (mcm)	**Total** (mcmoe)	**Oil** (mcm)	**Gas** (bcm)	**NGL** (Mt)	**Cond** (mcm)	**Total** (mcmoe)
Project status category										
Produced	4169	2217	190	116	6863	94	117	10	2	232
Reserves*	991	1782	112	23	3009	-32	-74	-4	-5	-119
Contingent resources in fields	351	246	21	3	640	22	24	-1	0	45
Contingent resources in discoveries	367	299	14	3	697	-8	-23	0	-10	-42
Possible future measures for improved recovery	145	60			205	-10	0	0	0	-10
Undiscovered resources	1285	1465		120	2870	-30	-20	0	0	-50
Total	**7308**	**6070**	**337**	**264**	**14284**	**37**	**24**	**5**	**-13**	**56**
North Sea										
Produced	3581	1722	136	75	5635	77	72	6	0	160
Reserves*	842	1220	72	-4	2194	-32	-59	-3	-4	-101
Contingent resources in fields	312	130	12	0	464	26	14	1	0	42
Contingent resources in discoveries	139	121	9	1	277	-22	0	0	-8	-30
Undiscovered resources	430	230		40	700	-25	-20	0	0	-45
Total**	**5303**	**3422**	**228**	**111**	**9270**	**24**	**7**	**4**	**-12**	**26**
Norwegian Sea										
Produced	585	454	52	34	1172	14	39	4	1	61
Reserves*	121	380	34	8	574	0	-9	-1	0	-10
Contingent resources in fields	35	102	8	2	154	-3	10	-3	1	2
Contingent resources in discoveries	38	133	5	2	182	-11	-17	0	-2	-30
Undiscovered resources	320	410		45	775	0	0	0	0	0
Total**	**1099**	**1479**	**99**	**91**	**2858**	**1**	**24**	**-1**	**0**	**23**
Barents Sea										
Produced	3	41	2	7	55	3	6	0	1	10
Reserves*	28	182	6	19	241	0	-7	0	-1	-8
Contingent resources in fields	4	15	1	0	21	-1	0	1	0	1
Contingent resources in discoveries	191	46	1	1	239	26	-7	0	0	19
Undiscovered resources	535	825		35	1395	-5	0	0	0	-5
Total**	**761**	**1109**	**10**	**62**	**1951**	**23**	**-7**	**1**	**-1**	**17**

* Includes resource categories 1 (in production), 2 (approved plan for development and operation), and 3 (decided by the licensees) of the NPD.

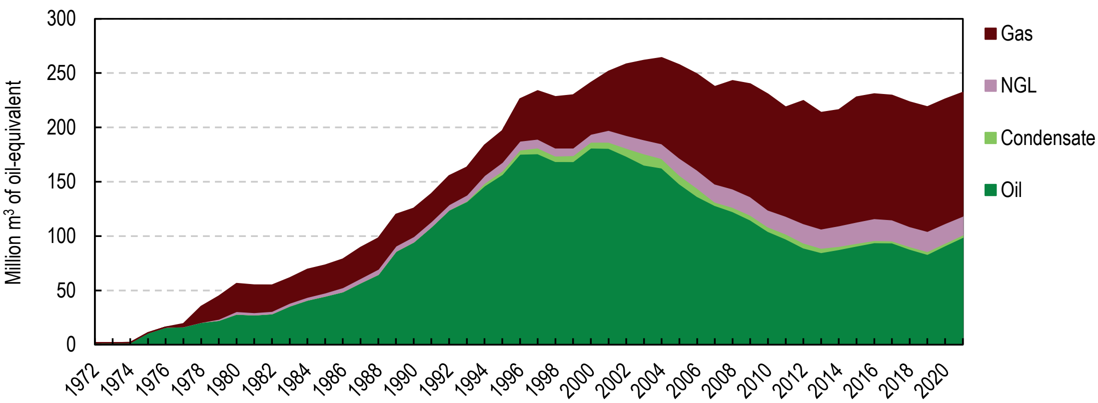
** Resources from future measures for improved recovery are calculated for the total recovery potential and have not been broken down by area.

Note: Cond = condensate, Mt = million tonnes, mcmoe = million cubic metres oil-equivalent.

Source: MPE, www.npd.no/en/Topics/Resource-accounts-and--analysis/Temaartikler/Resource-accounts/2016/.

Production from new fields that come on stream will compensate for the decline in production from ageing fields. However, in the longer term, the level of production will depend on new discoveries being made, the development of the discoveries, and the implementation of improved recovery projects at existing fields. Figure 4.2 shows the total historical production and the production forecasts until 2030, distributed by maturity of the resources.

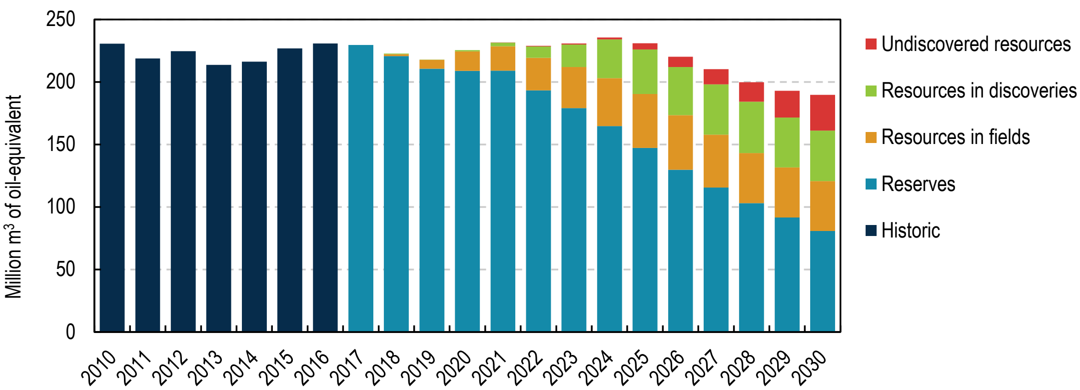
Figure 4.1 Oil and gas production, 1972-2021



Note: Projected for 2016-21.

Source: MPE/NVD (2017), *The Shelf in 2016*, www.norskpetroleum.no.

Figure 4.2 Oil and gas production by resource category, 2010-30



Note: Projected for 2017-30.

Source: MPE/NVD (2017), *The Shelf in 2016*, www.norskpetroleum.no.

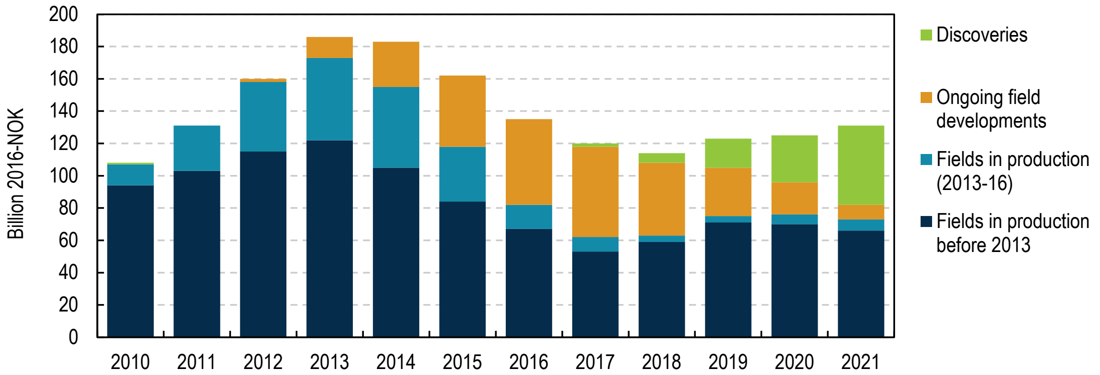
Investments

Investments in oil and gas production peaked at NOK 185 billion (Norwegian kroner) in 2013 (around USD 31 billion) and, mainly following the steep decline in crude oil prices from 2014, declined by 27% to NOK 135 billion in 2016. The NPD expects investments to fall further to around NOK 120 billion in 2017 and by another 5% from 2017 to 2018. From 2018 on, investments are expected to rise moderately to 2021, the end of NPD's forecast period (MPE/NPD, 2017). Figure 4.3 shows a pattern of cyclicality quite typical to petroleum and other natural resources sectors.

The decrease in investments is not just because of lower activity; it is also a consequence of reduced costs, as companies have found efficiency measures and lower prices for equipment and services. For example, in a comparison of the construction costs of seven field development projects in the NCS, in 2014 the operators estimated investments for these projects to total around NOK 220 billion, but in the autumn of 2016 the estimates had declined to NOK 110 billion, or by 50%, without any changes in the development concepts. The seven projects are expected to break even at less than USD 40 (US dollars) per barrel, and some even at less than USD 30 per barrel.

In the next few years, the lower level of investments is also linked to the completion of several fields that have recently come or will soon come on stream.

Figure 4.3 Historical and foreseen investment in oil and gas production, 2010-21



Note: Excludes investment in exploration.

Source: MPE/NVD (2017), *The Shelf in 2016*, www.norskpetroleum.no.

Exploration

After several years of high exploration activity, 36 exploration wells were drilled in 2016 (28 wildcat wells and eight appraisal wells), 20 less than in 2015. The decline in exploration in 2016 is mainly because of a lower oil price and a need to cut costs. However, exploration activity in 2016 was still somewhat higher than the annual average of 34 wells per year since 1970.

The 2016 exploration efforts brought 18 discoveries, one more than in 2015. The North Sea saw 14 discoveries, and two discoveries were made in both the Norwegian Sea and the Barents Sea. The discoveries are estimated to contain recoverable resources of 113 million barrels to 277 million barrels of oil and of 12 to 33 bcm of gas. The discoveries are mostly close to fields in production and can come on stream fairly quickly. Around 30 wells are expected to be drilled in 2017, which is still relatively many in a historical perspective.

Production licensing

The 1996 Petroleum Act provides the general legal basis for the licensing system that regulates oil and gas activities in Norway. The act and related secondary regulations authorise the awarding of licences to explore for, produce, and transport oil and gas.

The Petroleum Act establishes that the Norwegian state has proprietary rights to subsea oil and gas deposits on the NCS. Before permission for exploration drilling and production (a production licence) may be granted, the area in question must have been opened up for oil and gas activities by the parliament. An impact assessment of the environmental, economic, and social impacts of oil and gas activities on other industries and in adjacent regions is conducted prior to the parliament's decision. As part of this process, local authorities and relevant stakeholder organisations are also consulted.

Production licences are normally awarded through licensing rounds according to announced and non-discriminating criteria. The government invites applications for a certain number of blocks or in a pre-defined area, and companies may apply individually or in groups. The MPE generally awards licences to groups of companies to maximise the expertise and experience in operations. The ministry appoints an operator for the joint venture to manage the daily operations in the licence. The number of companies that operate on the NCS has increased from 23 in 1997 to 54 at the end of 2015, 34 of which held operatorships in one or more production licences. At the end of 2015, Statoil held the most licences (259) and operatorships (182) and was by far the largest producer in the NCS.

Many fields on the NCS contain both gas and oil. When the MPE awards production permits, it considers the prospects for the optimal recovery of the oil and gas resources. On occasion, the ministry has awarded production permits to produce less gas than applied for by the companies, out of consideration for the need to produce oil.

Since the early days of the Norwegian oil and gas industry, the authorities have successfully attracted a large range of international companies that have made a strong contribution to the development of the resource base on the NCS. Simultaneously, one of the main goals throughout the 1970s and 1980s was to encourage the development of the Norwegian oil and gas competence. As the NCS is gradually maturing, the industry structure is changing to reflect this situation. Today, the Norwegian-based service industry is a large and innovative Norwegian export industry. An increasing number of smaller Norwegian and international companies have entered the NCS, with an interest in the more-specialised projects to develop more marginal resources or fields in the tail production phase.

Mature areas

Two systems award licences on the NCS. Licences in mature areas of the NCS are awarded every year under the Awards in Predefined Areas (APA) system. Acreage is announced in the first quarter and production licences are awarded in January the following year. In 2016, 33 companies submitted applications, and the ministry decided in January 2017 to send ownership offers to 29 of them. The APA system ensures that mature areas close to the existing and planned infrastructure are available for the industry. The companies allowed to explore in these areas must have relevant experience, technical and geological expertise, and a solid financial base. The APAs expand as new areas mature.

Frontier areas

Licences in frontier areas, in turn, are awarded in numbered concession rounds normally held every two years. Frontier areas are characterised by less knowledge of the geology and a lack of infrastructure. The companies allowed to explore in these areas must have relevant experience, technical and geological expertise, and a solid financial base. The 24th licensing round is expected to be announced before mid-2017 and awarded by mid-2018.

The areas currently considered to be frontier areas on the Norwegian continental shelf include major portions of the Barents Sea and the Norwegian Sea. In the Norwegian Sea, this applies particularly to deep-water regions and the northern-most areas. The coastal areas in the southern part of the NCS are also relatively immature.

Unopened areas

The Norwegian Parliament has opened up for oil and gas activities the greater part of the North Sea, the Norwegian Sea, and the southern Barents Sea. Large parts of the NCS remain to be opened up, including all of the northern Barents Sea.

In general, the gradual expansion of oil and gas activities towards the vast frontier areas in the northern parts of the NCS requires a balance of the interests of fishing, tourism, oil and gas production, and shipping, while protecting the environment. As a policy tool to this effect, the government uses specific integrated management plans for the marine environment.

The plan for the Norwegian Sea dates from 2009 and that for the North Sea and Skagerrak from 2013. In 2011, the previous government revised the 2006 plan, Integrated Management for the Marine Environment of the Barents Sea and the Sea Areas off the Lofoten Islands. As part of this revision, the previous government left the disputed Lofoten-Vesterålen-Senja region unavailable for oil and gas activities, as did the current government in its 2013 programme. The oil and gas industry has continued to push for opening the Lofoten-Vesterålen-Senja region for exploration as, according to official estimates, the region holds some 1.3 billion barrels of oil-equivalent. In contrast, some of the closest local communities are against opening the region (as at the end of 2016). Most environmental organisations are also against opening the area for oil and gas activities, and the fishing and tourism industries have raised concerns about a potential opening. The region includes the spawning grounds of the world's largest cod stock and unique cold water reefs, and employment from tourism is increasing as the region attracts more and more visitors.

In September 2010, Norway and Russia signed a treaty concerning the maritime delimitation and co-operation in the Barents Sea and the Arctic Ocean. The treaty brought to an end a negotiation process of 40 years and, among other activities, it also enables oil and gas exploration in an offshore area the covers 175 000 square kilometres. The Arctic is believed to hold vast untapped oil and gas reserves. Any oil and gas fields that straddle the border would have to be unitised and developed jointly.

State oil and gas revenue

The state receives a large share of the value created from oil and gas activities through:

- taxation of oil and gas activities
- direct ownership in fields and infrastructure through the state's Direct Financial Interest (SDFI)
- charges and fees
- dividends from ownership in Statoil.

Taxation of oil and gas activities is based on the rules that govern ordinary business taxation. As the extraction of oil and gas generates considerable excess return (resource rent), a special tax (54% for 2017) is levied on this income, in addition to the ordinary company tax (24% for 2017). The combined tax rate has been 78% for many years, whereas the company and special tax rates have varied.

The state direct ownership is organised into the SDFI and is managed by the state-owned trust company, Petoro AS (Petoro). The state holds, through the SDFI arrangement, around one-third of the reserves on the NCS. At the beginning of 2016, the state had direct financial interests in 180 production licences. In 2015, Petoro's share of petroleum production in the NCS was 28%, according to the NPD.

The MPE decides on any share to be held by the state when production licences are awarded. This share is typically 20% in new licences when it is decided that SDFI will hold shares. The state's (Petoro's) share does not carry any privileges, as the state pays its share of investments and costs, and receives a corresponding share of the income from the production licence.

The Norwegian state also owns 67% of the shares of Statoil ASA, the largest producer of oil and gas on the NCS.

Important auxiliary taxes linked to the oil and gas activities are the carbon dioxide (CO_2) tax, the nitrogen oxides (NO_x) tax, and the area fee. The CO_2 tax was introduced in 1991 and is an instrument to reduce CO_2 emissions from the oil and gas sector. It is levied at a rate per standard cubic metre (scm) of gas burned or directly released and per litre of oil burned. To fulfil its international obligations to reduce NO_x emissions, a NO_x tax was introduced from 1 January 2007. The area fee, in turn, is used to encourage both an efficient exploration of the awarded acreage, so that the potential resources are produced as quickly as possible within a prudent financial framework, and extensions to the lifetime of existing fields.

The net cash flow from the oil and gas activities to the state was NOK 124.5 billion for 2016 (Ministry of Finance, National Budget 2017), which is around 13% of all government revenue. In 2016, company taxes amounted to NOK 51.3 billion. Income from the SDFI amounted to NOK 55.8 billion and the dividend from Statoil to NOK 10.8 billion. Environmental taxes and area fees brought in NOK 6.6 billion. The significant decline in crude oil prices reduced the net government cash flow from oil and gas activities from NOK 312 billion in 2014, or by almost 60%. The government expects the cash flow to increase in 2017 to around NOK 138 billion.

Since 1990, the state's revenues from oil and gas activities have been held in a separate fund, the Government Pension Fund Global (called the Norwegian Oil Fund prior to 2006). The Fund may only invest abroad to limit the disruptive effects of large (and fluctuating) oil and gas revenue on the Norwegian economy. For the same reason, the government may only use on average 4% per year of the Fund, which equals the Fund's expected real return.[1]

At the beginning of 2017, the Fund had an estimated NOK 7.4 trillion (around USD 900 billion) in diversified assets (stocks, bonds, and real estate) in around 80 countries. The Fund has more than tripled in size since early 2009, and it has become

[1] In February 2017, the Ministry of Finance proposed to reduce the average spending to 3% per year.

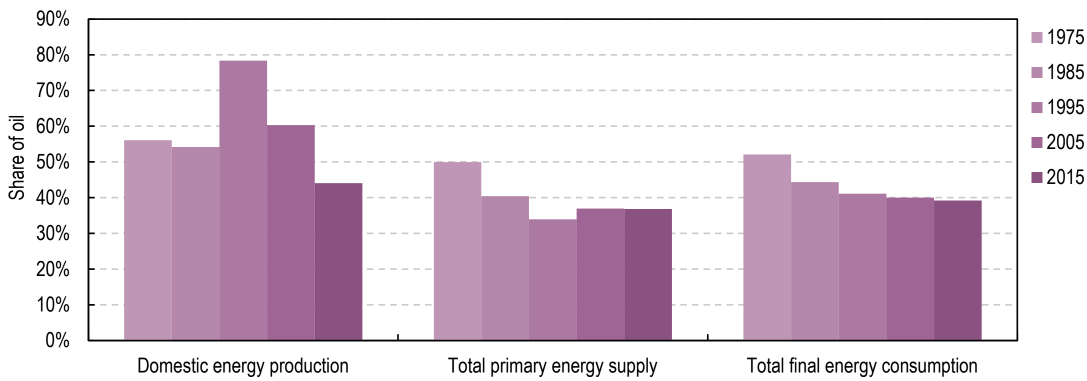
the largest sovereign wealth fund in the world. The Fund's total assets equal around 240% of the country's GDP. According to Norges Bank (the Norwegian Central Bank), the Fund's annual return from 1998 to 2015 averaged 3.7% after fees and inflation. At that rate, the Fund is delivering more than the net cash flow from the actual oil and gas activities. The Ministry of Finance is responsible for managing the Fund, while Norges Bank is responsible for its operational administration.

Oil

Overview

Norway is a major oil producer. Total liquids production peaked at 3.4 mb/d in 2001. After a decade of decline, production has now stabilised at around 2 mb/d. Oil production is expected to remain at current levels for the coming years and oil remains an important export fuel.

Figure 4.4 Share of oil in energy production, TPES, and TFC, 1975-2015



Note: TFC = total final consumption; TPES = total primary energy supply.

Source: IEA (2017a), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Around one-fifth of the produced crude oil is consumed in the two domestic refineries and the rest is exported, mainly to large consuming countries in neighbouring North Western Europe. Decreased production levels have led to declining exports. Natural gas production is larger than oil production, as it has been since 2012.

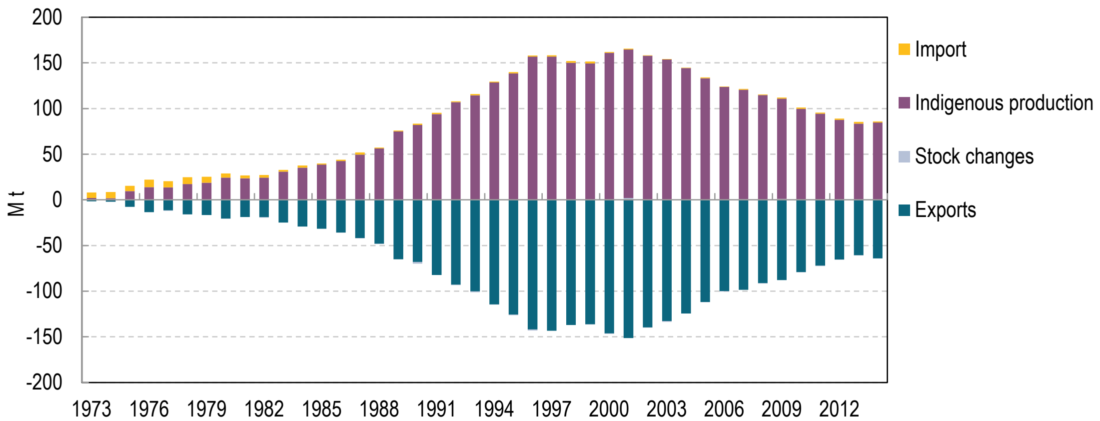
Unusually, oil is only the second largest energy source in the TPES after hydropower. Transport and industry are the largest consuming sectors of oil products in Norway, and diesel is the most-consumed fuel.

Supply and demand

Production and exports

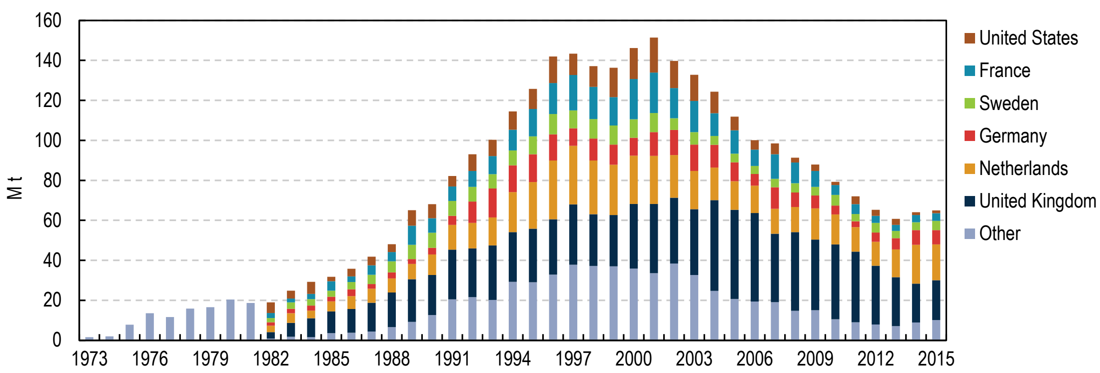
Norway's crude oil production (including natural gas liquids and feedstocks) was 88 Mt in 2015, significantly lower than the peak in 2001 (Figure 4.5). After 12 years of consecutive decline, production has recovered slightly in the past three years. Although production in the existing fields is declining, new fields will add to production towards the end of this decade. In particular, Phase 1 of the Johan Sverdrup mega-project is expected to be on line in 2019 and have a production capacity of 440 kilobarrels per day (kb/d). A second phase could bring production up to 660 kb/d, at some 40% of the total oil production from the NCS.

Figure 4.5 Crude oil supply by source and inland consumption, 1973-2015



Source: IEA (2016a), *Oil Information 2016* (database), www.iea.org/statistics/.

Figure 4.6 Crude oil net exports from Norway by importing country, 1990-2015



Source: IEA (2016a), *Oil Information 2016* (database), www.iea.org/statistics/.

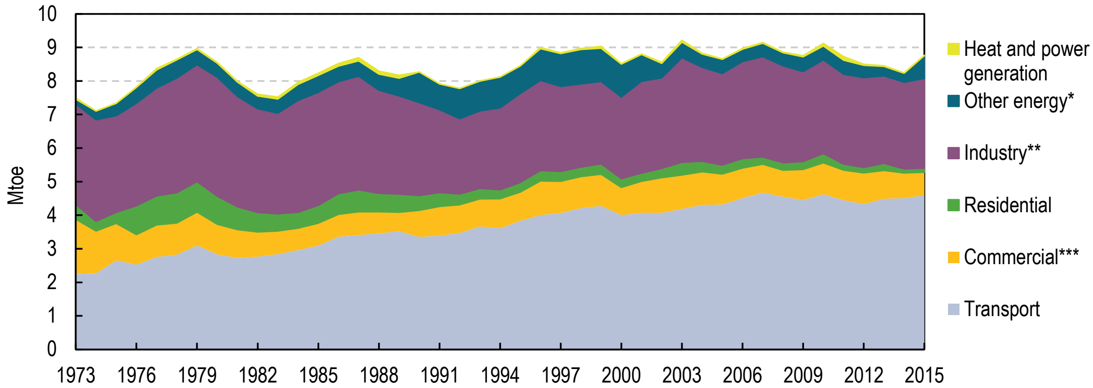
Norway is the third-largest oil producer among the IEA member countries, after the United States and Canada, and the second-largest oil exporter after Canada. Net exports accounted for 81% of the total oil production in 2015, with the rest consumed domestically. Inland consumption has been rather stable, so the falling production has resulted in a corresponding decline in exports.

The United Kingdom is the largest importer of oil from Norway, at 31% of the total exports (Figure 4.6). The second-largest importer is the Netherlands (28% of the total), followed by Germany (11%) and Sweden (7%).

Demand

Oil consumption has been stable at around 8-9 million tonnes oil-equivalent (Mtoe) per year in the recent decades, with a slight decline since 2010.[2] Total consumption, including the energy transformation sector, was 8.2 Mtoe in 2014, a decline by 7% since 2004.

Figure 4.7 Oil consumption by sector, 1973-2015



* Other energy includes coke ovens, other refining and energy own use.

** Industry includes non-energy use.

*** Commercial includes commercial and public services, agriculture, forestry, and fishing.

Note: TFC by consuming sector including energy transformation, for crude oil (plus refinery feedstock, natural gas liquids, additives and other hydrocarbons) and oil products.

Source: IEA (2017a), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

The transport sector is the largest oil consumer, at over half of the total consumption (Figure 4.7). Road transport consumes the most oil in the sector, but aviation and navigation are also relatively large consumers (Figure 4.8). Industry is the second-largest oil-consuming sector, at almost one-third of the total consumption, of which the majority is for non-energy use. Chemicals industry using oil mostly as a process input accounts for almost half of total industrial consumption.

The commercial sector, which includes a large fishing industry, accounted for 8% of the total oil consumption in 2015. Residential oil consumption has gradually reduced from 10% of the total consumption in the late 1970s to just over 1% in 2015. The energy industry's own use, mostly in refineries, more than doubled in 2015 from the year before and accounts for a 8% of the total consumption.

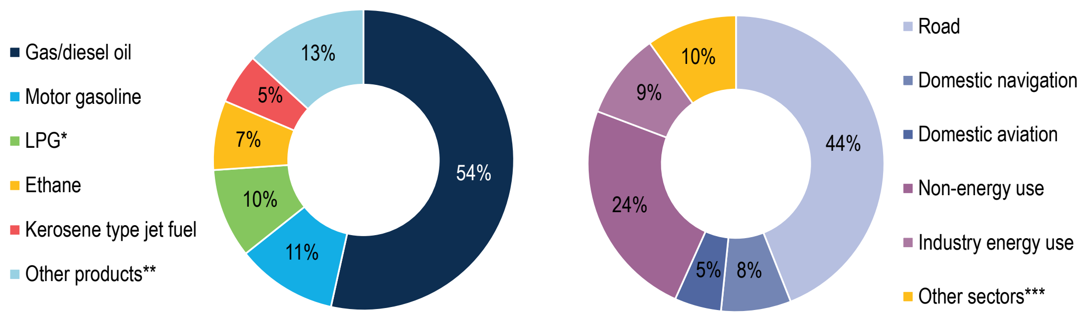
Around half of oil the consumption in Norway is from diesel products, mostly used in transport (Figure 4.8). Other important oil products are kerosene type jet fuel, used in the aviation sector, gasoline, primarily used in road transport, and liquefied petroleum gas (LPG) and ethane, mainly used in industry.

In the transport sector, gasoline sales have nearly halved in the past ten years from 2 138 000 cubic metres (m^3) in 2005 to 1 182 000 m^3 in 2015. At the same time auto diesel sales increased from 1 778 000 m^3 in 2005 to 2 988 000 m^3 in 2015.

[2] The available data on oil consumption in Norway are uncertain. The statistical difference, measured as the difference between supply data in TPES and consumption data in TFC, has been very large for Norway in recent years (up to 39% of TPES).

Heating-oil sales collapsed from 1 238 000 m^3 in 2005 to 319 000 m^3 in 2015. From the start of 2016, it has been prohibited to install new heating systems based on fossil fuels, and the government has decided to ban fuel oil for heating in new and existing buildings from 2020 on.

Figure 4.8 Oil in TFC by product (by volume) and sector, 2015



* LPG is liquefied petroleum gases.
** Other products include bitumen, petroleum coke, lubricants, fuel oil, white spirit and non-specified oil products.
*** Other sectors include residential, commercial and public services, agriculture, forestry and fishing.
Source: IEA (2016a), *Oil Information 2016* (database), www.iea.org/statistics/.

Infrastructure

Offshore transport infrastructure

Norway has established a network of subsea oil pipelines to link offshore oil fields with onshore terminals. The oil transport infrastructure on the NCS is divided into four different systems. Oil pipelines from fields in the North Sea run to the Norwegian terminals Sture, Mongstad, and Kårstø (condensate), and to Teesside in the United Kingdom. At the Norwegian terminals, oil is stored in rock caverns before most of it is loaded onto tankers for export

Statoil operates the 115 kilometre (km) Oseberg Transport System (765 kb/d) that connects the Oseberg field with the receiving Sture terminal. Statoil is also the operator of the 212 km long Grane oil pipeline (265 kb/d), which links its Grane field to the Sture terminal. Statoil also manages the twin pipeline system called Troll I and II (565 kb/d) that connects all the crude from Troll, Kvitebjørn, Fram, Gjøa, and Valemon to the Mongstad crude oil terminal.

The Norpipe oil AS pipeline is operated by ConocoPhillips Skandinavia AS. The 810 kb/d, 354 km pipeline leads from the Ekofisk Centre to the UK continental shelf to come ashore at Teesside. A tie-in point for UK fields is allocated about 50 km downstream from Ekofisk. Almost half of Norway's crude production is loaded offshore and, therefore, does not enter the pipeline network.

Ports

The main port for the country's oil industry is the Mongstad oil terminal near Bergen on the west coast. The terminal is operated by Statoil and owned by Petoro (the state) and Statoil. The terminal is linked by pipeline to the offshore production, and is also connected to the Mongstad refinery, the largest one in Norway.

The Sture terminal is also located on the west coast close to Bergen. The Sture facility comprises jetties able to berth tankers up to 300 000 deadweight tonnes, plus five artificial rock caverns for crude with a total capacity of 6.3 million barrels (mb).

The region around the capital, Oslo, in the east also has notable port activity. Norway's other refinery, Slagen, is located near Tønsberg, roughly 70 km south of Oslo. The refinery can berth tankers up to 190 000 deadweight tonnes. Also, the oil port located in Oslo is an important centre for the domestic fuel distribution. Oslo oil port and the product storage facilities at Ekeberg cover around 40% of Norway's fuel demand. The storage facilities are owned by the retail companies. Both the storage facilities and the Oslo oil port are operated by Sisterne Drift.

Refineries

Norway has two refineries; Mongstad located on the coast near Bergen with a refining capacity of about 240 kb/d, and the refinery of Slagen located near Oslo, with a smaller capacity of about 100 kb/d. Mongstad is owned by Statoil and Slagen by ExxonMobil. The two refineries purchase crude oil from and sell products to the world market, so not all the feedstock is necessarily produced on the NCS. As its two refineries produce some 300 kb/d of products in a domestic demand market of around 220 kb/d, Norway is a net exporter of refined products, which include both gas/diesel oil and gasoline.

In 2016, the refineries' combined output was 37% gas/diesel, 31% gasolines, 10% naphtha, and 8% residual fuels. The refineries produce a surplus of gas/diesel, gasolines, residual fuels, and naphtha, which is then exported mainly to the Organisation of Economic Co-operation and Development (OECD) Europe. In contrast, some volumes of jet fuel and kerosene need to be imported to satisfy demand. In 2016, Norway's net imports of jet fuel and kerosene amounted to about 8 kb/d.

Storage

Norway has 26 main storage facilities, spread over 17 localities, all owned by downstream companies (Figure 4.9). By law, companies that import or produce more than 10 000 m^3 per year must hold stocks equal to 20 days of supply. The regulation only prescribes the product type and volumes, not the location.

The main storage sites are located at the two refineries, Mongstad and Slagen, which combined can store around 15.7 mb of crude oil. In addition, retail oil companies have several types of storage facilities to hold and sell oil products. The companies also possess larger storage facilities situated on service bases for off-shore activity. These are operated by the service companies themselves. Several companies have entered into agreements on stock draw in each other's storage facilities. The agreements reduce the distribution costs. There are about 45 distribution storage facilities in Norway.

Figure 4.9 Map of oil infrastructure, 2016

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Retail industry structure

According to Norsk Petroleuminstitutt's annual statistics, at the end of 2015 the country had 1 580 filling stations. The largest station chain was Circle K (owned by the Canadian company Couche-Tard, and previously by Statoil) with 418 stations. Smart Fuel (owned by the Finnish company St1, and previously by Shell) had 373 stations, as did Uno-X. Esso came fourth, with 249 stations,[3] followed by Best with 128 stations. The four largest chains had 89% of all the filling stations. The number of filling stations has steadily declined over the past decades and is now 60% lower than in 1969, when the first annual filling station statistics were published.

Prices and taxes

High taxes on fossil fuels make oil-based fuels expensive in Norway (Figure 4.10). In the third quarter of 2016, diesel cost USD 1.41 per litre, of which 59% was taxes. Only four IEA member countries had higher diesel prices. Similarly, gasoline cost USD 1.64 per litre and light fuel oil USD 1.04 per litre, the second- and the fourth-highest, respectively, among the IEA member countries. Taxes on light fuel oil were higher in Norway than in any other IEA member country.

Security of supply

As a crude oil producer and significant net oil exporter, Norway has a particular position within the IEA based on the agreement concluded in February 1975, by which the Norwegian government has the right to decide whether and how it would participate in the IEA oil-sharing system.

As demonstrated in 1991, 2005 and 2011, as well as in specific situations when other IEA response plans have been put together but not implemented, Norway has thus far contributed to such plans with volumes of the magnitude calculated based on its inland consumption. Although the Agreement gives Norway formal and special rights compared with other IEA member countries, Norway has not made use of this special position to opt out of a collective action. Norway's preferred measure to contribute to an IEA collective action is stock draw in the form of a reduction of the industry obligation.

Emergency reserves

For emergency purposes, the 2006 Act of Petroleum Product Storing for Emergency Purposes obliges companies that produce oil products in Norway or that import them to the country to store them for 20 days of normal consumption in the Norwegian market. The companies are Circle K, Esso (see footnote 4), Smart Fuel, and Uno-X and the required volume totals around 400 000 scm. In the case of a supply deficit, the law also obliges these companies to implement stock draw upon the government's request.

The 2006 legislation covers only oil products and divides them into three categories, namely gasoline, middle distillates, and heavy fuels. At least 40% of the stored products must consist of these three categories, and up to 40% of the total stockholding commitment may consist of crude oil, condensate, or semi-finished products. The legislation mandates government control of company stocks during peacetime in the

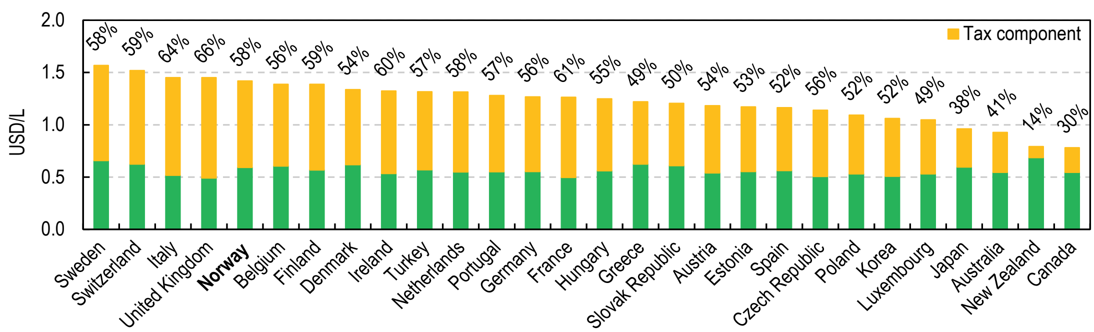
[3] In February 2017, ExxonMobil announced that they had sold their filling stations to the Irish company DCC.

event of a supply disruption. However, in wartime, the government may still take control of all crude oil stocks as well as of industry-held product stocks.

The compulsory stocks are co-mingled with commercial stocks. Several companies have entered into agreements on stock-draw in each other's storage facilities, and thus reduce the distribution costs. Although there are no restrictions on the location of stocks abroad, Norway has no bilateral stockholding arrangements with other countries and all the stocks are held at home.

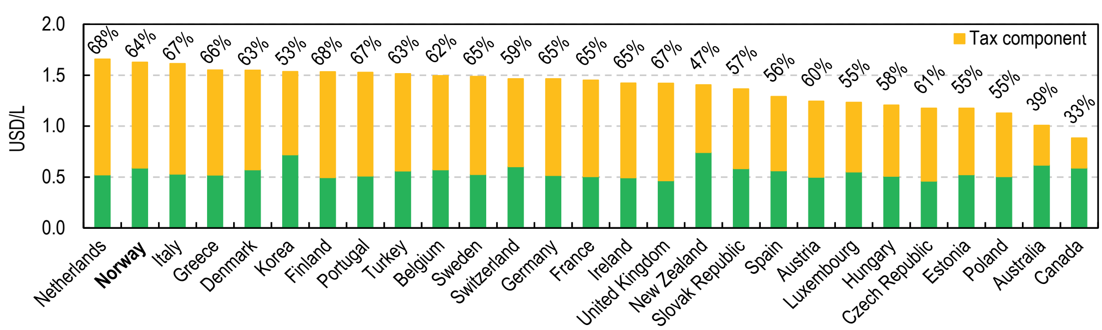
Figure 4.10 Transport fuel prices in the IEA member countries, fourth quarter 2016

Automotive diesel



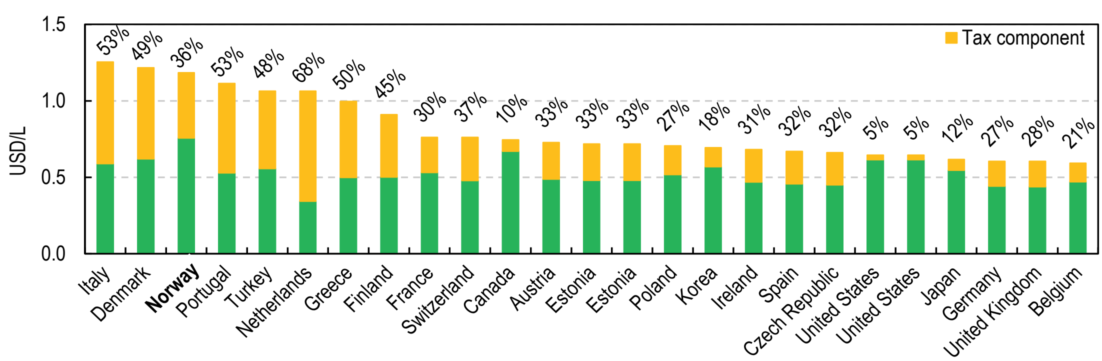
Note: USD/L, USD per litre.

Premium unleaded gasoline (95 RON)*



Note: Data are not available for Japan.

Light fuel oil



* RON = research octane number.

Note: Data are not available for Australia, New Zealand, Hungary, Sweden, and the Slovak Republic.

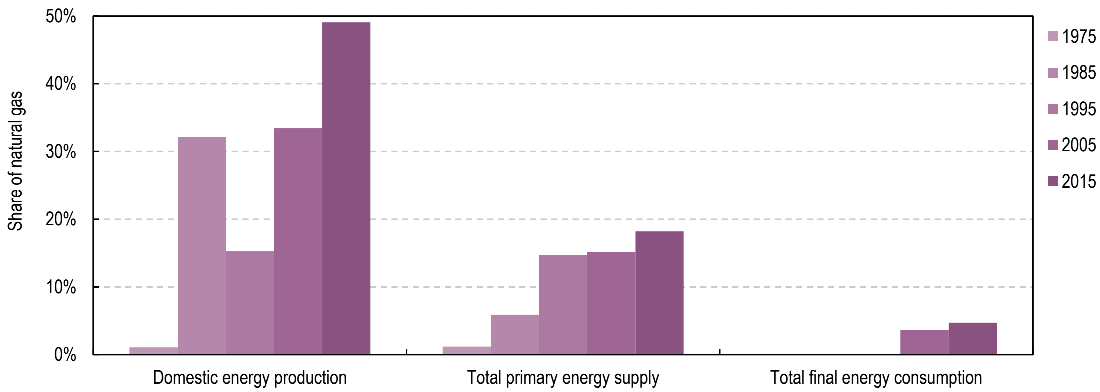
Source: IEA (2017b), *Energy Prices and Taxes, fourth quarter 2016*, www.iea.org/statistics/.

Natural gas

Norway is a major oil and gas producer and, since 2012, natural gas is the largest energy source produced in the country. In 2015, it accounted for half of the total energy produced in Norway. The vast majority, around 95%, of the gas is exported, mainly to neighbouring consuming countries in the North Sea area.

Domestic consumption is concentrated in the upstream oil and gas sector, and natural gas makes a very small share of the total final energy consumption (TFC). The industry sector is the largest consumer of natural gas in the TFC, and household consumption is negligible (Figure 4.11).

Figure 4.11 Share of natural gas in energy production, TPES, and TFC, 1975-2015



Note: 2015 values are provisional.

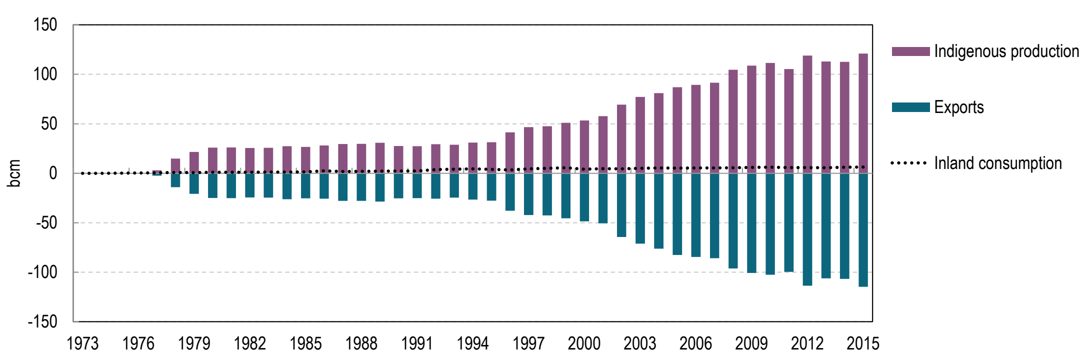
Source: IEA (2017a), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Supply and demand

Production and exports

Total gas production reached a new record in 2015 with 121 bcm, an increase by 39% since 2005 (Figure 4.12). After growing steadily from the mid-1990s, natural gas production has stabilised in recent years at a high level. All the natural gas is produced from combined oil and gas extraction.

Figure 4.12 Natural gas production, exports, and inland consumption, 1973-2015



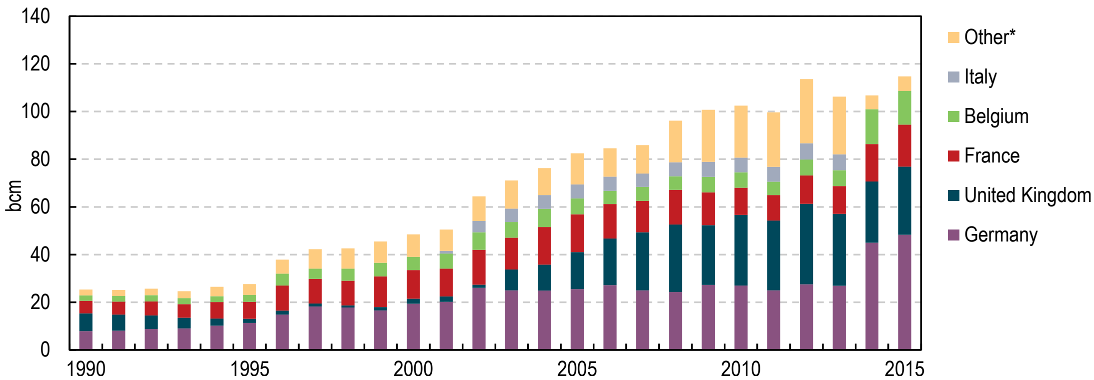
Note: 2015 values are provisional.

Source: IEA (2016b), *Natural Gas Information 2016*, www.iea.org/statistics/.

Norway is the second-largest gas producer among the IEA member countries, after the United States. Unlike in the United States, where most of the gas is used domestically, in Norway only 5% of the produced gas is consumed in the country. The large production and small domestic consumption make Norway the leading gas exporter in the IEA, and the third-largest exporter in the world after Russia and Qatar. Export levels are expected to remain high and stable over the coming two decades.

Most of the gas is exported via subsea pipelines to destinations in Western Europe (see Figure 4.13). Germany is the main importer, accounting for 42% of Norwegian gas exports in 2015, followed by the United Kingdom (25%), France (15%), and Belgium (12%). Exports from Norway cover more than 20% of the European gas demand and are a major contributor to the European gas supply security.

Figure 4.13 Natural gas exports from Norway, 1990-2015.



* Other includes Spain, Netherlands, Brazil, Argentina, Denmark, Lithuania, the United States, Sweden, Chile, China, Greece, India, Portugal, Mexico, and Turkey.

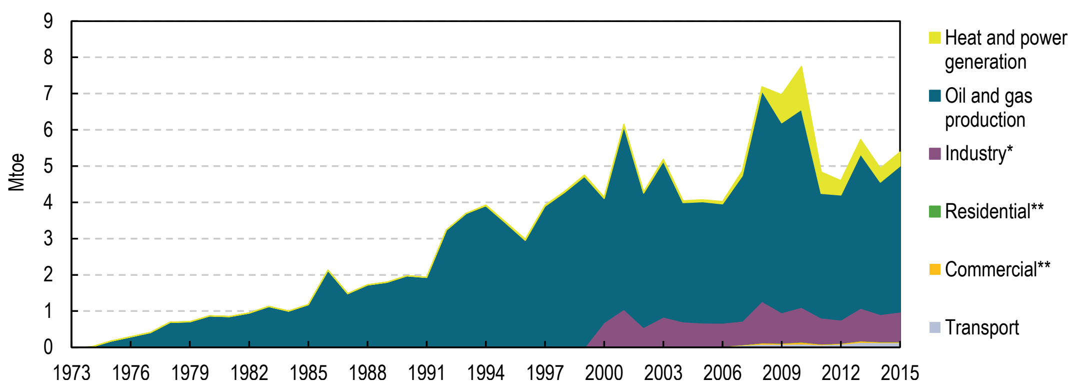
Note: 2015 values are estimates.

Source: IEA (2016b), *Natural Gas Information 2016*, www.iea.org/statistics/.

Demand

Natural gas is used directly at production sites to fuel the oil and gas extraction process. This accounts for three-quarters of the gas in Norway's TPES, with another 7% used in the power sector.

Figure 4.14 Natural gas demand by sector, 1973-2015



* Industry include non-energy use.

** Negligible.

Note: TPES by consuming sector.

Source: IEA (2017a), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

The remaining gas is consumed mainly in industry and a minor share as transport fuel. Chemicals and petrochemicals account for around 80% of gas consumption in industry. Natural gas is typically not used for space heating in Norway, and consumption in the residential and commercial sectors is negligible.

Infrastructure

Offshore transport infrastructure

The Norwegian gas transportation system consists of a network of more than 8 000 km of pipelines and has a capacity of 342 mcm per day (around 125 bcm per year). There are four receiving terminals for Norwegian gas on the continent: two in Germany, one in Belgium, and one in France. There are also two terminals in the United Kingdom (Figure 4.15).

In 2007, Norway also launched Europe's first liquefied natural gas (LNG) export terminal, Snøhvit. The terminal has an annual export capacity of 5.75 bcm of LNG and uses the resources of three gas fields in the Barents Sea – Snøhvit, Albatross, and Askeladd (240 m to 345 m deep) – that lie about 140 km northwest of Hammerfest. As exploration moves further north into the Norwegian and Barents Seas, the transport of LNG or compressed natural gas by ship may become more-viable alternatives to the traditional pipelines.

The Norwegian upstream gas transportation system includes three central instruments: the operator Gassco AS (Gassco), the joint venture that owns the system (Gassled), and the regulated conditions for access to and tariffs in the transportation system. Each one is described below.

Gassco

Gassco is the operator of the integrated gas transportation system from the NCS to other European countries. Gassco is wholly owned by the Norwegian state. It was created in 2001 as part of an extensive reorganisation of the Norwegian oil and gas sector.

Gassco's responsibilities are to, among others, plan, monitor, co-ordinate, and administer the transport of gas from the fields to the receiving terminals, as well as to allocate capacity in the transportation system. It also serves as the operator for the receiving terminals in Dunkerque (France), Zeebrugge (Belgium), Emden and Dornum (Germany), and Easington and St. Fergus (United Kingdom). As a neutral and independent operator of the gas transportation system, Gassco ensures equal treatment of all users of the system, as regards both the access utilisation of the system and the consideration of capacity increases. Gassco also has a role as an architect of the Norwegian gas transport system.

Gassled

The gas transportation system, that is pipelines and terminals, is mainly owned by the Gassled partnership (Table 4.2). This common ownership structure was established in December 2002 through a merger of the existing gas transportation system. Gassled encompasses all the rich and dry gas facilities that are currently in use or are planned to be used to any significant degree by third parties. New pipelines and transport-related facilities are intended to be included in Gassled from the time they are put to use by the third parties, and are thus part of the central upstream gas transportation system. Most Gassled facilities are licensed until 31 December 2028.

Table 4.2 Gassled ownership share by company, 2016

Company	Ownership (%)
Petoro*	45.793
Solveig Gas Norway AS	24.765
Njord Gas Infrastructure AS	8.306
Silex Gas Norway AS	6.102
Infragas Norge AS	5,006
Statoil Petroleum AS	5.000
CapeOmega	2.965
Norsea Gas AS	2.261
Dea Norge AS	0.081

* Petoro is the licensee for the SDFI.

Source: Gassco, www.gassco.no/en/about-gassco/gassled-eng/.

Regulated access to the gas transportation system

The pipeline system is a natural monopoly, regulated for non-discriminatory third-party access by a December 2002 Royal Decree. Gas transportation tariffs are governed by special regulations issued by the MPE. Gas companies' access to capacity in the system is based on their needs for gas transportation. Transport rights may be transferred between users when needs change. Gassco is responsible for allocating capacity.

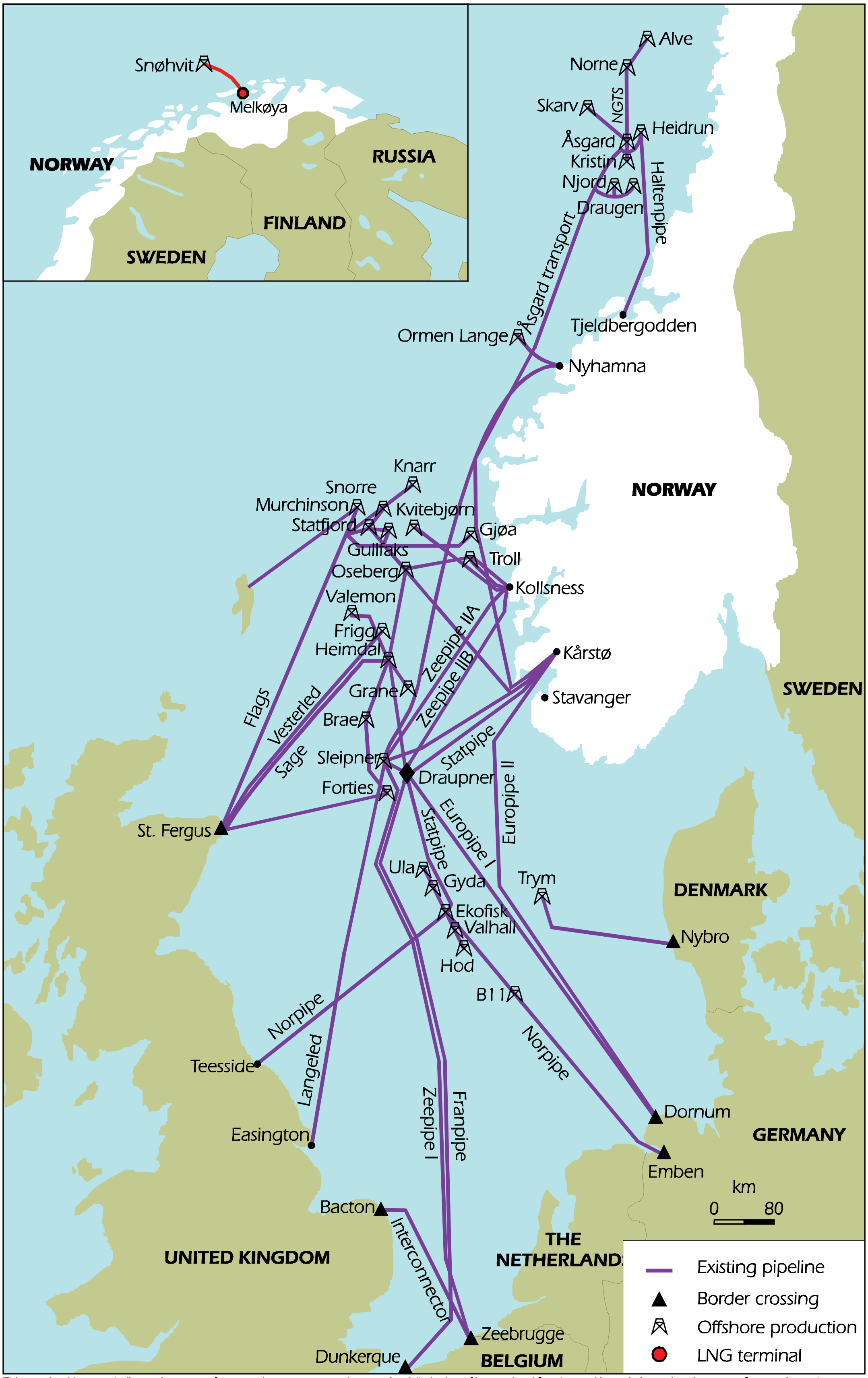
The MPE, through the regulation, plays an important part to ensure the transportation capacity and increase the system capacity when needed. The authorities verify that alternative transport methods are examined properly to ensure an efficient system development. At the same time, it is important to an ensure efficient operation, which includes achieving economies of scale.

Mainland distribution network

Norway has two main natural gas distributors; Gasnor AS (Gasnor) and Lyse Gass AS (Lyse Gass). Gasnor has around 120 km of pipelines in the southwestern part of Norway, in the Haugesund-Karmøy region. Lyse Gass has around 620 km of distribution pipelines in the Stavanger area in the southwest of the country.

Small-scale LNG distribution has become a Norwegian alternative to gas transmission and distribution networks. In 2014, around 70 small-scale LNG reception terminals were in operation. The receiving terminals serve industrial and commercial customers.

Figure 4.15 Map of natural gas infrastructure, 2016



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Security of supply

According to the government, the security of supply is not a concern in the small Norwegian downstream gas market. Natural gas customers in Norway will always be connected to the electricity grid, and thereby supplied with energy for various needs. Unlike in other IEA countries, natural gas is not a key source of power generation. In 2009, it generated a record of 4 TWh, but this was only 3% of the total generation, whereas hydropower provided 96% (see chapter 6).

Coal

Coal is a minor fuel in Norway. In 2015, its supply amounted to 0.8 Mtoe, or 2.8% of the TPES. Domestic production, however, was higher, which makes the country a net coal exporter. Norway has two coal mines, Lunckefjell and Gruve 7, both in Spitsbergen, the main island on Svalbard, some 960 km north of the Norwegian mainland. The state-owned Store Norske Spitsbergen Kulkompani AS operates the mines through its wholly owned subsidiary Store Norske Spitsbergen Grubekompani AS (SNSG). SNSG produced 1.9 Mt in 2013, 1.7 Mt in 2014, and 1.1 Mt in 2015.

As to mining in Svalbard, the government policy is to operate the company on commercial principles and with a view to a market rate of return on invested capital. The company has not received any subsidies since 2002. Coal mining is also subject to strict environmental regulations.

Given the fall in coal prices in recent years, the production in the Lunckefjell mine will be suspended from 2017 and the mine will be put into operational rest. The duration of the rest will be reviewed on a yearly basis, for a maximum period of three years. The costs related to the operational rest in 2017 will be financed by the state. The estimated yearly production in the Gruve 7 coal mine from 2017 is 150 000 tonnes.

Although Norway is a net exporter of coal, domestic demand is met mostly by imports. In 2015, coal demand amounted to 0.8 Mtoe, or 3.1% of the TFC. Coal is used in the process industries (iron and steel, chemicals, and cement), which require a year-round supply. Coal from the Spitsbergen mines is only lifted in the summer season, as pack ice blocks the sea route for a large part of the year. Norway's only coal-fired power plant, in Longyearbyen, Spitsbergen, uses around 30 000 tonnes a year.

Assessment

Norway is a major producer and exporter of oil and natural gas and, with the appropriate incentives for investments and opening of new acreage, can continue to be so for decades to come, as the proven and probable reserves are huge. Only about one-third of the probable gas resources and half of the oil resources have been produced to date.

Upstream oil

Norway is one of only three net exporters of oil (along with Canada and Denmark) among the IEA member countries. Around 80% of the crude oil is exported, primarily to other European countries.

The total recoverable oil resources are estimated to be around 46 billion barrels (end of 2016). Of these, 57% are already produced, 25% are discovered, and 18% are undiscovered resources. Of the estimated undiscovered resources, the North Sea has one-third, the Norwegian Sea one-quarter, and the Barents Sea 41%.

Oil production has declined by 40% since the peak in 2001. The decline in production stopped in 2013, and it has since grown slowly. The production outlook for the next five years remains relatively stable; however, new projects, in particular Johan Sverdrup, will add to production. The IEA expects Norway's oil production to slip from 2.0 mb/d in 2016 to a low of 1.8 mb/d in 2019, before the start-up of Johan Sverdrup lifts output to around 2.0 mb/d by 2021 (IEA, 2017c).

Downstream oil

The domestic consumption of oil was 14.7 Mt in 2014. To optimise the refinery runs about 4.3 Mt of crude oil and oil products were imported. About 45% came from other countries in Scandinavia, and the United Kingdom, Russia, and the Netherlands each contributed about 8%.

In the future, oil use in Norway is set to decline, as the government works to meet the climate goals. Oil consumption is the main source of CO_2 emissions in the country and efforts to limit its use have been adopted in all the sectors. Oil use for space heating is planned to be prohibited from 2020, in the transport sector electric vehicle use and public transport are being promoted and, in 2020, a 20% biofuels blending obligation will be introduced.

Natural gas

In 2015, Norway produced about 121 bcm of natural gas. Domestic gas use is (and will remain) small, and around 115 bcm was available for exports. Norway ranks third in gas exports globally, after Russia and Qatar. Norway expects exports to continue at a stable level over the next two decades. Most of the gas is exported via pipelines to landing destinations in the United Kingdom, Belgium, France, and Germany. Norwegian gas covers more than 20% of the European gas demand, and as such is a major contributor to European gas security.

The total recoverable gas resources are estimated to be around 6 100 bcm (end of 2016). 37% of these are already produced, whereas 38% are discovered and 24% are undiscovered resources. Of the estimated undiscovered resources, the North Sea has around 16%, the Norwegian Sea 28%, and the Barents Sea 56%.

Norway has a unique pipeline and terminal system. The system, as far as the use by third parties is required, was brought together in a partnership of the upstream operators in 2002, and is since then it has expanded as required by new discoveries. The operation of the system is in the hands of the state-owned company Gassco, which acts as a kind of TSO for the upstream system, guaranteeing open access for the operators according to their needs, and using tariffs that are cost-based and allowing for a reasonable return for the investor of the pipeline. Gassco is also an "architect" of the system. It is responsible for planning the expansion of the system, in which it takes into account potential future discoveries, but does not itself invest in these expansions; such investments are normally done by the upstream companies themselves.

Investments in the transportation capacity might be necessary to promote new gas from the Barents Sea to allow Norway to maintain its position as a major supplier of pipeline gas to Europe. The IEA encourages the government to continue to attract the necessary investments in gas pipelines.

The licensing system for oil and gas

New acreage is awarded via two systems. In the developed/mature areas of the North Sea, the Norwegian Sea and the Barents Sea, a yearly system of APA prevails. The annual APAs were established in 2003 to boost the activity level in the mature areas, which are often close to the existing or planned infrastructure. In frontier areas, a biennial system of numbered rounds is used. In the numbered licensing rounds companies can nominate blocks, which provides for a block-by-block approach to licensing.

The most recent numbered round, the 23rd oil and gas licensing round, focused on unexplored areas in the Barents Sea with a limited existing infrastructure. During this round, 13 companies were offered ten licenses, which included three production licenses in the previously disputed area in the southeastern Barents Sea that borders Russia. These licenses are in unexplored frontier areas. It is necessary to drill exploration wells in these licenses to prove the resources, so it is not yet clear when these licenses will result in oil or gas production. In August 2016, the Norwegian authorities announced the start of the 24th licensing round.

The Norwegian licensing system is discretionary and not based on auctions or sign-on fees. The awards of any production licenses are based on objective criteria. Oil companies submit applications, in which they describe their geological understanding of the area applied for, the companies' technical expertise, and their financial capacity. The government (NPD) carries out a comprehensive scientific assessment of these applications. Licenses are awarded to companies that show the best understanding of the acreage. For the same acreage, the government gives a license to at least two companies, and the government unites these companies in a joint venture for the exploration and production of the area.

If the acreage looks very promising, the government can also decide to participate directly, normally with 20%, through the SDFI. The state has participating interests in around 180 production licenses. The MPE decides if and where the state will participate when production licenses are awarded. The purpose for any such participation is to secure a higher government take from the field than the regular 78% profit tax. The state participation in licenses through SDFI is purely commercially driven and managed by a state-owned company, Petoro. It is important to ensure that Petoro has sufficient human resources for thorough evaluations of the investment plans.

The award system may, as all other activity in the Ministry, be subject to control by the Auditor General of Norway. The licensing system was last evaluated by the Auditor General in 2010 and the government's own evaluation of the APA system was presented to the parliament in a White Paper in 2011.

Added value of the oil and gas sector

The oil and gas industry creates high value for the state and the country as a whole. In 2015, the industry accounted for 37% of exports, 12% of GDP, and 13% of state revenues. All these figures were much higher just a few years previously, when oil and gas prices were higher. The state has accumulated a government pension fund of USD 900 billion, to secure an income stream for future generations.

To continue this value creation for the Norwegian state and the country as a whole, continuous investments are needed, as oil and gas fields decline, once production has peaked. These investments can be expected to come forward if the investment climate remains competitive internationally, as Norway competes with other oil and gas basins around the globe. The attractiveness for large players is partly dependent on opening new frontier acreage, as can be seen in the recent developments in Brazil and Mexico, for example. To maintain Norway's oil and gas production at current levels beyond 2025, new profitable resources must be discovered.

The Norwegian upstream sector is among the most-efficient and least-emitting globally, and therefore has a good starting point to remain competitive under global climate agreements that aim to limit the rise in global temperatures to 2 degrees centigrade (°C) or even well below 2°C.

Security of supply

Norway is a net exporter of both oil and gas and can therefore, under most plausible scenarios, more than meet its domestic needs for these two fuels for decades to come. The capacity at the country's oil refineries exceeds the domestic consumption by a wide margin. Gas, in turn, is little used outside of the oil and gas sector, and will probably remain so. Therefore, energy security has a very different context in Norway compared with most other IEA member countries. As a net exporter of oil, Norway does not have any IEA stockholding obligation that equals 90 days net imports of the previous year. However, the 2006 Act of Petroleum Product Storing for Emergency Purposes obliges companies that produce or import oil products to hold stocks equivalent in volume to 20 days of their sales or imports into the domestic market. This additional resilience in the oil sector reduces the risk of any oil supply disruptions to the domestic market.

Recommendations

The government of Norway should:

- Pursue its policies to maintain oil and gas production, as the oil and gas sectors are important economic sectors with a high added value for the country, produce with relatively low emissions by international comparison, and are important for the security of supply for Europe.
- Ensure sufficient human resources to prepare the decisions related to Petoro's participation in licenses with SDFI participation.
- Ensure that areas opened up remain available for oil and gas activities, and open new acreage for exploration and future production.

References

IEA (International Energy Agency) (2017a), *World Energy Balances - 2017 Preliminary Edition (OECD Countries)*, OECD/IEA, Paris. www.iea.org/statistics/.

IEA (2017b), *Energy Prices and Taxes, fourth quarter 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2017c), *Market Report Series: Oil 2017,* OECD/IEA, Paris.

IEA (2016a), *Oil Information 2016* (database), OECD/IEA, Paris, www.iea.org/statistics/.

IEA (2016b), *Natural Gas Information 2016*, OECD/IEA, Paris, www.iea.org/statistics/.

MPE/NPD (Ministry of Petroleum and Energy/Norwegian Petroleum Directorate) (2017), *The Shelf in 2016*, Norwegian Petroleum Directorate, Oslo, www.norskpetroleum.no.

Further reading

Ministry of Finance (2017), *The National Budget 2017*, Oslo, www.statsbudsjettet.no/upload/Statsbudsjett_2017/dokumenter/pdf/summary_nb2017_engelsk.pdf.

5. Carbon capture and storage

Key data
(2016)

Number of commercial scale CCS projects in operation: 2

Total amount of CO_2 stored: 21 Mt

Overview

Norway has been one of the pioneers of carbon capture and storage (CCS) technology, with forward-looking CCS policies across a broad range of measures, which include research, development, and demonstration (RD&D), full-scale CCS development, and international co-operation to promote CCS. Two large-scale CCS projects are in operation in the country – Sleipner and Snøhvit. Sleipner marked an important milestone in 2016, with 20 years of safe carbon dioxide (CO_2) storage operations. In total, 21 million tonnes (Mt) of CO_2 have been injected offshore across these projects in two distinct storage sites. The main driver for the development of these two projects was the introduction of a CO_2 tax in 1991, which has now reached 60 US dollars per tonne (USD/t).

Political support for CCS in Norway has been relatively stable across all the main political parties for over 20 years. To address climate change and a related "moral imperative" have been key components in Norwegian CCS policy from the early days. The government has adopted a CCS strategy, and as part of the 2017 budget, it is to provide significant public funding to potentially full-scale CO_2 capture plants on three industrial sites and associated offshore CO_2 transport and storage. The intent is that at least one project will be operational by 2022.

Over the years, Norway has also developed CCS research and development (R&D) excellence through the internationally recognised CO_2 Technology Centre Mongstad (TCM) to test capture technologies at scale and to lead CCS-related research organisations/initiatives with a global outreach. Norway's global engagement goes beyond CCS R&D, as Norway also very proactively promotes CCS in other countries through its participation in many international CCS-related fora. To expand its knowledge and share information, the country supports other CCS activities in Europe (in partnership with the European Union) and in other strategic regions, such as South Africa, Mexico, the People's Republic of China (hereafter, "China"), and Indonesia.

Policy framework

The CCS policy benefits from a broad political consensus on its importance. CCS is also one of the government's five prioritised areas for enhanced national climate action and thus an important tool to reach Norway's 2030 and 2050 climate goals (chapter 2).

Norway has been actively involved in climate policy since the late 1980s. In 1991, a tax on CO_2 emissions became effective for petroleum activities on the Norwegian continental shelf (NCS), one of the main contributors to the country's CO_2 emissions given that Norway's onshore power generation is almost completely hydro based. The CO_2 tax applies to industry sectors, the transportation sector, and the offshore oil and gas production sector, and varies across these sectors.

The CO_2 tax is considered as the main driver for the first commercial-scale CCS activity in Norway. It triggered Statoil to separate CO_2 offshore and inject it underground as part of the Sleipner CCS project. The tax is currently around USD 60/t of CO_2 for oil and gas production. Since 2005, successive governments have stated that all new onshore gas-fired power in Norway must have CCS technology.

Regulatory framework

With the Sleipner CCS experience, since 1996 Norway has taken action independently to address the regulatory challenges of CCS. Norway did not have dedicated CCS legislation to provide permits for the Sleipner and Snøhvit projects. These successful experiences in CCS demonstrate that the permitting process substantially depends on the close co-operation between project developers and national competent authorities. The regulations were based on the Petroleum Act.

In 2009, the regulatory authority for CCS was delineated among three ministries. The Ministry of Petroleum and Energy (MPE) regulates the exploration, development, and use of subsea reservoirs for the permanent storage and transportation of CO_2 on the NCS. The Ministry of Climate and Environment regulates issues that relate to pollution and protection of the environment, which includes the permitting and monitoring of CO_2 in subsea reservoirs, whereas the Ministry of Labour and Government Administration regulates issues related to health, safety, and the work environment.

The EU CO_2 storage directive (Directive 2009/31/EC) was adopted in 2009. It regulates both the exploration of storage sites and the storage of CO_2 in the EU Europe. As the directive is considered relevant to the European Economic Area (EEA), it had to be transposed into national law in Norway. This was done in 2014 through new regulations on the storage and transport of CO_2 on the NCS, as well as new chapters to the pollution regulations and to the petroleum regulations.

Gassnova SF (Gassnova) – one-stop shop for CCS

Gassnova was set up in 2008 by the government to ensure that CCS technology can be implemented to play an effective role in climate mitigation in Norway. This dedicated CCS enterprise is involved in technology development, including the CLIMIT R&D programme and the CO_2 TCM.

Through the CLIMIT research programme, Gassnova grants financial support for the development, demonstration, and piloting of CCS technologies. Although the Research

Council (RCN) of Norway is responsible for the research aspects of the programme, Gassnova heads the CLIMIT secretariat.

Gassnova also manages the state's interest in the CO_2 TCM. Its role on TCM is to facilitate the sharing and dissemination of the results to reduce the costs and risks of CO_2 capture.

One of Gassnova's important roles is to provide strategic advice to the MPE on technical CCS issues, which include the full-scale CCS project. Gassnova has played a pivotal role in co-ordinating the full-scale CCS feasibility studies at industrial sites towards building at least one full-scale CCS project in Norway.

International collaboration

Norway makes a considerable effort to develop and promote CCS internationally. It recognises that the exchange of experience and knowledge are integral to regional and international co-operation on CCS. Norway participates in a range of international initiatives and organisations engaged in CCS technology and policy development, such as the International Energy Agency (IEA), Carbon Sequestration Leadership Forum (CSLF), the IEA GHG R&D Programme, Zero Emissions Platform, the North Sea Basin Taskforce (NSBT), and the Four Kingdoms Initiative, to foster international capacity building in CCS.

Norway has, for instance, an excellent international track record with the CSLF-recognised projects in total. First, starting from 2003, Norway led, with the European Commission (EC), a three-year CO_2 storage assessment programme of potential sites in Denmark, Germany, Norway, and the United Kingdom. Building on the experience with the Sleipner project, this programme led to the development of key scientific methodologies for the assessment, planning, and long-term monitoring of both onshore and offshore underground CO_2 storage.

Second, the CO_2 Technology Centre Mongstad Project (formerly European CO_2 Technology Centre Mongstad Project) became a CSLF-recognised project in October 2009. This facility is designed to evaluate equipment, materials, process configurations, different CO_2 capture solvents, and different operating conditions. This facility has already delivered key engineering, construction, and health, safety, and environmental knowledge to reduce the cost and the technical, environmental, and financial risks related to large-scale CO_2 capture, and its operations are still ongoing.

Third, launched in 2010, is the CO_2 Field Lab Project located in Svelvik Ridge, which involves Norway (as the lead country), France, and the United Kingdom. This R&D project consists of injecting small amounts of CO_2 underground to investigate monitoring technologies for CO_2 leakage detection in a well-controlled and well-characterised permeable geological formation to assure and increase CO_2 storage safety.

Fourth, listed in October 2014, is the Norcem AS (Norcem) CO_2 capture project. Supported by Germany, this test facility, located in southern Norway at a commercial cement production facility, is testing four different post-combustion CO_2 capture technologies at scales that range from very small to small pilots, with a focus on CO_2

capture rates, energy consumption, the impact of flue gas impurities, space requirements, and projected CO_2 capture costs.

Norway not only demonstrates leadership in such international fora, but is also committed to funding the deployment of CCS in other countries. For instance, through its Norway Grants, Norway has partnered with the EEA Grants from Iceland and Liechtenstein to strengthen bilateral relations with 16 EU countries in Central and Southern Europe and the Baltics; this includes promoting the use of CCS as one of the technologies available for to reduce emissions and tackle climate change. Part of Norway's funding to CCS (around EUR 5 million [Euros]) was committed in 2013 to support CCS programmes in the Czech Republic. These include CO_2 storage assessment in preparation for a CCS pilot project, research on CO_2 capture technologies, study of CCS pilot technologies for coal-fired power plants in the Czech Republic, and the CCS Sharing Knowledge and Experience programme.

More broadly, the government also invests to enable large-scale CCS deployment. Norway has committed to spend up to NOK 125 million to realise a full-scale CCS project in Europe in addition to the full-scale CCS development in Norway.

Norway has also worked together with neighbouring countries, especially the United Kingdom, the Netherlands, and Germany, as part of the North Sea Basin Taskforce to develop common principles to manage and regulate the transport, injection, and permanent storage of CO_2 in the North Sea subsea bed.

Also, Norway builds capacity and develops CCS in developing countries and emerging economies. The government has prioritised four geographic regions for CCS co-operation: China, Indonesia, the Persian Gulf, and Southern Africa. Norway participates in the EC's CCS co-operation with China, with pre-feasibility studies for three CCS projects in China recently being completed. In Indonesia, Norway's Embassy in Jakarta has recently provided financial support towards the development of a pilot CCS project in East Java (the CCS Gundih project) and financially contributed directly towards the CO_2 Storage Mapping Program, one of the Coordinating Committees for Geoscience Programmes in East/Southeast Asia. Norway has supported the South African CCS centre for many years and the next step is a CO_2 test injection currently considered in conjunction with World Bank. Norway is one of the key contributors (NOK 113.5 million [Norwegian kroner]) to the World Bank's CCS fund, which was prioritised to develop CCS in South Africa and Mexico.

In addition to investing in CCS large-scale deployment, Norway also leads international co-operation in CCS through its research organisations and programmes. Norway formally participates in the EU Horizon 2020 programme through the RCN, but Norwegian collaboration in CCS R&D spans beyond Europe. In 2004, a Memorandum of Understanding on Collaboration in the Field of Energy Research, Development, and Demonstration (RD&D) was signed between Norway and the United States. This bilateral collaboration has led to numerous research programmes across various fields of carbon capture, utilisation, and storage.

Ongoing projects

The Sleipner and Snøhvit projects are the only large-scale CCS projects in operation in Europe. So far, they have stored safely around 21 Mt CO_2 without any leakage observed.

Sleipner

Sleipner is one of the first large-scale CCS projects with a dedicated CO_2 storage project and associated CO_2 monitoring and verification programme. In 2016, the project marked 20 years of successful operations to store safely and permanently more than 16 Mt of CO_2 offshore Norway. This pioneering project was initiated in 1991 mainly because of the introduction of the CO_2 tax.

Sleipner is an industrial project in which CCS was implemented as part of a gas field development. Statoil is the operator and its partners are ExxonMobil and Total. The Sleipner West reservoir contains 9% CO_2, which is separated from the natural gas and captured (the first time that this process was implemented offshore), rather than vented into the atmosphere, using a conventional monoethanolamine process. The captured CO_2 is injected underground at a rate of around 1 Mt per year (Mt/yr), into a porous and permeable sandstone – the Utsira sandstone formation filled with water, some 800-1 100 metres (m) beneath the seabed and capped under a thick layer of sealing rock.

Comprehensive monitoring was established in conjunction with a network of Norwegian and international research institutions and partly funded by the EC and the RCN. Gravity field measurements and seismic surveys demonstrated the CO_2 storage security of the project and show that CO_2 injected underground has behaved in line with the model predictions. Many of the Sleipner technical papers on CO_2 modelling and monitoring are benchmark references and have helped to build confidence worldwide in CO_2 storage safety.

Lessons from Sleipner have also helped to guide and shape CCS regulations (for example, the 2009 EU directive on the geological storage of CO_2) and build CCS globally.

Snøhvit

The Snøhvit CCS project started in April 2008 at Melkøya, near Hammerfest in northern Norway, where a liquefied natural gas (LNG) plant was built to export, from 2007, the gas by ship to Europe and the United States. The Snøhvit gas contains 5-6% CO_2, which is removed before the gas is liquefied. The captured CO_2 is transported by a dedicated pipeline from the onshore LNG facility back to the offshore Snøhvit field in the Barents Sea, where it is injected underground at a rate of 0.7 Mt/yr. The CO_2 injection began in 2008, first into a depleted gas field in the Tubåen formation located 2 600 m below the seabed, but was then was halted when pressure built up faster than predicted.

The injection was diverted from 2011 into a shallower formation (around 2 000 m deeper) called the Sto Formation, where it is stored at a stable rate of around 1 800 tonnes per day. By 2016, up to 4 Mt CO_2 was stored from the Snøhvit CCS project. A second injection well is currently being evaluated to be drilled into this formation. A dedicated monitoring programme, which is partly financed by the European Union, has been established to examine how CO_2 behaves in the reservoir. Statoil is the operator for the development and operation of Snøhvit, including the CCS related operations.

CCS strategy and planned projects

The 2014 CCS strategy

Norway's current CCS strategy dates from 2014. It reinforces the government's commitment to CCS with a broad range of measures, which include RD&D to realise a full-scale CCS facility, the transport, storage, and alternative use of CO_2, and international co-operation.

The government's ambition is the construction of at least one full-scale CCS facility by 2022. Options for full-scale CCS demonstration plants in Norway are being reviewed. The government is also considering contributions to full-scale CCS demonstration projects abroad.

Kårstø and Mongstad demonstration projects

Although the government's desire to deploy quickly CCS to reduce domestic GHG emissions and to prove that CCS is a vital technology to tackle climate change worldwide has been strong, Norway has also experienced two setbacks. Two CCS demonstration projects, the Kårstø power plant and the Mongstad combined heat and power (CHP) plant, were cancelled, but they provided knowledge used in the 2014 CCS strategy to develop full-scale CCS projects.

The Kårstø power plant was originally built to address peak electricity demand. At the time for the approval of the design and construction of the plant in 2000, the government requested that the gas power plant should include CO_2 capture and storage. This highly politicised process led to a vote of confidence in parliament, which the government subsequently lost. The gas power plant started its operation in 2007 with free CO_2 quotas until 2012. Gassnova then announced a tender competition for a construction contract for the CO_2 capture facility, and signed contracts with four suppliers to complete a front-end engineering design (FEED) study as part of the pre-qualification of a potential building contract. However, since the start-up, the power plant has operated for fewer hours than planned because of changes in electricity demand, low electricity prices, and high prices for gas, which has made the plant unprofitable to generate power. The plans to add a capture plant were abandoned for commercial and operational reasons. The Kårstø power plant has been decommissioned.

The second setback was at Mongstad where a CHP was approved for design and construction in 2006, on the basis that CO_2 capture and storage should be added at a later stage, and its operations began in 2010. There were several delays in building the capture plant because of its complexity.

A second challenge came from the amine that which would be used on Mongstad. As it turned out, this could have undesirable health and environmental effects because when amines are released into the air and water, nitramines and nitrosamines are formed. Research was carried out to establish the health hazards of these substances, which were unknown. After being pushed back, the final decision not to build a capture plant was made in 2013. The main reasons were that the risk connected with the Mongstad facility was too high and that to integrate a full-scale capture facility at Mongstad would be both challenging and costly. Statoil has decided to shut down and decommission the Mongstad CHP plant by the end of 2018.

Although these projects were not carried out, Norway has managed to learn from them and used these lessons for the new CCS strategy to develop full-scale CCS projects. Other CCS projects, such as the Boundary Dam in Canada, have benefitted from the extensive research undertaken on the amine technologies that resulted from the Mongstad experience.

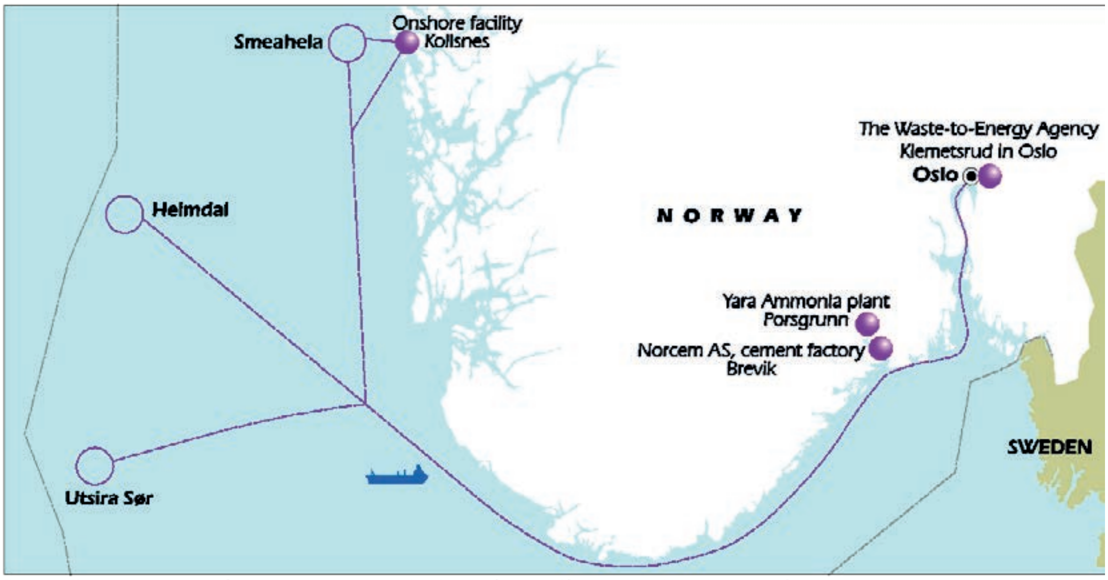
Developing new full-scale projects

In 2015, the MPE commissioned a feasibility study for a potential full-scale CCS project deployment in Norway. The study was co-ordinated by Gassnova for CO_2 capture and storage and by Gassco for CO_2 transport. The feasibility study was completed in July 2016 with the following three industrial options assessed to capture CO_2:

- Norcem evaluated the possibility to capture CO_2 from the flue gas at its cement factory in Brevik.
- Yara Norge AS assessed CO_2 capture from its ammonia plant at Herøya in Porsgrunn.
- The Waste-to-Energy Agency in the Oslo municipality considered CO_2 capture from the waste recovery plant at Klemetsrud (Klemetsrudanlegget AS).

These projects assess the potential for CCS in three new industrial sectors. If realised, they will also provide valuable insights for those are considering industrial CCS projects in other countries.

Figure 5.1 Potential new CCS projects in Norway



This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Source: MPE (2016), *Feasibility Study for full-scale CCS in Norway (Gassnova and Gassco, 2016)*.

In addition to these capture options, Gassco undertook a study of the ship transport of CO_2 between locations for capture and storage in different conditions (pressure) at a vapour/liquid equilibrium. From the CO_2 storage perspective, Statoil assessed three different sites on the NCS before it selected, in conjunction with Gassnova, the development of a CO_2 storage site with onshore facilities and a pipeline to the Smeaheia area as the best solution given the project's objective. The Smeaheia area is located east of the Troll field, around 50 km from the coast. This solution has the lowest implementation risk, a large storage capacity, and is relatively easy to develop.

The overall conclusion of the study shows that to realise a full-scale CCS chain in Norway by 2022 is possible and at lower cost than for projects previously considered in Norway. The study estimates that the cost to plan and the investment for such a chain will be between NOK 7.2 billion and NOK 12.6 billion, respectively (excluding value added tax).

The next step is to conduct concept and Front-End Engineering and Design (FEED) studies. The government has provided funding to finance concept studies for up to three capture projects, and the associated concept studies on CO_2 transport and storage. The concept studies will continue until the autumn of 2017, followed by the FEED studies that will be completed by late 2018.

The government has already announced a clear timeline for the design, build, and start operations of a full-scale CCS chain in Norway by 2022, including:

- autumn 2016: invitation to tender
- first quarter 2017: start-up of the concept phase
- autumn 2017: concept selection and the initiation of FEED
- autumn 2018: finalised FEED and preparation for the final investment decision
- in 2022: full-scale CCS chain in operation.

For 2017, the government has granted NOK 360 million for the continued planning of a full-scale CCS demonstration facility in Norway.

CO_2 storage

Norway has gained considerable experience in the CO_2 storage assessment of geological formations from the NCS through its operational CCS projects (Sleipner and Snøhvit) and the feasibility studies related to the Kårstø and Mongstad demonstration projects (see above). Wider CO_2 storage assessments, such as the CO_2 Norwegian Petroleum Directorate's CO_2 storage atlas for the NCS, show several possible storage sites.

In 2006, Gassnova, Gassco, the Norwegian Petroleum Directorate, and the Norwegian Water Resources and Energy Directorate completed the investigations of two storage locations – the Johansen Formation and the Utsira Formation as part of the Mongstad and Kårstø CCS projects. For instance, the estimate was made in 2010 that the Johansen Formation could store at least 160 Mt of CO_2. Further studies were completed in 2012 on the CO_2 storage potential for the Mongstad CCS project with the Troll Kystnær Formation as a potential CO_2 storage target.

More recently, as part of the feasibility studies related to the full-scale CCS chain deployment, Norway identified the Smeaheia area as a potentially extensive CO_2

storage. A full-scale project would only utilise less than 1% of the storage potential of the aquifer.

RD&D

RD&D is a fundamental element of Norway's CCS strategy. The key RD&D centres and programmes in this field include TCM, CLIMIT, and Norwegian CCS Research Centre (NCCS), a centre for Environment-friendly Energy Research (FME).

The TCM is the world's largest facility to test and improve CO_2 capture. Situated north of Bergen, since 2012 it has developed long-term and targeted testing and qualification of technologies for CO_2 capture. TCM is the only test centre in the world at which suppliers, in collaboration with the international research community, can test multiple capture technologies. Flue gas is currently available from two sources: a gas power plant and an oil refinery. CO_2 concentration from the refinery is comparable to flue gas from a coal power station.

The main advantage of the TCM is that its size is appropriate for scaling up to full scale, which allows international suppliers to test and further develop their capture technologies before commercial-scale deployment by end users. The TCM is recognised as a global competence centre for many aspects of CO_2 capture technologies. The government recently proposed to continue operations at the TCM after the current agreement expires in August 2017. The centre is owned by Gassnova (75.12%), Statoil (20%), Shell (2.44%), and Sasol (2.44%). Beyond the management of the state's interest in the centre, Gassnova also facilitates the sharing and dissemination of the capture technology knowledge to reduce the costs and risks of CO_2 capture. Recognising that the TCM bridges a gap in the technology chain because it enables the testing of capture technologies on an industrial scale, the government proposed in the budget for 2017 to continue operations at the TCM after the current agreement expires in August 2017.

In addition to the TCM, the government has, since 2005, a large national programme for RD&D on technologies for the capture, transport, and storage of CO_2 from fossil-based power production and industry (CLIMIT). Administered by the RCN (CLIMIT R&D) and Gassnova (CLIMIT Demo), CLIMIT has helped place Norway in the forefront of international research, innovation, and technology development from basic research to pilots and demonstration. It has delivered more than 260 projects across the entire CCS value chain, which include power generation with CCS, CO_2 capture technologies, CO_2 compression, transport and storage, and enhanced oil recovery with CO_2. In the 2017 budget, the government allocated NOK 200 million to the CLIMIT programme – NOK 105 million to the R&D part and NOK 95 million to the demo part.

NCCS is one of the eight FMEs established in 2016. It is led by the R&D institute SINTEF and involves about 15 industrial partners and 15 research partners. It runs for eight years and has a total budget of EUR 50 million. NCCS is designed to enable fast-track CCS deployment through industry-driven science-based innovation, and addresses the major barriers identified within demonstration and industry projects in Norway and Europe. NCCS aims to become a world-leading CCS centre, and it will build on the FME BIGCCS, which delivered top level innovations and significantly helped develop CCS between 2008 and 2016. The RCN will provide funding (NOK 23 million per year) towards NCCS.

Norway is participating in for European Carbon Dioxide Capture and Storage Laboratory (ECCSE) infrastructure. The ECCSEL consortium teams up selected centres of excellence on CCS research from nine countries across Europe. The mission is to implement and operate a European-distributed integrated research infrastructure initially based on a selection of the best research facilities in Europe for CO_2 capture, storage, and transport research. The Norwegian University of Science and Technology co-ordinates the project, with SINTEF as another Norwegian partner.

Norway also participates in an EU ERA-NET Cofund within CCS called Accelerating CCS Technologies (ACT) as a new low-carbon energy vector. The RCN is the Norwegian partner and is also co-ordinating the programme. A consortium with ten partners from nine countries was established in 2015. The countries that participate in ACT contribute EUR 29 million and the EU Commission EUR 12.9 million, which makes the total budget around EUR 42 million. In spring 2016, funds were made available for a major joint announcement for European CCS projects.

Assessment

Communicating the value of CCS

Norway's support for CCS as a critical climate mitigation option is well recognised. This has been possible thanks to stable political commitment and public acceptance for over 20 years. Although to address climate change and a related "moral imperative" have been key components in Norwegian CCS policy from early on, Norway should be more pro-active in communicating the socio-economic and environmental value of CCS to other countries. This would enable the government to consolidate further its role as a global CCS leader. Information as to Norway's experience, both success and failure, can help other countries to deploy CCS successfully.

The state-of-the-art projects of Sleipner and Snøhvit are the testimony of Norway's leadership in the CCS field and are likely to pave the way for new waves of CCS deployment in Norway and worldwide. Of particular interest will be how Norway sets up its next wave of full scale CCS deployment and, specifically, how the government structures the development of CO_2 transport and storage. The reduction of the long-term risks of CO_2 capture projects and the role of Gassnova, a unique CCS-focused state enterprise, deserve to be highlighted.

It is undeniable that Norway has led the world in CCS over the past 20 years achieving important milestones in many CCS fields. Provided that Norway continues its current effort, the country is in the best position to overcome future barriers to large-scale CCS deployment domestically and influence the CCS development globally.

Concentrating efforts to develop CO_2 infrastructure in the North Sea

For a wide deployment of CCS in Europe from 2020 on, the government sees a key role for the North Sea basin. Norway has worked together with neighbouring countries, especially the United Kingdom, as part of the NSBT to develop common principles to manage and regulate the transport, injection, and permanent storage of CO_2 in the North Sea subsea bed. However, there is a need to re-energise the effort to plan large-scale CO_2 transport and storage infrastructure.

Building on the work from the taskforce and recent studies related to North Sea, Norway should play a leading role to address key technical, commercial, legal, and regulatory CO_2 transport and storage barriers across jurisdictions to boost CCS deployment in the North Sea area. In particular, there is a need to oversee the North Sea CO_2 transport and storage infrastructure plans and to match potential captured CO_2 from various sources in Europe to CO_2 storage areas/sites. Part of this work should focus on a co-ordinated effort to identify, screen, and select potential large-scale CO_2 storage areas and sites and to undertake exploration and appraisal activities to characterise further these sites. Norway is well placed to co-ordinate these activities actively in conjunction with interested parties, such as governments and industrial partners.

Recommendations

The government of Norway should:

- ☐ Continue Norway's leadership at home by funding at least two full-scale Norwegian capture projects.
- ☐ Initiate and co-ordinate CO_2 storage assessment programmes to prove the large-scale offshore CO_2 storage capacity in the North Sea, which could potentially accommodate all the European CO_2 emissions from point sources (power and industrial processes).
- ☐ Lead efforts to develop large-scale CO_2 transport and storage infrastructure plans for Europe in collaboration with other European countries and in partnership with industry, and continue its active global engagement in CCS technology and policy setting and development.
- ☐ Disseminate information and knowledge gained about CCS development worldwide, in particular related to the full-scale CCS projects.
- ☐ Continue the CCS RD&D effort in collaboration with industry and international research organisations and universities that underpins the implementation of the current full-scale CCS projects and the deployment of the next wave of CCS investments through the strategic development of pilot, demonstration, and full-scale projects in Norway and around the world.

References

Ministry of Petroleum and Energy (2016), *Feasibility Study for full-scale CCS in Norway, Gassnova and Gassco*, MPE, Oslo, www.gassnova.no/en/Documents/Feasibilitystudy_fullscale_CCS_Norway_2016.pdf

Further reading

IEA (International Energy Agency) (2016), *Carbon Capture and Storage: Legal and Regulatory Review, Edition 5*, IEA, Paris, www.iea.org/publications/insights/insightpublications/InsightsSeries2016CarbonCaptureandStorageLegalandRegulatoryReview.pdf

IEA (2016), *20 Years of Carbon Capture and Storage*, IEA, Paris, www.iea.org/publications/freepublications/publication/20-years-of-carbon-capture-and-storage.html

IEA (2014), "CCS Regulatory Network, workshop No.6. Norway: legal and regulatory CCS framework", presentation by M. Agerup, Ministry of Petroleum and Energy, IEA, Paris, iea.org/media/workshops/2014/ccsregnet/2.1_Agerup.pdf

IEAGHG (2016), "Study report on CCS options in Norway released", IEAGHG Information Paper 2016-IP19, IEAGHG, Cheltenham, www.ieaghg.org/docs/General_Docs/Publications/Information_Papers/2016-IP19.pdf

MPE (Ministry of Petroleum and Energy) (2016), "Presentation to the IEA delegation, Carbon capture and storage in Norway", presented by E. Meisingset, Deputy Director General, Oslo, 16 November 2016), MPE, Oslo.

MPE (2016), "Norway's strategy for carbon capture and storage", presentation by I. S. Tybring-Gjedde (State Secretary), GCCSI European CCS Forum (14 October 2016), MPE, Oslo.

Statoil (2016), "Norwegian CCS feasibility study – CO_2 storage findings and recommendations", presentation by O. Skalmeraas, Vice President), GCCSI European CCS Forum (14 October 2016), Oslo.

Statoil (2015), "Offshore CCS projects in Norway: 20 years of experience and 20 million tonnes CO_2 stored", presentation by S. Hagen et al.), CCS workshop, ISO/TC 265 plenary meeting, 10 September 2015, International Organization for Standardization, Geneva.

6. Electricity

Key data

(2015)

Total electricity generation: 143.9 TWh, +4.9% since 2005

Electricity generation mix: hydro 95.8%, natural gas 1.8%, wind 1.7%, biofuel and waste 0.3%, heat 0.2%, coal 0.1%, oil 0.02%

Installed capacity: 33.8 GW

Peak load: 24.0 GW

Electricity consumption: industry 38.1%, residential 31.5%, commercial and other services 23.2%, other energy 6.5%, transport 0.7%

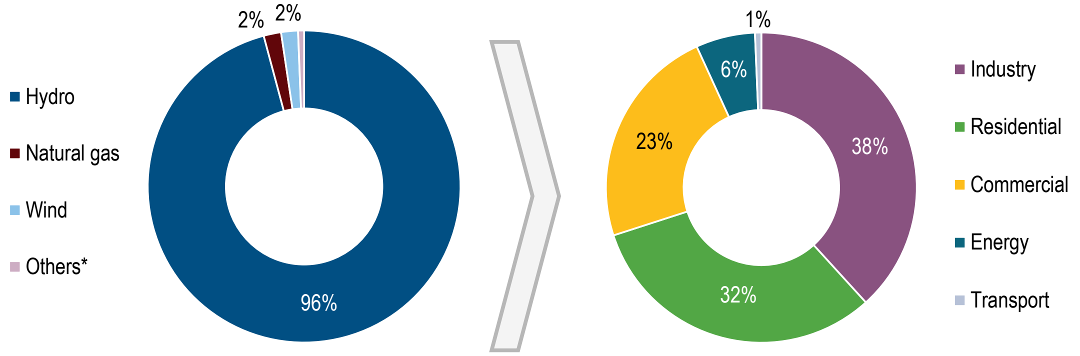
Overview

The defining feature of Norway's power system is the dominance of hydroelectric power. Hydropower (most is publicly owned) accounts for almost all of the electricity generation in Norway, provides the lowest cost of domestic electricity among the International Energy Agency (IEA) member countries, and enables the net export of electricity to interconnected countries. Norway is an electricity-intensive country, and the share of electricity in the final energy consumption is the highest across the IEA. Also, electricity use per person is higher in Norway than in any other IEA member country. This is driven, in large part, by the fact that Norway has a cold climate and that the heating is electricity based.

The industrial sector is the largest consumer of electricity, followed by the residential and commercial sectors. Electricity consumption has increased in residential and commercial applications and in the energy sector (oil and gas industry). The transport sector is also becoming more electrified, but despite a recent boom in electric vehicle (EV) sales, consumption is still relatively small.

Norway is part of a highly integrated Nordic power system that has interconnectors to the Baltics, Northern Europe and the Russian Federation. The high degree of regional integration provides access to a diverse and stable supply mix and therefore aids in the security of supply. Nordic and Baltic power is traded through the Nord Pool power exchange.

Figure 6.1 Electricity generation by source and consumption by sector, 2015

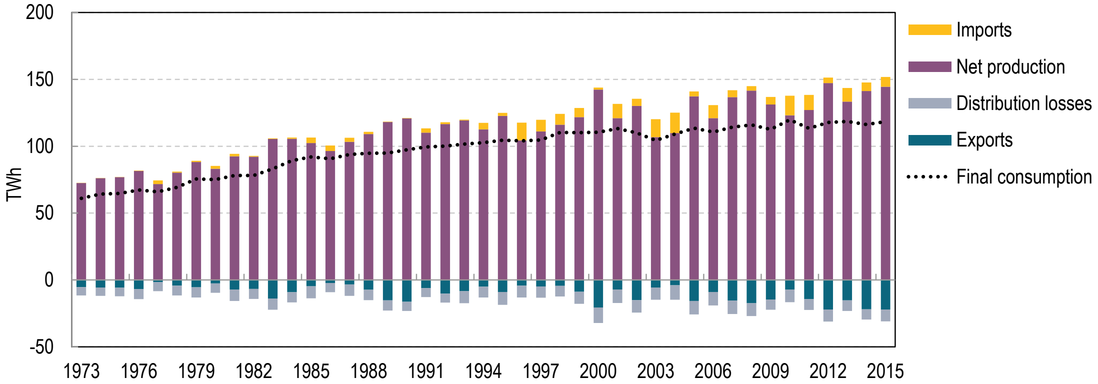


* Others refers to biofuels and waste, heat, coal, and oil.
Sources: IEA (2016a), *Electricity Information 2016*, www.iea.org/statistics/.

Supply and demand

Norway, despite an increasing domestic consumption (Figure 6.1), has sufficient clean electricity resources to meet the domestic demand in most years, and, in fact, is usually a net exporter (Figure 6.2). In 2015, net exports accounted for 10% of the total electricity production. Imports and exports help to balance the supply and demand for electricity.

Figure 6.2 Electricity production, imports and exports, 1973-2015

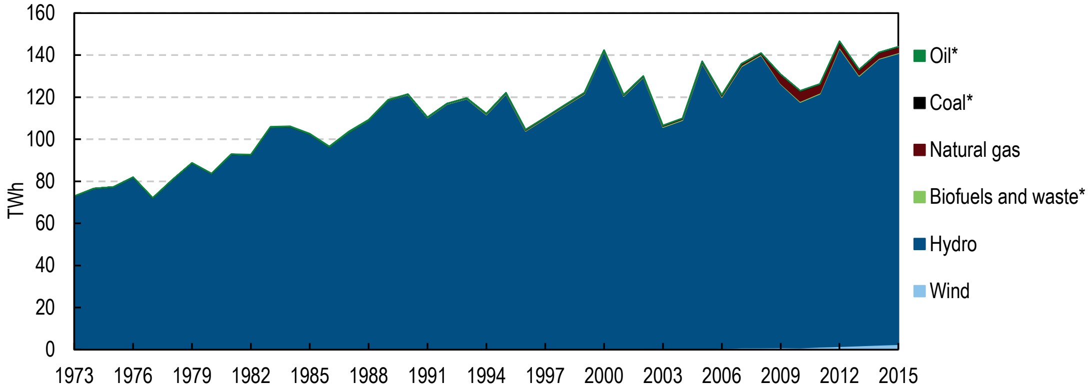


Notes: No data for distribution losses and final consumption in 2015; TWh = terawatt hours.
Sources: IEA (2016a), *Electricity Information 2016*, www.iea.org/statistics/.

Electricity generation

Total electricity generation was 144 TWh in 2015, an increase of 5% since 2005 (Figure 6.3). For decades, Norway's electricity production has relied almost entirely on hydroelectric power. In 2015, hydropower accounted for 96% of the production, followed by small shares of mainly natural gas and wind power.

Figure 6.3 Electricity generation by source, 1973-2015



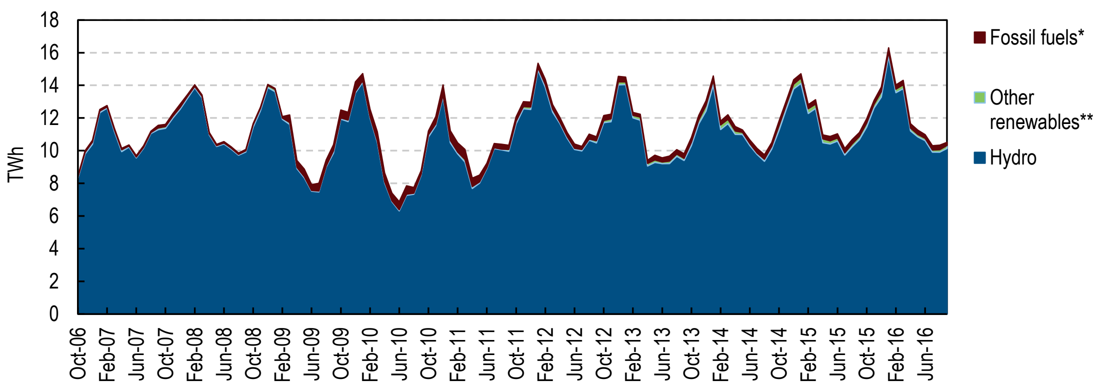
* Negligible.

Note: Data are estimated for 2015.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Electricity generation has increased over time with demand, but production varies annually because of the weather conditions, which affect both demand and precipitation. Production over the course of a year is determined by all the factors that affect the market prices of electricity. These include domestic demand, hydrological balance, reservoir levels (over 75% of the installed capacity is connected to reservoirs), and market conditions in both the Nordics and Northern Europe. A hydro plant connected to a reservoir must either use the available water or store it to sell electricity later at a higher price. Production (and wholesale prices) is normally highest in winter, mainly because of the high domestic demand for electric heating in the residential and commercial sectors. Between July 2015 and January 2016, the monthly production ranged from a summer low of 10.3 TWh to a winter high of 16.3 TWh (Figure 6.4). In 2015, the average load factor for Norway's hydroelectric fleet was 45% (NVE, 2016).

Figure 6.4 Monthly electricity generation by source, October 2006 to September 2016



* Fossil fuels includes mainly natural gas, plus small shares of oil and coal power.

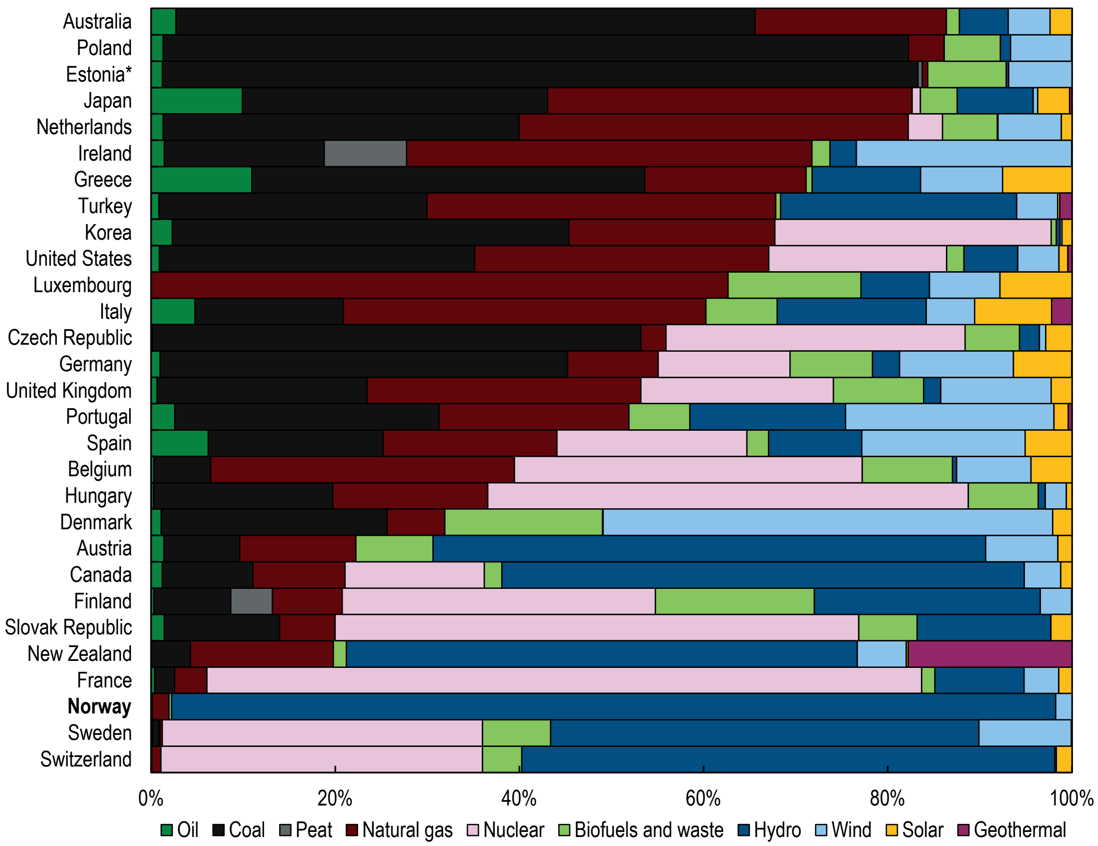
** Other renewables includes biofuels, wind, and solar power.

Sources: IEA (2016b), *Monthly Electricity Statistics 2016*, www.iea.org/statistics/.

The very high level of hydropower provides Norway with an exceptional electricity generation mix in comparison with other IEA member countries (Figure 6.5). Canada has the second largest share of hydropower with 60% of the total generation, far below

Norway's level. Switzerland and Sweden are the only countries with a lower share of fossil fuels in the electricity generation mix, but 35% of their generation comes from nuclear power. Norway has the highest share of renewable energy in the electricity supply with 98%, significantly above New Zealand's 80% and Austria's 78%. Norway has the lowest share of biofuels and among the lowest shares of coal, oil, natural gas, wind, and solar power among IEA countries.

Figure 6.5 Electricity generation by source in IEA member countries, 2015



Note: Data are provisional.

* Estonia's coal represents oil shale.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Capacity

Hydropower accounts for 93% of the total installed capacity (Table 6.1). This is a decline from a 98% share ten years previously, because of the increased installed capacity of natural gas and wind power. Norway currently has a capacity surplus, and expects this surplus to last through to at least 2020. As nearly all its generation is weather dependent, however, a capacity surplus does not guarantee an energy surplus. According to Statnett SF (Statnett) estimates, during a typical cold winter the available capacity is around 80% of the installed capacity (NVE, 2016).

Table 6.1 Electricity-generating capacity, 2000-15 (MW)

Energy source	2000	2005	2010	2015
Coal and coal products	81	55	5	5
Natural gas	35	40	1386	1414
Liquid fuels, including refinery gas	13	17	18	18
Other combustible fuels	141	140	119	131
Solid/liquid	0	21	12	0
Total combustible fuels	**270**	**273**	**1540**	**1568**
Hydro	28126	28549	29693	31372
Wind	13	265	425	867
Solar photovoltaics	6	7	-	-
Other sources	0	28	35	35
Total capacity	**28 415**	**29 122**	**31 693**	**33 842**

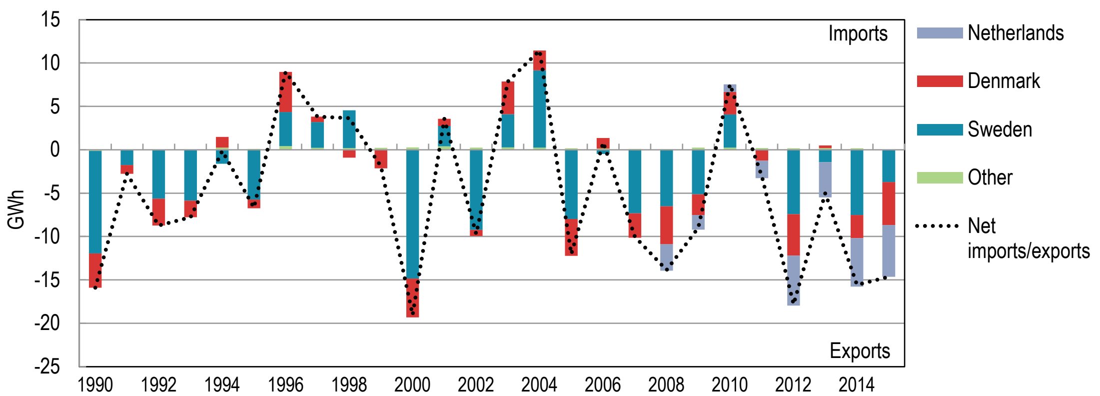
Note: MW = megawatt.

Source: IEA (2016b), *Electricity Information 2016*, www.iea.org/statistics/.

Imports and exports

Norway's electricity system is well interconnected with those of neighbouring countries. Nearly all the imports and exports go via land cables to Sweden or subsea cables to Denmark and the Netherlands. Trade with Denmark and Sweden tends to be balanced, but Norway is a net exporter to the Netherlands. The flexibility of Norway's hydro fleet makes it a valuable resource to balance variable renewable power.

Figure 6.6 Net imports and exports of electricity by country, 1990-2015



Note: Some countries can both import and export in one year. The chart shows the net imports and exports.

* Others includes Finland and Russia.

Source: IEA (2016a), *Electricity Information 2016*, www.iea.org/statistics/.

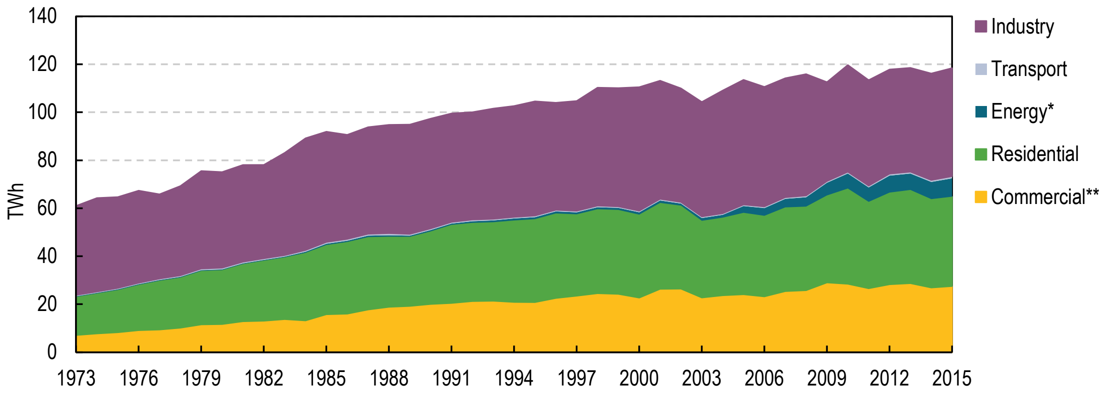
Norway exported 22.0 TWh and imported 7.4 TWh in 2015, which resulted in a net electricity export of 14.6 TWh (Figure 6.6). Since 2008, a new subsea transmission line has made the Netherlands a major importer of electricity. The Netherlands was the largest net importer in 2015, accounting for 41% of Norway's total net exports. Norway is usually a net exporter of electricity, but occasional high demand and low production levels can lead to net imports in some years. This happened most recently in 2010, a year with low precipitation and a relatively cold winter, which resulted in high electricity demand.

Electricity consumption

The total consumption[1] of electricity was 118 TWh in 2015, an increase by 4% from 2004. Norway consumes the most electricity per person among the IEA member countries, 22 600 kWh in 2014, half more than the second-highest country (Finland, at 15 000 kWh). The 46% electricity share in the total final consumption of energy in Norway was by far the highest among the IEA member countries (the second was Sweden at 33%).

Industry was the largest consumer of electricity, accounting for 38% of the total in 2015 (Figure 6.7). Industry consumption has declined slightly – its share has fallen from 47% in 2004 because of an increased consumption in other sectors. The non-ferrous metals (aluminium) industry is the largest subsector; its 20 TWh of consumption accounted for almost half of the total industrial electricity demand. Aluminium production is electricity intensive and Norway's low electricity prices make it attractive for the subsector.

Figure 6.7 Electricity consumption by sector, 1973-2014



* Energy includes energy own-use and the transformation sector.

** Commercial includes commercial and public services, agriculture, fishing, and forestry.

Source: IEA (2016a), *Electricity Information 2016*, www.iea.org/statistics/.

The residential sector is the second-largest electricity consumer, at 32% of the total, followed by the commercial sector with 23%. Both residential and commercial consumption have increased over the past decade, by 10% and 14% respectively. Access to cheap hydropower has led to a higher level of electricity use for space and hot water heating in buildings than that in other countries (MPE, 2016a). In Norway, the electricity demand peaks in winter, usually in January (Table 6.2).

[1] Total consumption = final consumption + energy industry consumption.

Table 6.2 Peak demand, 2006-16

Year	Date	Hours	Demand (MW)
2006	6 March	8	21 575
2007	14 December	8	21 255
2008	14 February	9	21 589
2009	5 January	8	21 984
2010	6 January	8	21 994
2011	21 February	8	22 129
2012	5 December	8	23 443
2013	23 January	8	24 180
2014	22 January	9	23 489
2015	4 February	8	22 530
2016*	21 January	8	24 485

* Data for 2016 is not complete.

Source: NVE (2016), *National Report 2016*.

Electricity consumption by the energy sector has increased sixfold since 2004, and represents 6% of the total in 2015. Oil and gas production accounts for the major part of the energy sector, and many of its processes have been electrified in recent years.

Under the EU renewable energy directive, Norway has a target of 67.5% renewable energy in the gross final consumption of energy in 2020. Given that electricity production is already nearly carbon free, to meet this target the share of electricity consumption will have to increase

Electricity for transport has increased in recent years because of a rapid growth in EVs. Despite this, the transport sector accounts for only 1% of the total electricity consumption, and most of electricity for transport is still used in trains. If the growth in number of EVs continues, however, the transport sector will become a more important consumer of electricity. The NVE (2016) estimates that electricity demand in the transport sector could grow to 3.0 TWh per year by 2030, and that the total potential (assuming complete electrification) is around 15 TWh.

Institutions and legal framework

Institutions

Responsibility for the electricity system rests with a relatively small number of government agencies and government-owned institutions. Of primary importance is the Ministry of Petroleum and Energy (MPE). The MPE is responsible for developing policies across all the energy sectors, with a particular focus on the environmentally sustainable management of energy resources. In practice, its work on electricity mostly focuses on hydropower.

Three entities relevant for electricity operate under the authority of MPE: the Norwegian Water Resources and Energy Directorate (NVE), Statnett SF (Statnett), and Enova SF (Enova).

The NVE Directorate takes on many responsibilities, which include to license new generation and transmission lines, monitor the fulfilment of license requirements, maintain the national centre for hydrology, maintain dam safety, monitor floods, and be prepared for energy sector emergency. One of its most critical responsibilities is to act as the regulator for the energy sector. Although legally independent, the NVE is structured as a directorate under the MPE. Regulatory responsibilities are planned to be insulated from the Ministry's interference, although they will remain within the NVE and therefore under the authority of the Director General. The regulator will also take on the responsibility to monitor the wholesale market, a task that is currently the responsibility of Nord Pool. This will require an increased regulatory capacity and collaboration with regulators from other countries that participate in the Nord Pool market, as well as other relevant agencies within Norway (most notably the competition and finance authorities on market surveillance and financial derivatives for electricity, respectively).

Statnett is Norway's state-owned electricity transmission system operator (TSO). It develops and maintains the high-voltage transmission network, and manages system operations through a central national control centre and three regional control centres. Statnett is also a founding member and part owner of the Nord Pool wholesale market.

Enova is a state-owned enterprise with the goal of contributing to reductions in greenhouse gas emissions and increasing security of supply for energy. It supports the development of energy and climate related technologies development, and thereby contributes to the long-term reduction of greenhouse gas emissions. Enova has an annual budget of more than 2.6 billion Norwegian kroner (NOK).

The Ministry of Finance is responsible for Norway's economic policy and for the preparation of the state budget. Implementation of tax policy also falls under its purview, and includes the "resource rent tax", a tax on profits earned by hydroelectric plant owners.

The Ministry of Climate and the Environment is responsible for, among other things, meeting the climate targets set for Norway by the European Union (EU), and for its contributions to the Paris agreement. Although not a member of the European Union, Norway participates in the EU Emissions Trading Scheme (EU-ETS).

Statkraft SF (Statkraft) is an energy company wholly owned by the Ministry of Trade, Industry, and Fisheries. It owns the largest portion of Norway's hydropower fleet and, therefore, participation in the Nord Pool wholesale market. It also owns hydropower and gas-fired power assets outside Norway, as well as wind generation plants both domestically and abroad. Statkraft is Europe's largest generator of renewable energy.

Norway is one of seven countries that participate in the Nord Pool wholesale spot market. Nord Pool originated as Statnett Marked AS, a fully owned subsidiary of Statnett that served the Norwegian market. Statnett Marked AS became Nord Pool AS when Sweden joined in 1996, although it remains licensed for the NVE to organise and operate the market, and for the MPE to operate it internationally. It has since expanded to include Denmark, Estonia, Finland, Latvia, and Lithuania. Nord Pool is fully owned by its member TSOs, with Statnett owning approximately 29%.

Legal framework

Norway's energy policies are governed primarily by the Energy Act, which came into force in 1991 and has been amended numerous times since. The Energy Act deregulated the electricity market and made Norway one of the front runners in electricity market liberalisation.

Through different licensing schemes, the Act regulates the construction and operation of electrical installations, district heating systems, electricity trading, control of monopoly operations, external trade in power, metering, settlements and invoicing, the physical market for trade in power, system co-ordination, rationing, electricity supply quality, energy planning, and contingency planning for power supplies. The authority to take independent decisions pursuant to the Energy Act has, to a large extent, been delegated to the NVE, the national regulatory authority for the electricity market. NVE's objectives are to control monopoly operations, to safeguard consumer rights, and to ensure an efficient operation, utilisation, and development of the grid.

Norway has been a member of the European Economic Area (EEA) since 1994. Electricity-sector legislation is harmonised with EU legislation, as EU internal market law is implemented when considered relevant under the EEA agreement.

Norway is still in the process of implementing the Third Package, which the European Union adopted in 2009. For example, while the TSO unbundling requirement is complete, Norway must still implement the various network codes and guidelines. A full implementation of the third package is expected to be complete in 2017.

In addition, Norway will need to comply with any EEA-relevant legislation adopted under the next legislative package, the Clean Energy (also known as the Winter) package. The European Commission published its proposal at the end of 2016.

Electricity certificate system

Norway has participated in the electricity certificate system (*elsertifikatsystemet*) together with Sweden since 2012. The system supports the new generation of renewable electricity through a market-based quota system in which all the electricity suppliers are required to possess a certain quantity of green certificates. Every megawatt hour of electricity from renewable sources (built within the time frame of the scheme) allows for one certificate, which can be traded on a market. The electricty certificate system incentivises investments in the cheapest form of renewable electricity generation capacity.

After 2020, Norway no longer intends to be part of the electricty certificate system (MPE, 2016a). The scheme is considered to have supported investments in new electricity generation, but an excess of capacity in the Nordic power system has led to low electricity prices and low revenues for the producers. Norway's position is that in a well-functioning market, the electricity price will provide the right incentive for new long-term investments.

Transmission and distribution

Transmission system

Norway has around 11 000 kilometres (km) of high voltage transmission lines.[2] 2 900 km of 420 kilovolt (kV) lines, 5 100 km of 300 kV lines, 200 km of 220 kV lines, and 2 900 km of 132 kV lines.

There are currently around 20 different entities that own transmission lines. Statnett, however, is the only TSO in Norway. Over the next few years, Statnett will acquire the entire transmission grid. Statnett is already fully unbundled, under the ownership unbundling (OU) model.[3]

The total interconnector capacity is expected to increase from approximately 6 300 MW today to 9 100 MW by 2021. Recent amendments to the energy law allow for the third-party (merchant) ownership of interconnectors. Although some merchant lines are under consideration by project developers, none have been formally submitted for permitting approval requests.

Statnett's role is to, among other things, plan transmission development and upgrades, define Norway's price zones based on transmission constraints, and operate the real-time balancing and ancillary services markets. Statnett also determines the appropriate transmission tariffs. Tariffs are set on a four-year basis under the principle that all grid-connected customers should contribute to cost recovery. Tariffs should be non-discriminatory, although Statnett can establish different tariffs based on objective and verifiable network criteria. Statnett's revenues are fixed based on its approved investment plan. Revenues earned in excess of its cap must be returned to consumers; if revenues fall short, future tariffs may be increased accordingly.

In recent years, Norway has made some changes to the grid planning and licensing process. Planning is scenario based, with one baseline scenario and two alternative scenarios. The planning horizon is 20 years. Under the current plan, Statnett expects to invest NOK 50-70 billion over the next decade, a relatively high level of investment by historical standards (Figure 6.9).

Third-party review is now required for any project with a voltage of 300 kV or higher and/or that is at least 20 km long, and the MPE must provide a written statement that evaluates the degree to which the project is necessary. Interconnectors are exempted from this requirement. In addition, the authority to issue licences to construct transmission lines has been moved from the NVE to the Cabinet Meeting, although the NVE still provides a recommendation. Decisions in the Cabinet Meeting are made by consensus, and cannot be appealed.

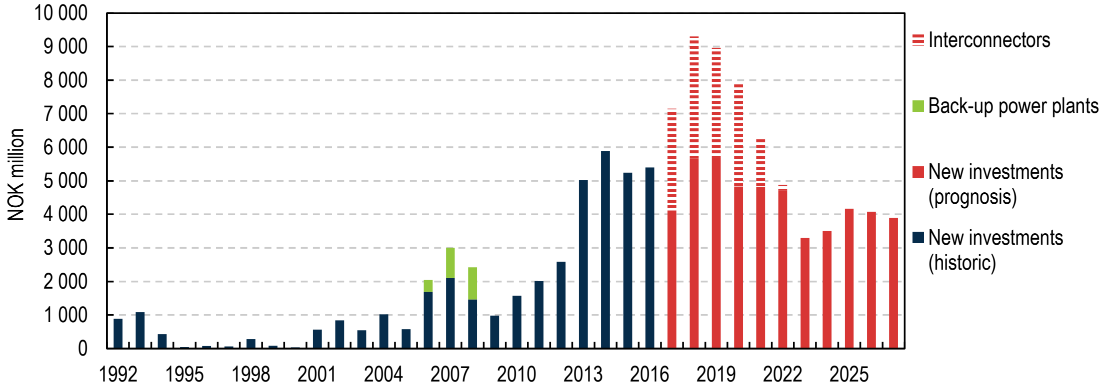
[2] Transmission lines in Norway are defined as any line with a voltage level of 200 kV or higher, or any 132 kV lined deemed to be of "significant importance" to system operations.

[3] Under EU regulations, unbundling can be done under one of three models: OU, in which the integrated energy companies sell off their electricity networks; the independent transmission operator, under which energy supply companies may still own and operate electricity networks, but must do so through an independently governed subsidiary; and independent system operator, in which energy supply companies may still own, operate, and maintain the network assets, but investment is done by an independent company.

Figure 6.8 Map of Norway's transmission grid, 2016

This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Figure 6.9 Historic and planned transmission investment, 1992-2025 (NOK million)



Source: Statnett (2017).

Three recently approved transmission projects are intended to reduce congestion within Norway.

- The first is a 297 km, 420 kV line to connect Sogndal to Ørskog (both in the middle of Norway). It is meant to improve the security of supply in the area, and to allow for the integration of higher penetrations of variable renewable energy (VRE). It was commissioned in 2016.
- The second is a 150 km, 420 kV line to connect Ofoten and Balsfjord, in the north of Norway. It will help meet the expected load growth and also allow for higher penetrations of VRE, and is expected to be commissioned in 2017.
- The third is a 300 km, 420 kV line to connect Balsfjord and Skaidi, also in the north. Its primary purpose is to improve the security of supply in the region. The planned commissioning date is 2021.

Distribution system

Norway has nearly 19 000 km of regional distribution lines (medium voltage, 33 kV to 132 kV) and around 300 000 km of local distribution lines (low voltage, 22 kV and below) (Figure 6.9.and Table 6.3).

Table 6.3 Total length of distribution network by voltage level, 2016

Voltage level (kV)	Length (km)
132	7 500
66	8 500
45	2 400
33	260
1-22	100 000
1 and below	200 000

Norway has 146 distribution system operators (DSOs), a relatively high number given the size of the population, although a decline from the 162 that were active in 2009. The DSOs with more than 100 000 customers are legally and functionally unbundled. Seven DSOs fall into this category, and, as of 2015, they collectively served 57% of the market.

DSOs with fewer than 100 000 customers must unbundle (legally and functionally) by 1 January 2021. This unbundling requirement will ensure that DSOs focus only on activities that are clearly monopolistic in nature in order to leave other activities open for competition.

For planning purposes, DSOs are required to collaborate on a regional basis. The NVE has defined 17 regional planning areas, and DSOs within these areas are required to submit power system plans on an annual basis.

Cross-border collaboration

Norway's reliance on weather-dependent generation has led it to become well interconnected with the rest of the Nordic region. This is especially the case with Sweden (3 615 MW) and Denmark (1 700 MW). The country was also interconnected with the Netherlands (700 MW) in 2008 (Table 6.4). Apart from the interconnection with Russia, interconnector capacity is allocated implicitly based on the Nord Pool power exchange. Interconnections are planned with Germany (2020) and to the United Kingdom (2021).

National TSOs retain control over system operations and transmission planning. Regional co-operation for both planning and operations, however, is necessary to maintain the security of supply. Statnett therefore co-operates closely with the other Nordic TSOs. For example, although interconnector capacity is allocated implicitly through the Nord Pool day-ahead market, the available and net transmission capacity are calculated by the respective TSOs.

Norway and its neighbours have a long history of collaboration. One area of active collaboration is in the provision of balancing services. The TSOs have developed a common balancing capacity market for manual frequency restoration reserves, which functions during the winter season and has weekly and seasonal products. The TSOs are developing a common market for automatic frequency restoration reserves (aFRR), and three of the Nordic TSOs (Norway, Finland, and Sweden) plan to combine their balance settlement process in a single organisation, eSett Oy. Originally set to launch in late 2016, eSett Oy is expected to start operations in 2017.

Statnett develops its own transmission development plan for Norway, but it also participates in the regional transmission development planning. Since 2002, the Nordic TSOs have published a joint transmission development plan (Statnett et al., 2016). Cross-border projects are negotiated on a bilateral basis, with costs generally shared on a 50-50 basis. In 2013, the Norwegian government introduced a requirement that interconnectors be owned by the TSO or a company controlled by the TSO to be granted a foreign trade license. In 2016, however, this requirement was repealed, which opens the way to a potential third-party (merchant) ownership of the interconnectors.

Projects have historically been evaluated on a purely economic cost-benefit analysis basis, in which the overall cost of the project is compared with estimated consumer savings. Statnett and the other Nordic TSOs have noted, however, that the value of such projects should also include security of supply benefits.

Interconnector capacity across the Nordic power system is expected to increase by more than 50% by 2025 (Statnett et al., 2016). By 2030, the interconnection capacity between the Nordic region and Europe is expected to increase from its present level of 3 GW to around 13 GW, according the NVE.

Table 6.4 Existing and planned interconnectors

Name of connection	Export market	Year of commissioning	Export capacity (MW)	Import capacity (MW)	Voltage (kV)	Status of connection
Nea-Järpstömen	Sweden	1960	450	700	420	In operation
Sildvik-Tornehamm	Sweden	1960	120	120	132	In operation
Nedre Røssåga-Ajaure	Sweden	1963	250	300	440	In operation
Hasle-Borgvik	Sweden	1963	600	600	420	In operation
Boris-Gleb	Russia	1971	0	50	132	In operation
Skagerrak 1 and 2	Denmark	1976/77	500	500	420	In operation
Ofoten-Rites	Sweden	1979	500	400	420	In operation
Halden-Skogssäter	Sweden	1979	600	600	420	In operation
Hasle-Borgvik	Sweden	1982	300	300	420	In operation
Finland	Finland	1988	70	70	220	In operation
Eidskog-Charlottenberg	Sweden	1986	95	95	132	In operation
Hasle-Borgvik	Sweden	1990	550	500	420	In operation
Skagerrak 3	Denmark	1993	500	500	420	In operation
NordNed Nea-Järpstömen	Netherlands	2008	700	700	420	In operation
Upgrade	Sweden	2010	150	300	420	In operation
Skagerrak 4	Denmark	2014	700	700	420	In operation
NORD.LINK/NorGer	Germany	2020	1 400	1 400	420	Under construction
North Sea Network Link (NSN).	UK	2021	1 400	1 400	420	Under construction

Source: Statnett (2016).

Electricity markets and trade

Generation ownership

The vast majority of electricity generation in Norway is publicly owned by both the state and the municipalities: approximately 90% of hydroelectric generation, 90% of thermal generation, and 80% of wind generation. In pure quantity terms, however, thermal and wind generation make up a very small portion of the total generating fleet.

For hydropower specifically, the government views it as a strategic resource and, therefore, either owns or controls this resource. Under the 1917 Industrial Concessions Act, the government has a "right of reversion", which allows it to resume ownership of privately owned hydropower assets without compensation once the original 60-year licence expires. As a result, as the reversion date stated in the licence nears, private power plants will be sold to public sector companies or reverted to the government. As expected, the Act has resulted in privately developed hydropower plants gradually passing into public ownership.

In capacity terms, the three largest generation owners (Statkraft, Adgr Energi, and E-co) control just under half of the fleet. In generation terms, these same three market participants produce around 40% of Norway's domestic generation (Table 6.5). Statkraft, however, is dominant among even these, as it owns around one-third of Norway's generating capacity and produces nearly 28% of the net generation. These figures are slightly misleading, however, as Norway participates in the Nord Pool wholesale market (see the next section), and so generation in Norway competes in this regional market.

Table 6.5 Top ten electricity producers in Norway, 2015

Company	Production (GWh)
Statkraft Energi AS	40 330
Agder Energi Vannkraft AS	9 032
E-co Energi AS	8 270
Sira Kvina Kraftselskap	8 073
BKK Produksjon AS	7 191
Lyse Production AS	6 803
Hydro Energi AS	4 299
Opplandskraft DA	3 337
Hydro Aluminium AS	3 326
Hafslund Produksjon AS	3 160

Source: MPE (2016b).

In addition to participating in the spot market, Statkraft has one remaining legacy long-term contract with some energy-intensive consumers, the terms of which were set by the Norwegian government. The contract price is below market level, and is not due to expire until 2030.

Licences for new hydropower projects are granted by the Cabinet Meeting. In addition, the granting of licenses for grid installation for new hydro projects has also been moved to the Cabinet Meeting, to allow for a more co-ordinated licensing process.

Norway's thermal generation fleet is made up almost entirely of three plants fired by natural gas. The Melkøya gas-fired plant generates power and heat exclusively for the Snøhvit liquefied natural gas facility, whereas the Mongstad plant serves the nearby refinery and the giant Troll gas field. The CHP at Mongstad is to be shut down in 2018. The 430 MW Karsto plant (jointly owned by Statkraft and Statoil), although only built in 2007, was approved for decommissioning in March 2016. In addition, 300 MW of capacity is held in reserve for use in "severe power situations", specifically in parts of Norway that have limited transmission capacity. These plants are owned by Statnett (the TSO), and are treated as regulated assets, because investments in the plants were made as an alternative to transmission investment. These plants, therefore, do not participate in the wholesale market.

Wholesale market

More than 90% of the physical power trade in Norway takes place at the Nord Pool, a regional power exchange that includes Sweden, Finland, Denmark, Estonia, Latvia, and Lithuania. There are 362 market participants of various sizes. For the regional market to function properly, regulatory frameworks are harmonised across all the member countries.

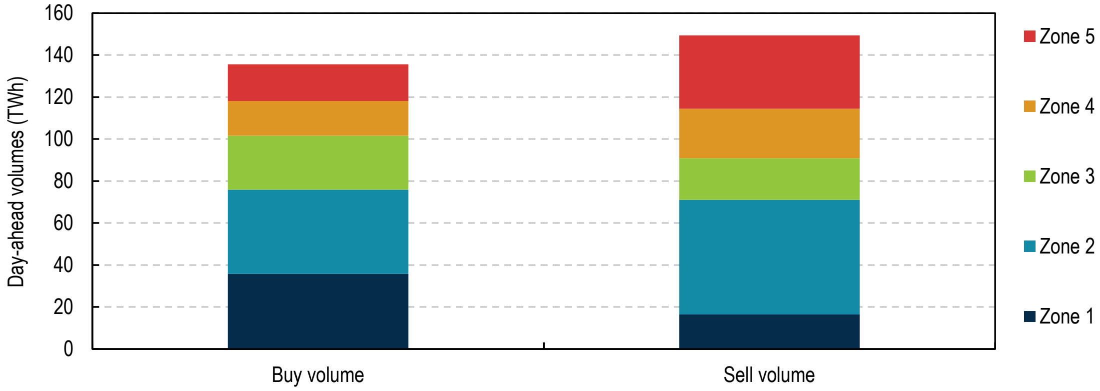
The Nord Pool has two physical power markets: a day-ahead market (Elspot) and a continuous intraday market (Elbas). Although the intraday market is growing (albeit slowly), the vast majority of trading occurs in the day-ahead market. In 2015, a record 374 TWh cleared in Elspot, of which 133 TWh was in Norway compared with only 4.6 TWh in Elbas (0.3 TWh in Norway) (NVE, 2016).

The Nord Pool is responsible for the market up to the point of gate closure, which is currently defined as one hour before real time. After gate closure, the responsibility for the power system is handed over to the various national TSOs.

Market participants are responsible for balancing, and the "balancing responsible parties" are defined by the TSOs (for Norway, it is Statnett). The Nord Pool is a zonal market, with zones defined at the national level by the relevant TSO. The zone definitions in Norway, however, are defined dynamically, and may be changed with a minimum of four weeks' notice. Between 2000 and 2013, Statnett adjusted the bidding zone definitions eight times, and the number of zones ranged from as few as two to as many as five. Currently, Norway is divided into five zones.[4] Generally, two of the zones (zones 1 and 2) make up around half of Norway's trade volumes (Figure 6.10). The Nord Pool pricing algorithm accounts for transmission congestion, and so prices may (and often do) diverge across zones.

[4] Sweden has four zones, Denmark two, and Finland, Estonia, Latvia, and Lithuania have one each.

Figure 6.10 Buy and sell trade volumes by zone, 2016 (TWh)



Source: Nord Pool (2017).

In addition to the Nord Pool power exchange, National Association of Securities Dealers Automated Quotations (Nasdaq) operates a separate financial derivatives market (Nasdaq OMX, or NOMX [also known as Nasdaq Nordic]) that offers market participants products for long-term financial hedging. In 2015, 743 TWh of power products were traded on NOMX (NVE, 2016).

At present, the Nord Pool is the only power exchange in the Nordic region. Under the European Union's recently adopted Network Codes, additional power exchanges will be allowed, and therefore may be developed within the Nordic area. The Nordic power market also participates in the Price Coupling of Regions, and is coupled to the rest of Europe. Therefore, price developments in other regions can impact Norway, and vice-versa. The increasing level of interconnection is set to increase price convergence across regions.

Retail market

Norway has introduced full retail competition. According to the Agency for the Cooperation of Energy Retail Competition Indicator, in 2015 Norway's retail electricity was one of the most competitive in Europe, after Finland, Sweden, and Great Britain. The market share of the three largest suppliers is below 40% – the lowest in Europe.

Norway does not have regulated electricity prices except in specific and limited circumstances – namely, when the customer is served by the default supplier. The local distribution company functions as the "supplier of last resort" for customers who are not under contract. Prices for these customers are regulated for the first six weeks, and are set at the spot price plus some premium.[5]

Retail prices vary significantly across DSOs, driven by differences in both the energy component and the fixed component. For smaller, more remote DSOs, in particular, network costs can be high. The NVE has set modernization of the tariff as a priority to make them more cost reflective and harmonised across DSOs. The NVE is also considering changes to the tariffs from energy-based to ones that are capacity based to

[5] The premium is meant to act as an economic incentive to persuade customers to switch to a competitive supplier.

better allocate network costs to consumers and incentivise a more-efficient network utilisation.

Norway offers consumers a price comparison website (www.strompris.no) that allows the comparison of different supplier and pricing options. Customers can choose between options linked to the spot (or wholesale) price, fixed price, or variable price (similar to the spot price option, but with a two-week delay), or they can choose options that promise, for example, to provide power from 100% renewable sources. Around 60% of Norwegian consumers have contracts tied to the spot price, one of the highest rates in Europe (www.strompris.no/en/home/).

Retail switching rates in Norway are high by international standards. According to NordREG (the collaborative body of Nordic energy regulators), in 2014 around 13% of consumers switched suppliers, or around 350 000 households. Within each DSO service territory, though, the incumbent supplier maintains, on average, approximately 70% of residential customers.

The penetration of smart meters at the residential level is at present relatively low. The government has mandated, however, that that smart meters be installed in all houses by 1 January 2019.

The primary intent of the smart meter rollout is to provide customers with more information about their consumption, and to allow them to participate in demand-response programmes. The mandate to install smart meters rests with the DSOs, although consumers retain ownership of their data. Access to data is restricted to the DSO and any third party granted access by the customer. Responsibility for storing and (appropriately) disseminating the data, however, rests with Statnett, which was mandated by the NVE to create a centralised data hub.

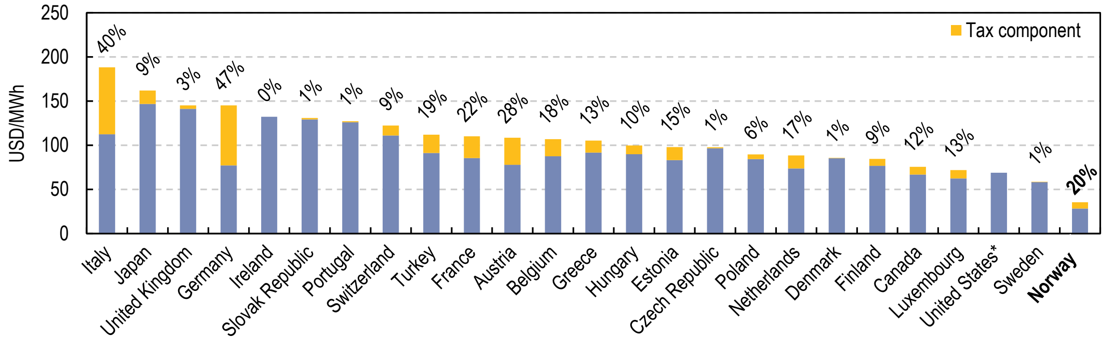
Named elhub and due to launch in late 2017, this data hub will primarily allow for the efficient exchange of customer information (including metered consumption) with the appropriate retail supplier. It is also, however, a key first step in the creation of a common (or at least harmonised) Nordic retail market – a proposal currently being spearheaded by NordREG. The smart meter rollout should also enable consumers with behind-the-meter generation to sell excess power back to the grid. With that in mind, the NVE has updated regulations to allow for greater participation by "prosumers". Small prosumers (those that produce less than 100 kW of electricity) will not be required to pay an additional grid charge.

Electricity prices

Hydropower requires no fuel purchases and thus benefits from low operational costs. As a result, Norway has the lowest electricity prices of all the IEA member countries, both for industries and households (Figure 6.11). The average industry price was USD 34/MWh in 2015, significantly below Sweden with the second-lowest price of USD 59/MWh. The household price was USD 91/MWh in 2015, the lowest among IEA countries despite a relatively high tax rate of 38%.

Figure 6.11 Electricity prices in IEA member countries, 2015

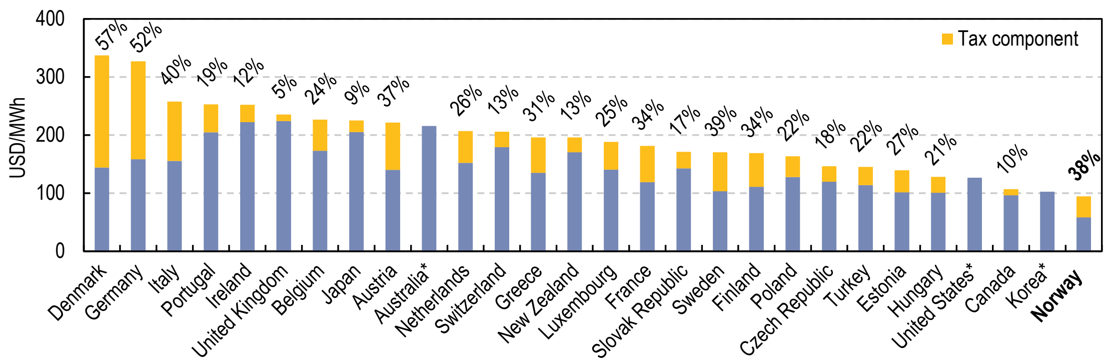
Industry



* Tax information is not available.

Note: Data from 2015 are not available for Australia, Estonia, Korea, New Zealand, and Spain.

Households



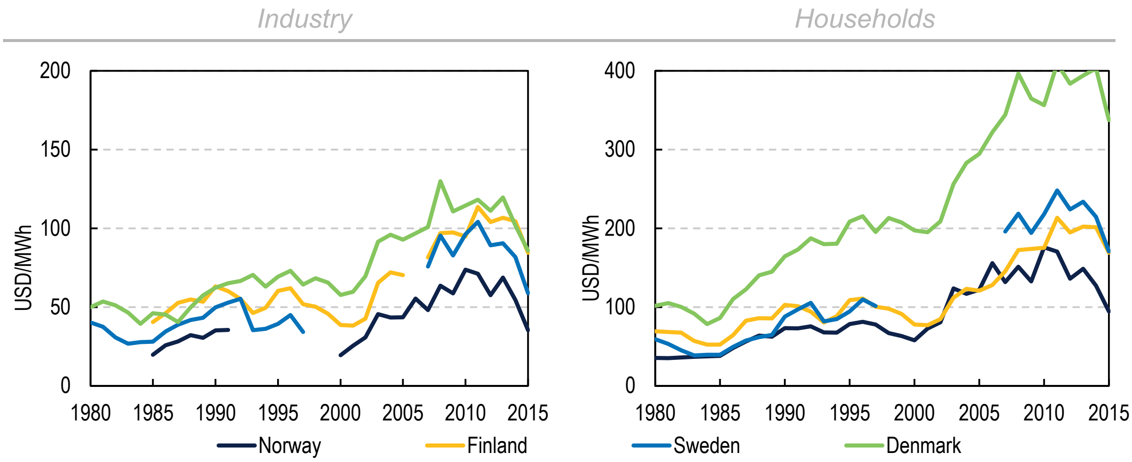
* Tax information is not available.

Note: Data are not available for Estonia and Spain.

Source: IEA (2016c), *Energy Prices and Taxes 2016*, www.iea.org/statistics/.

Prices in the Nordic countries that trade on Nord Pool follow the same trends, but Norway's electricity prices are lower than those of the others and have been so historically (Figure 6.12). The difference between highest and lowest prices on the market is especially large for households. Danish households pay almost 150% more per kilowatt-hour than households in Norway. This is a result of both higher production costs and higher taxes on electricity in Denmark.

Figure 6.12 Electricity prices in Norway and in other selected IEA member countries, 1980-2015



Note: Data are not available for Norway 1992-99 (industry), Finland 2006 (industry), and Sweden 1998-2006 (households and industry).

Source: IEA (2016c), *Energy Prices and Taxes 2016*, www.iea.org/statistics/.

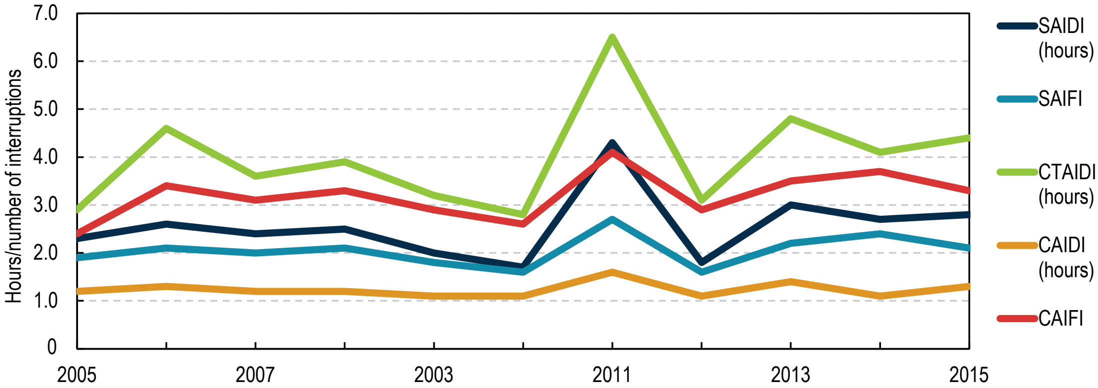
Security of supply

Norway's hydroelectric resource base is well managed, and in normal years it supplies enough energy for the country to be a net exporter. Approximately 70% of Norway's annual hydropower production comes from plants with reservoirs. Even with reservoirs, however, hydro resources are weather dependent, and during dry periods Norway must rely on imported power to meet the peak demand. To aid in the planning and operational decisions by market participants, reservoir levels are published on a weekly basis for each region.

Grid owners are responsible for managing all situations and for restoring the electricity supply, thus outage costs are borne by the respective DSOs. If there is unserved load for any reason, an amount equivalent to the costs of energy not supplied (CENS) is deducted from the DSO's allowed revenues. The CENS is based on the value of lost load, which is differentiated by DSO based on the estimates for six different consumer groups.

Although the power supply system is designed to withstand the forces of nature, most outages in Norway are weather related. Storms were responsible for relatively lengthy outages in 2003, 2006, 2011, and, most recently, 2013 (Figures 6.13 and 6.14). Norway expects that climate change will lead to an increase in extreme weather events, and as a result, increase the probability of damage to the power system infrastructure. Potential impacts of climate change include more thunderstorms (expected to be 25% more frequent by 2050), changes in icing patterns (some regions will experience warming, and therefore less icing of the power lines, and other regions will experience more extreme temperature variations, and therefore more icing), and increased variability of precipitation (although this should be managed by the efficient use of reservoirs and increased interconnection).

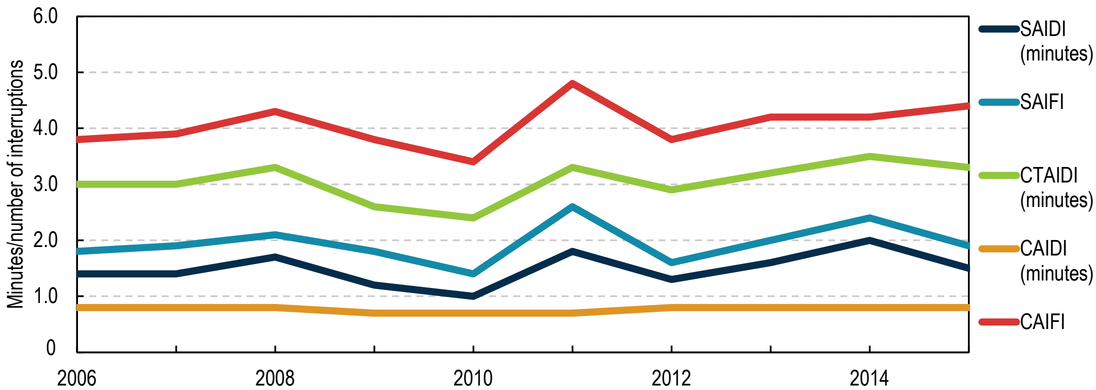
Figure 6.13 Continuity of supply indices for interruptions longer than 3 minutes



Notes: SAIDI is the system average interruption duration index, or the length of an interruption averaged over the entire customer base; SAIFI is the system average interruption frequency index, or the number of interruptions averaged over the entire customer basis; CTAIDI is the customer total average interruption index, or the average duration of interruptions for customers who experienced at least one interruption over the year; CAIDI is the customer average interruption duration index, or the length of interruptions averaged only over the affected customers; CAIFI is the customer average interruption frequency index, or the length of interruptions averaged only over the affected customers.

Source: NVE (2016), *National Report 2016*, Oslo.

Figure 6.14 Continuity of supply indices for interruptions of three minutes or less



Source: NVE (2016), *National Report 2016*, Oslo.

Several policy instruments are in place to help the energy sector adapt to climate change. For example, the NVE includes consideration of weather and climate change risks in their licensing recommendation and inspection processes, and, furthermore, conducts research and development to examine potential challenges to the energy sector posed by climate change. As a general principle, distribution lines (up to 22 kV) are buried underground and tree trimming or clearing is practiced regularly.

The Nordic region as a whole has a significant generating surplus, and, given the overall high level of interconnection, the overall security of supply has not been an issue. This surplus is expected to remain for at least the next decade.

Generally, low wholesale prices have reduced the profitability of much of the hydroelectric fleet. The Nord Pool spot average system price for 2015 was EUR 20.98 euros/MWh, the lowest since 2000. For 2016, the price was

EUR 26.91/MWh. Norway's generation fleet earns its income from the Nord Pool wholesale market or through bilateral trade agreements and, if the plant is eligible, from the electrical certificate (elcert) market.

Hydroelectric generators with an installed capacity of 10 MW or more also pay a "resource rent tax" of 34.3% on revenues less operating costs, depreciation, and "tax-free revenues", which are defined by the Ministry of Finance. In 2015, tax-free revenues were set to 0.7% of the value of the plant's taxable assets (Nordenergi WG, 2016).

Norway's stated policy is to rely as much as possible on market solutions to ensure the security of supply. This has a wide range of impacts on energy policy. For example, despite its heavy reliance on hydroelectric generation, Norway does not have an explicit requirement that water reservoirs be maintained with some "buffer" to be used during dry periods or during scarcity events. Instead, the assumption is that proper price signals and the use of bilateral contracts will incentivise market participants to make decisions that are best for the system as a whole. Similarly, Norway does not have, and has no plans to implement, a capacity mechanism.

Participation in the regional Nord Pool market, combined with a relatively high level of interconnection, means Norway's power system is affected by developments across the border. For example, Sweden is reducing its reliance on nuclear power, has implemented a strategic reserve, and is continuing the green certificate scheme despite Norway's decision to no longer participate. Each of these decisions impacts, to different degrees, the level and type of capacity available in the system and, therefore, the functioning of the wholesale market. For example, although the net impact on price levels of reducing the amount of nuclear power while increasing the quantity of variable renewable power is unclear, one probable impact is that it will increase price volatility.

Assessment

Norway's power system continues to be an example of the effective stewardship of energy resources. Electricity production is nearly entirely free of carbon emissions, and electricity prices are the lowest among the IEA members. System reliability is high, and the large degree of integration with neighbouring countries helps to ensure resource adequacy even during dry years. The Nord Pool, which Norway helped to found, continues to be a model for market design around the world.

Nevertheless, there are issues worth addressing. Firstly, reforms at the distribution level, although welcome, may be disruptive if not managed effectively. Secondly, Norway's reliance on hydropower offers challenges and opportunities, particularly as European efforts at decarbonisation and regional integration continue. Finally, it is important to consider whether Norway's existing institutional frameworks are structured appropriately, given the probable challenges ahead.

The evolving distribution system

A number of recently adopted policy measures will have a profound impact on the distribution system and on the retail market more broadly. Most notably, by 2021 DSOs with fewer than 100 000 customers must become legally and functionally unbundled. Of

146 DSOs, 139 fall into this category, with the seven largest DSOs already unbundled. In addition, DSOs must roll out smart meters to all consumers by the beginning of 2019, and the NVE is implementing rules that allow consumers to participate in the energy market as prosumers. Finally, the establishment of a centralised data repository (elhub) will change the relationship between the DSOs and their customer base. As a result of these changes, DSOs will no longer be able to offer non-energy-related services, which will reduce their available revenue streams, and they will no longer have a monopoly on consumer data, which reduces their comparative advantage as competition comes into their markets. Nevertheless, they will need to continue to provide an efficient, reliable, and affordable service to their customers.

Many DSOs may find the transition manageable with little or no outside assistance. This will be particularly true for the larger DSOs – those that come relatively close to the 100 000 customer limit – as these will probably already have the economies of scale necessary to perform effectively as unbundled entities. Smaller DSOs, however, may find it more difficult to manage this transition. Many of the necessary changes will require implementing new information and communication technologies that require specific technical knowledge. Smaller DSOs in more remote parts of the country may find it difficult to attract and retain qualified staff.

At the same time, DSOs will need to deal with changes in demand patterns. Norway is already a leader in the deployment of EVs. Even if the current incentive policies are removed, it is reasonable to expect the number of EVs to continue to increase, which potentially requires additional investment in the distribution grid.

Norway's low electricity prices undermine the economic case for behind-the-meter distributed generation. Nevertheless, the costs for many technologies are decreasing rapidly, and many first adopters may choose to install distributed technologies for non-economic reasons. As the penetration of EVs and distributed generation increases, many small DSOs may find grid planning and operations more of a challenge.

Many small DSOs may choose to partner or merge to decrease costs and better serve their customer base. Although these decisions should be made at the DSO level, the government can and should help support them when they are made. This could be to provide advice to DSOs when they consider such a move, help develop tools to evaluate the costs and benefits of such mergers, or even provide directly financial and technical support to DSOs that have made the decision to merge but that lack the resources to manage the process effectively on their own.

Hydropower as a domestic and regional resource

Norway occupies a somewhat unique place in Europe. Although not a member of the European Union, it has a long history of collaboration and power system integration with EU member countries – in particular, the other Nordic countries. This collaboration exists across multiple dimensions, and includes system planning, interconnector development, wholesale market design, and the development of a common reserves market. Europe's continued efforts to develop a common market have been heavily influenced by the work done by Norway and its neighbours. In the future, Europe's efforts are likely to influence Norway in turn.

Norway's high level of integration with the rest of the Nordic region and Europe more broadly remains one of its strengths. The combination of high levels of interconnection and its large hydropower fleet means that Norway can provide the region with a significant source of low-cost, highly flexible, and zero-carbon generation. Statnett, in particular, plays a key and growing role in the region as it:

- Participates in regional transmission development planning.
- Develops significant new cross-border interconnections to new markets.
- Works with other TSOs on the development of the aFRR.
- Implements elhub, a critical component of the regional retail market integration.

There is, however, room to do more. For example, the regional resource adequacy assessments continue to be developed under a static set of assumptions. To integrate more probabilistic analyses into both the regional and the domestic assessments could allow planning to better capture the impact of increasing penetrations of variable renewable power and the possible effect of changing weather patterns on Norway's hydroelectric fleet.

New variable renewables will primarily be deployed outside Norway. With a significant progress made towards the 2020 renewables target, the European Union has agreed a new target of 27% renewables by 2030. Much of this target will be met by the additional deployment of wind and solar power in countries whose power sectors have higher average carbon dioxide emissions than Norway. These renewables, although, benefit greatly when paired with hydroelectric resources, which can provide both seasonal storage and short-term flexibility. Therefore, Norway's hydropower will play an increasingly important role in the European power system.

A key question is how to ensure that these hydro resources are incentivised appropriately. The development of the aFRR is one positive example of how regional collaboration can enable the more-efficient use of the resources within and outside Norway. At the same time, more can be done. The role of the Nord Pool and, in particular, the relationship between the Nord Pool and the TSOs should be considered in this context. As currently designed, the Nord Pool market may not sufficiently value the roles of hydropower and flexible resources more broadly. One possible solution is to create products of shorter duration and to move the hand-off from the Nord Pool to the TSOs (i.e. gate closure) closer to real time. This would require increased collaboration both among the TSOs and between the TSOs and the Nord Pool. As new power exchanges will probably begin to operate in the region, the complexity of co-ordination will increase.

Changes to the supply mix, which include an increase in the shares of variable renewables, decommissioning of some nuclear plants, and, probably, a decrease in the shares of coal generation, in the Nordic countries and Europe more broadly will impact wholesale prices. Plants will face a higher price volatility and extended periods of low or zero prices. Already, relatively low wholesale prices have reduced revenues for many plants. The low prices have a number of causes, including a low EU-ETS price and the widespread use of renewable support schemes, which has introduced a large quantity of low- and zero-marginal cost generation into the EU power system.

Although there does not seem to be any concern over plants in Norway closing for economic reasons, a number of plant owners have noted that reduced revenues make it more difficult to pay for plant maintenance. They have also noted that the 31% resource rent tax compounds this difficulty. To revise the tax may be one way to improve plant revenues without distorting the wholesale market.

Norway is usually a net exporter, but it also periodically relies on imports to meet peak demand. One critical question is whether and how this situation may evolve. For example, there is significant uncertainty in how demand in Norway may evolve over the next few decades. Some see demand growing significantly, while others expect it to stay relatively flat or even decline.

Norway could address this uncertainty by an explicit focus on energy efficiency and demand-side management efforts on measures that reduce or shift the peak load. To do so will enhance the security of supply and also reduce system costs.

Policy decisions made outside Norway may also have a significant impact on the security of supply. For example, the decommissioning of nuclear plants in Sweden may reduce the available capacity in the region. The increasing number of capacity mechanisms in the Nordic region and throughout Europe more broadly may also have an impact. Norway has clearly stated that is has no intention to develop a capacity mechanism of its own – a reasonable stance given the overall level of resource adequacy. However, an uncoordinated development of national capacity mechanisms can distort the functioning of the wholesale market. This is especially true when the boundaries of the capacity market do not align with those of the wholesale market – as is currently the case in the Nordic countries.

Poorly designed capacity markets may undermine the formation of the wholesale market price, which will impact all the countries in a regional market. Even well-designed capacity mechanisms, however, can have a long-term impact as they influence investment decisions. This is especially true given the uncertainty over long-term demand. Norway will need to engage with other countries as they develop these mechanisms to understand their potential impact, and ideally help influence their design to minimise any potential market distortions.

Regulatory independence

Norway's has proved through its long history of collaboration with the other Nordic countries, and more broadly with the European Union, that it is a valuable and reliable regional partner. The situation in Europe, however, is evolving quickly. Norway needs to be able adapt to these changes in a way that balances the best interests of its citizens and the region more generally. The NVE's role as a neutral, independent regulator will, in particular, grow in importance. Although legally independent, the NVE as it is presently structured may be seen by some as not being sufficiently free of outside influence. A perception of bias, even if incorrect, may be enough to undermine the effectiveness of a regulatory institution. Norway could do more to separate the regulatory functions of the NVE from unrelated functions.

Recommendations

The government of Norway should:

- ☐ Continue to support DSOs that choose to partner or merge by providing technical and other forms of assistance.

- Support efforts by Statnett and other Nordic TSOs to:
  - Strengthen the development of the regional resource adequacy assessments by considering a wider range of potential scenarios, including a reduced hydro capacity sensitivity, and by using a probabilistic methodology.
  - Improve co-operation and move market functions closer to real time, for example moving gate closure closer to 15 minutes ahead of real time instead of the current 60 minutes.
- Create a fully independent regulator and increase resources for technical capacity.
- Further decrease the electricity peak load by the deployment of energy efficiency measures and diversification of the heating sector to enhance the security of supply.

References

IEA (International Energy Agency) (2017), *World Energy Balances - 2017 Preliminary Edition, www.iea.org/statistics/.*

IEA (2016a), *Electricity Information 2016*, OECD/IEA, Paris. www.iea.org/statistics/.

IEA (2016b), *Monthly Electricity Statistics 2016*, OECD/IEA, Paris. www.iea.org/statistics/.

IEA (2016c), *Energy Prices and Taxes 2016*, OECD/IEA, Paris. www.iea.org/statistics/.

MPE (Ministry of Petroleum and Energy) (2016a), *Kraft til endring — Energipolitikken mot 2030 (Power for Change – an Energy Policy towards 2030)*, Oslo, www.regjeringen.no/no/dokumenter/meld.-st.-25-20152016/id2482952/sec4.

MPE (2016b), Submission of background energy policy information to the IEA review team.

NVE (Norges Vassdrags- og Energidirektorat, the Norwegian Water Resources and Energy Directorate) (2016), *National Report 2016*. www.ceer.eu/portal/page/portal/CEER_HOME/EER_PUBLICATIONS/NATIONAL_REPORTS/National_Reporting_2016/NR_En/C16_NR_Norway-EN.pdf.

Nordenergi WG (Nordenergi WG Taxes and Levies) (2016), *Nordic Tax Report 2015 Electricity Sector*, Nordenergi WG, Copenhagen, http://188.117.57.25/sites/default/files/sk-15-nordenergi-tax-2014.pdf.

Nord Pool (2017), Elspot volumes_2016_Daily, https://nordpoolspot.com/historical-market-data/.

Statnett (2017), *Nettutvicklingsplan 2017. Hoeringsversjon*, Statnett, Oslo.

http://www.statnett.no/Documents/Vedlegg/Nettutviklingsplan%202017/Statnett_Nettutviklingsplan%202017.pdf.

Statnett (2016), Grid development: Stronger, smarter and more interconnected. Presentation to the IEA team, Oslo, November 2016.

Statnett, Energinet, Fingrid and Svenska Kraftnät, (2016), *Challenges and Opportunities for the Nordic Power System*, Statnett, Oslo, www.statnett.no/Global/Dokumenter/Challenges%20and%20opportunities_Report.pdf

Further reading

Energimyndigheten (2015), *Elcertificatsystemet*, Energimyndigheten, Stockholm, www.energimyndigheten.se/fornybart/elcertifikatsystemet/.

7. Renewable energy

Key data
(2015 estimated)

Total supply: 13.7 Mtoe (45.3% of TPES) and 141.2 TWh (97.9% of electricity generation)
IEA average: 9.9% of TPES and 23.6% of electricity generation

Hydro: 11.9 Mtoe (39.4% of TPES) and 138.3 TWh (95.8% of electricity generation)

Biofuels and waste: 1.6 Mtoe (5.2% of TPES) and 0.42 TWh (0.3% of electricity generation)

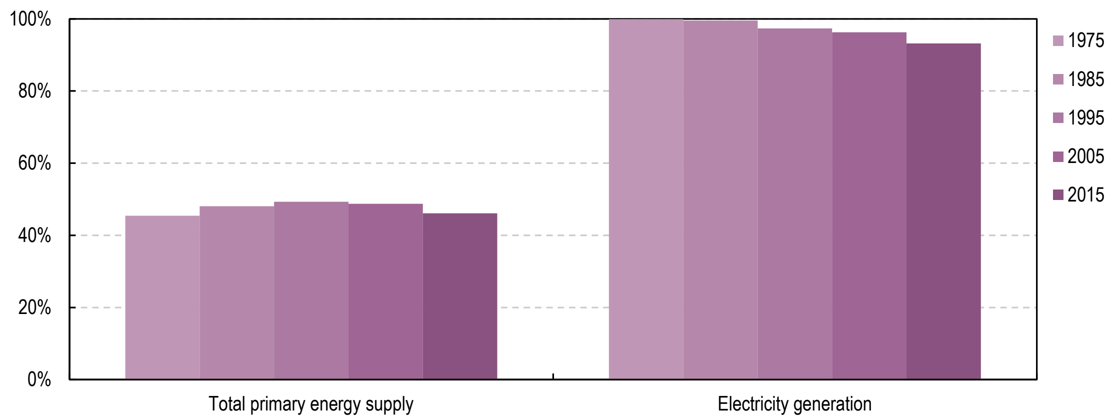
Wind: 0.22 Mtoe (0.7% of TPES) and 2.5 TWh (1.7% of electricity generation)

Overview

Norway has one of the highest shares of renewable energy in the energy supply among International Energy Agency (IEA) member countries. Electricity is generated almost completely from hydropower, the country's largest primary energy source in 2015. In total, renewable energy accounted for almost half of the total primary energy supply (TPES) (Figure 7.1).

Norway participates in an electricity certificate system with Sweden to support investments in new renewable electricity capacity, but it has decided not to set new targets after 2020. With its large share of hydropower in electricity generation and a heating system dominated by renewable electricity, a further increase in renewable energy in Norway can take place mainly in the industry and transport sectors.

Figure 7.1 Renewables share of the TPES and electricity generation, 1975-2015



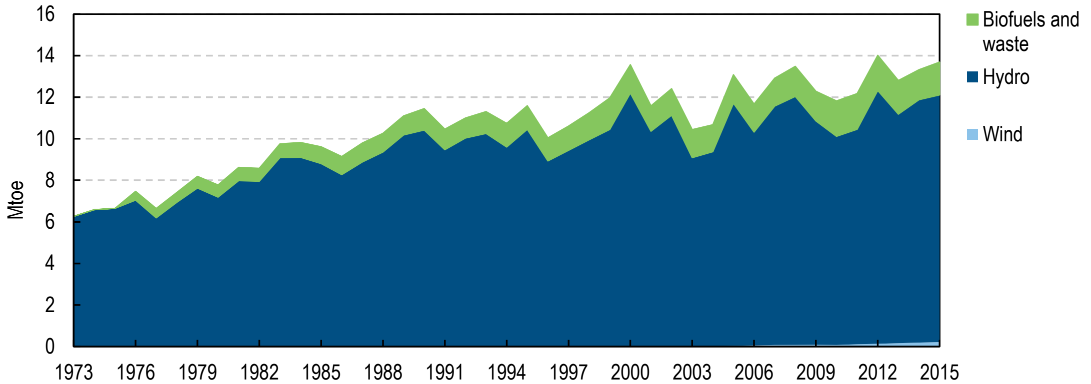
Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Supply and demand

Renewable energy in the TPES

In 2015, renewable energy sources (RES) provided 13.7 Mtoe of primary energy, or 46% of the total in Norway (Figure 7.2). This was the highest share among the IEA member countries, ahead of Sweden at 44% (Figure 7.3). Hydropower dominates the renewable energy supply in Norway, with a share of 40% in the TPES. Biofuels and waste account for 5% and wind energy for 1%. The share of renewable energy in the TPES has been stable at around 40% for many decades, but fluctuates annually with variations in the hydrological conditions (Figure 7.4).

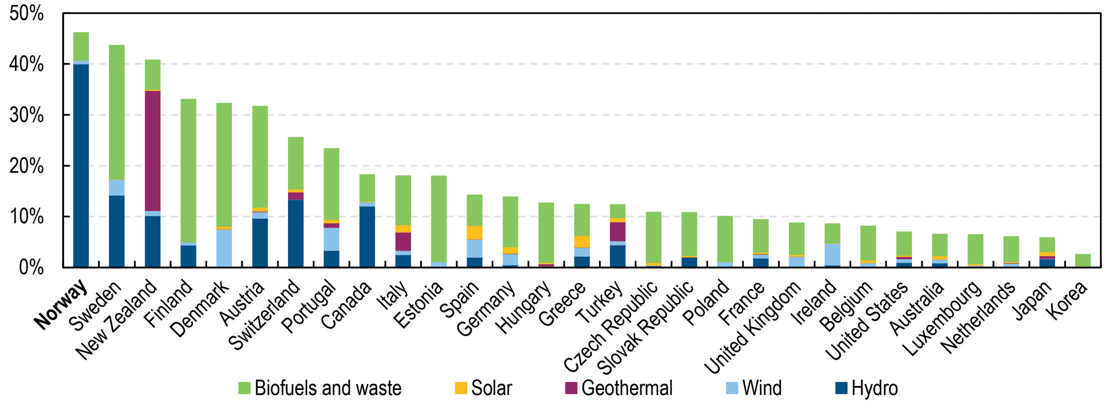
Figure 7.2 Renewable energy supply, 1973-2015



Notes: Biofuels and waste includes minor shares of non-renewable waste. 2015 data are estimated. Mtoe = million tonnes of oil equivalent.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

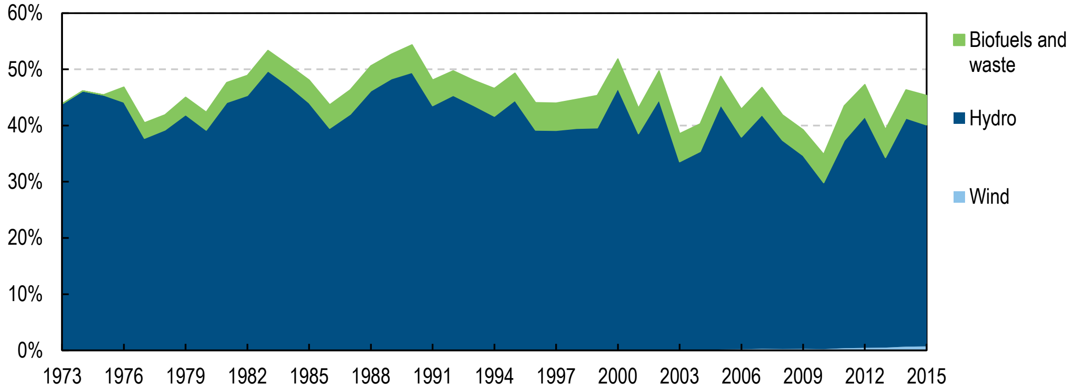
Figure 7.3 Renewable energy as a percentage of the TPES in Norway and the IEA member countries, 2015



Note: Biofuels and waste may include shares of non-renewable waste. Data are estimated.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Figure 7.4 Renewable energy as a percentage of the TPES, 1973-2015



Notes: Biofuels and waste includes minor shares of non-renewable waste. 2015 data are estimated.
Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Around two-thirds of solid biofuels (0.5 Mtoe per year) are used for residential space heating, and the rest is used in industry and, less so, for combined heat and power (CHP) production. An increased use of heat pumps and more-efficient biomass boilers will contain the growth in bioenergy use for space heating. Electricity prices are also expected to remain low, which has the same effect. Also, as wood use in the pulp and paper industry is expected to decrease rather than increase because of capacity reductions, it will also produce less waste wood, which otherwise would be used for energy. Municipal waste is used for energy at CHP and heat-only plants. In contrast, liquid biofuels use for transport may increase significantly from 2020, as the parliament has asked the government to increase the biofuels content in transport fuels to 20% in 2020 (the obligation for 2017 is 7%). The government aims to have a public consultation on the 2018–20 levels in 2017.

The government estimates the bioenergy resource potential to be around 2.5 Mtoe (30 terawatt hours [TWh]) per year. Forestry constitutes most of this potential, while other significant resources include waste from agriculture, industry, and households. The forest industry business cycle generally affects the supply of solid biomass.

Electricity from renewable energy

RES account for 98% of Norway's electricity generation. Historically, hydropower supplied more or less all the electricity in the country, whereas its current share is around 96%. Wind power production doubled between 2011 and 2015, and accounts for 1.7% of the total electricity generation. Another 0.3% is produced from biofuels and waste in CHP plants connected to district heating systems.

Norway's share of renewable energy in electricity production is significantly higher than that in any other IEA member country (Figure 7.5 and Table 7.1). New Zealand, in second place has a renewable share of 80%. Norway has low shares of other RES, which is a direct consequence of the hydropower dominance.

Table 7.1 Renewable electricity generating capacity, 1990-2015 (MW)

Technology	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
Hydro	26884	28052	28126	28549	29693	29969	30509	31033	31240	31372
Wind	0	3	13	265	425	512	705	818	859	867
Waste*	26	26	26	31	59	87	87	87	87	87
Solid biofuels	41	97	35	79	79	79	79	79	79	79
Biogas	0	0	0	0	13	17	17	17	17	17
Solar photovoltaic**	0	5	6	7	9	9	10	11	13	14
Total capacity	**26951**	**28183**	**28206**	**28931**	**30278**	**30673**	**31407**	**32045**	**32295**	**32436**

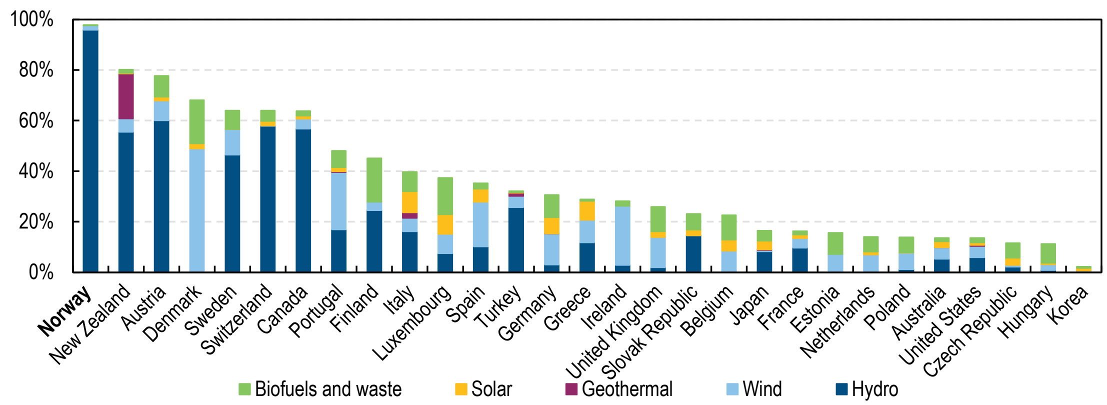
* Municipal and industrial waste. Estimated values for 1990-2005.

** Estimated values for 1995-2005.

Note: MW = megawatt.

Source: IEA (2016), *Renewables Information*, www.iea.org/statistics/.

Figure 7.5 Electricity generation from renewable sources as a percentage of all the generation in Norway and the IEA member countries, 2015



Note: Biofuels and waste may include shares of non-renewable waste.

Source: IEA (2017), *World Energy Balances - 2017 Preliminary Edition*, www.iea.org/statistics/.

Norway is the largest hydropower producer in Europe (excluding Russia) and seventh-largest in the world. According to the Norwegian Water Resources and Energy Directorate (NVE), significant potential remains for more hydropower, around 30-35 TWh per year (TWh/yr). This is the difference between the total potential that may be developed and the potential already developed.

On the basis of the 1981-2010 inflow period, the total hydropower potential in Norway is 214 TWh/yr, and climate models for Norway project increasing rainfall, which would raise this potential in the coming decades. The total hydropower potential includes some 50 TWh/yr in protected river systems, which, by definition, may not be developed. Generation from hydropower can also be increased by utilising the potential more efficiently through upgrading and expanding existing plants.

As of early 2014, the mean annual developed production capacity was around 131 TWh. In addition, projects under development and projects licensed to be developed amounted to around 5 TWh/yr (MPE, 2015).

For onshore wind, Norway generally has good resources compared with those of other countries. The average annual wind speed 50 metres above ground in an exposed coastal area in Norway can be 7-9 metres per second (MPE, 2015). Since 2012, new wind power projects, as all the other new renewable electricity projects in Norway, have received subsidies in the form of electricity certificates, but new subsidies under this system will no longer be available after 2020.

For offshore wind, the potential is significant. In a 2010 report led by the NVE, this potential was indicatively estimated at 18-44 TWh of annual generation in the areas most suitable for production. Offshore wind, however, needs to overcome several technological and economic challenges to become market competitive.

Institutions

The NVE, a subordinate agency of the Ministry of Petroleum and Energy (MPE), is responsible for managing energy and water resources on mainland Norway. NVE has a central role in licensing energy projects and has the authority to grant licences to small hydro (less than 10 MW), wind power plants, and district heating facilities. Licences for larger hydro projects are granted by the cabinet.

Regional authorities decide over hydropower plants up to 1 MW based on the recommendations of the NVE (hydropower plants in protected watercourses are an exemption to this). Local authorities (municipalities) handle permits for small wind turbines under 1 MW and small hydropower plants when the NVE has granted an exemption for a licence requirement.

Enova SF (Enova) (see chapter 2) has the three goals related to renewable energy:

- reduce greenhouse gas (GHG) emissions, which contributes towards Norway's 2030 climate obligations
- increase innovation within energy and climate technology in a low carbon perspective
- increase the security of supply through a flexible and efficient use of energy and grid capacity.

Innovation Norway aims to promote innovation and the development of Norwegian enterprises and industry. Innovation Norway offers investment subsidies on equipment to produce bioheat, woodchips, and biogas in the agricultural sector. Innovation Norway is owned by the Ministry of Trade, Industry, and Fisheries (51%) and the county authorities (49%).

Policies and measures

Targets

Under the EU Directive 2009/28/EC, member countries of the European Union are obliged to draft and submit to the European Commission national renewable action plans that outline the pathway that will allow them to meet their 2020 renewable energy targets. Norway has adopted the RES Directive as part of the European Economic Area agreement. Norway submitted its national action plan in June 2012.

Norway's 2020 renewable energy targets are:

- overall target: a 67.5% share of renewable energy in the gross final energy consumption
- transport: 10% of the energy demand met by RES.

Measured as required under the Directive, Norway's share of renewable energy in gross final energy consumption was 58% in 2004, 61% in 2010, and had increased to 69% in 2014.

Beyond 2020, the EU Commission has proposed a target for the share of renewable energy in the European Union in 2030 of at least 27%.

Electricity

Electricity certificate system

As its main measure to meet the 2020 RES target, in 2012 Norway joined the Swedish electricity certificate market, which has existed since 2003. Under this joint market, Norway and Sweden will increase their renewable electricity generation by 28.4 TWh from 2012 to the end of 2020 (an average of 3.2 TWh yr). Of this total, Norway finances and is accredited with 13.2 TWh. It is left to the market to determine where, when, and by which technology this electricity will be generated. (Please see chapter 6 for more information on the Norwegian and Nordic electricity systems.)

Both countries will also finance renewable energy production in plants commissioned before 1 January 2012 and eligible for electricity certificates. These plants are not included in the joint target.

New plants, and production increases in existing plants, are eligible for electricity certificates for up to 15 years, although not after the end of 2035. Hydropower plants commissioned after 1 January 2004 receive electricity certificates for 15 years from the date of approval, less the period the plant had been in operation before 1 January 2012.

The certificate market works as follows:

- The energy producers receive one electricity certificate for each megawatt of renewable energy produced, over a maximum of 15 years.
- The electricity certificates are sold in a market in which prices are determined by supply and demand. In this way, the producers receive extra income in addition to the energy price.

- The demand for electricity certificates arises because energy suppliers and certain electricity customers are obliged by law to buy electricity certificates that correspond to a certain proportion (quota) of their calculation-relevant electricity consumption.
- The electricity end users pay for the development of renewable energy production, because the cost of the electricity certificates is included in electricity bills.
- Every year, the market participants with quota obligations must cancel electricity certificates to fulfil their quota obligation.

The average market price traded in the spot market for electricity certificates was NOK 145 (Norwegian kroner) per megawatt hour (NOK/MWh) in 2015. This represents a fall in price of 12% from 2014. The electricity certificates prices ranged between NOK 130/MWh to NOK 165/MWh. The average of cost of the certificates per Norwegian household that consumed 20 000 kWh per year in 2015 was NOK 19 per MWh, according to the 2015 annual report of the system by the NVE and the Swedish Energy Agency (2015), the regulatory authorities.

By mid-2016, the electricity certificate system had contributed 16.4 TWh of new renewable electricity supply (normalised annual generation) since the beginning of 2012. Out of this total, 2.9 TWh was built in Norway and 13.5 TWh in Sweden.

In spring 2016, Norway's government decided not to set new targets in the electricity certificate system after 2020, as stated in the April 2016 White Paper on energy policy (MPE, 2016). The government sees the certificate system as affecting the functioning of the Nordic electricity market. Instead, the government wants to change the focus from the support of mature generation technologies to innovation and the development of new energy and climate solutions.

The government had already stated this position in the 2014 position paper on the EU 2030 targets, in which it underlined the importance of well-functioning power and energy markets. According to the government, to give the right incentives to investors and consumers in the long term, power prices should reflect the actual cost. Markets also need a predictable policy framework that outlines how different policy measures will work together. The government also views that measures taken to support the further development of renewables should be designed to avoid adverse market effects, both nationally and over borders.

The small volume of new renewable energy produced in Norway under the electricity certificate system may also be caused by the relatively heavy taxation on power generation in Norway. Investment is further discouraged by the current low wholesale electricity prices in the Nordic market area, which is structurally oversupplied, and this trend is growing. Since the 2010 peak, the combined electricity demand in Norway, Sweden, Denmark, and Finland has declined by 4% to 358 TWh in 2015, whereas the combined electricity generation has increased by 3% to 403 TWh.

Hydropower taxation

As well as the regular corporate tax, large hydropower, with an installed capacity of at least 10 megavolt amperes, is taxed with a resource tax (*grunnrenteskatt*). This is a specific tax introduced to compensate for the high revenue from the hydropower sector compared with that from other industries. The access to water streams gives hydropower plants low operating costs that enable high profits, which motivates the resource tax. A similar tax is used in Sweden as well, in terms of a high property tax for hydropower plants.

In a new tax shift programme introduced in 2015, the resource tax has increased from 31% to 34.3% in 2017, compensated by a reduction in the corporate tax from 27% to 24% (Ministry of Finance, 2017). The government claims that the total tax level for the hydropower sector remains unchanged after this tax shift (Ministry of Finance, 2016), but the energy industry does not agree.

The resource tax does not allow for a deduction of interest on debt. Instead, a deduction based on the risk-free rate of return is allowed for. The risk-free rate of return is used because the tax is designed so that the government "guarantees" for its share of the investment costs. At today's interest rates, the deductions allowed for in the resource tax are lower than the actual interest payed by the companies. As interest on debt is directly deductible in the corporate tax, the energy industry argues that shifting the tax from a corporate to a resource tax increases the total tax level. Pöyry Management Consultancy (Pöyry) has, on behalf of Energy Norway and the Federation of Norwegian Industries, analysed the new tax levels. They concluded that new hydropower investments that are based on a 60% debt[1] will be taxed more highly in the new tax regime (Pöyry, 2016).

As electricity wholesale prices have declined throughout the Nordic electricity market, a tax increase will further discourage new investments, both in refurbishment of existing plants and in new capacity. Pöyry estimates additional annual electricity generation to 4 TWh from improving the existing fleet and 2.6 TWh from adding new hydropower capacity. Furthermore, the study claims that 80% of planned investment in new capacity and 25% in refurbishment and maintenance risk being abandoned under the current low electricity prices and hydropower tax regime (Pöyry, 2016). This would put a total electricity generation of approximately 3 TWh in jeopardy.

In contrast, in Sweden the government has agreed to lower the property tax on hydropower to 0.5% by 2020, which is the same tax level as for other power plants.

Wind power development

In the April 2016 White Paper on energy policy to 2030 (MPE, 2016), the government states that it will facilitate the long-term development of profitable (unsubsidised) wind power generation in the country. To this end, the MPE will develop a national framework to license onshore wind power projects. It also intends to identify the sea areas most appropriate to be opened for potential offshore wind power projects.

Heat

For renewable heat, several public support schemes are available, mainly from Enova and Innovation Norway, but also from some municipalities.

Enova offers investment subsidies in renewable heat for both households and industries. For households, these comprise investment grants for bioboilers and biostoves with water jackets. The subsidy is 25% of the investment costs up to NOK 10 000. The

[1] The 60% debt level is chosen in the Pöyry study as a normal level for new hydropower investments, based on the debt level in the 25 largest hydropower producers in Norway.

subsidy may be combined with the subsidy to remove oil boilers and tanks and the subsidy to modify to water-borne heating. Enova also subsidises solar thermal collectors for households. The subsidy covers 25% of the investment costs up to NOK 10 000 plus NOK 200 per square metre (m^2) up to 25 m^2.

Enova's programme for environment-friendly district heating offers subsidies of 45% of the investment costs for district heating and cooling from renewable sources. It applies to new and existing plants and it may also be granted to convert a heat power plant to use renewable energy.

Subsidies for local heating plants aim to support the installation of local heating plants from renewable sources. The programme supports the following renewable sources: woodchips, pellets, briquettes, air-to-water and liquid-to-water heat pumps, and solar thermal collectors. The investment subsidy is calculated based on the installed capacity for bioenergy and heat pumps. The subsidy covers 45% of the investment costs up to NOK 1 million. In 2015, Enova supported renewable heating projects that correspond to 367 gigawatt hours (GWh), of which 40% were related to energy source conversion. This equals the annual heating needs of around 22 000 households (Enova, 2016).

Enova also subsidises investments in the sustainable production of bioenergy. Projects to upgrade biogas are also eligible for the investment subsidy. The production of biofuels from raw materials that may alternatively be used for food production is not eligible for the subsidy. Annual production of biogas has to be at least 1 GWh (about 100 000 newton cubic metres of methane). In 2015, Enova granted investment subsidies of NOK 83 million to two plants, which resulted in a contractual energy of 139 GWh (Enova, 2016).

Innovation Norway has a bioenergy programme for the agricultural sector to encourage farmers and forest owners to produce, use, and deliver bioenergy in the form of biofuels (solid and biogas) or heat. Direct investment subsidies are granted for investments in commercial heat plants, heating plants in the agricultural sector, heating in greenhouses, the production of biogas, and driers and storage for woodchips produced for sale:

- Heat sales facilities up to 4 MW may be supported by up to 40% of the investment costs up to NOK 8 million.
- Heating plants in the agricultural sector may be subsidised by up to 33% of investment costs up to NOK 1 million.
- Heating in greenhouses up to 2 MW is supported by up to 35% of the investments up to NOK 8 million.
- The investment subsidy for biogas production is up to 45% of the investment costs.
- The investment subsidy for driers and storage for woodchip production for sale is up to 25% and NOK 1.68 million.

Transport

Renewable energy use in transport mostly comprises biofuels, but Norway is also promoting the use of electric vehicles, which are fuelled by electricity from renewable sources, by a suite of measures (see chapter 3).

To increase the use of biofuels, the government introduced in 2009 a binding biofuels sales obligation that equalled 2.5% of the volume of fuel supplied to the road transport sector. This obligation has been gradually raised and in 2016 it was at 5.5%. From the beginning of 2017, the target was increased to 7%. Through a new sub-obligation of 1.5%, the increase from 5.5% to 7.0% is to be met by advanced biofuels (produced from waste, residue, lignocellulosic material, and cellulosic material other than food). Biofuels consumption in Norway is practically entirely covered by imports. In December 2016, the parliament asked the government to increase the biofuels content in transport fuels to 20% in 2020. The government aims to have a public consultation on the 2018–20 levels in 2017.

Norwegian authorities adopted the European Union's sustainability criteria for biofuels and bioliquids in January 2014. All the biofuels and bioliquids counted for compliance with the 2020 renewables target or the binding sales target must meet sustainability criteria. Also in January 2014, double counting (as allowed under Directive 2009/28/EC) towards the 2020 renewables in transport target was introduced for biofuels produced from waste, residue, lignocellulosic material, and cellulosic material other than food. The aim is to promote the conversion to more advanced biofuels with a higher sustainability that does not compete with food production.

Assessment

Renewable energy accounts for more than two-thirds of the total energy consumption and this share has been increasing because Norway is obliged to reach its 2020 target under the EU renewable energy directive. This high share of renewable energy makes Norway a leading low-carbon country. As 96%-98% of the power production comes from renewable sources and heating systems are mostly electric, the potential for further increases in new renewable energy exists mainly in the transport and industry sectors.

The power market is organised in a decentralised and flexible manner, as 60% of the hydro capacity is in reservoirs, which can be activated quickly when needed. Historically, the seasonal accumulation was important to guarantee a security of supply during periods of low inflows. Today, with integrated markets and the expected increased interconnector capacity, the flexibility can be deployed to balance the variable production of variable RES. As it accounts for about half of the reservoir capacity in Europe, Norway has the potential to supply clean and competitive flexibility to other countries. For Norway to be able to play a major role as a "blue battery" (supply hydro power storage capacity) in the international market, it is important that adequate frameworks and market instruments that allow short-term trading are introduced (see chapter 6).

The market-based electricity certificate system has proved to be an efficient way to reach higher renewable energy shares. However, as stated in the 2016 White Paper on energy policy (MPE, 2016), the government is not going to set new targets under the electricity certificate system after 2020. This can be explained by the fact that the electricity supply is already almost entirely renewable and consists of a mature and commercially viable technology that does not need a support scheme. Therefore, actors in the power market should base their investment decisions on market signals.

Generally, low power prices indicate a reduced profitability of the hydropower fleet. This has not resulted in plant closures, as they produce at a very low marginal cost, but some plants have indicated it is difficult to pay for general maintenance as the revenues decline. As the power plant fleet is ageing, there is an increasing need for large investments to refurbish, but these are currently postponed. Also, the investments to make plants more flexible so that they meet the expected increased demand in balancing energy are not profitable. In the case that prices remain low for a longer period and the sector signals a potential substantial loss of the existing capacity, measures should be considered to guarantee the security of supply. Linked to this, Norway and the other governments in the Nordic electricity market area should co-ordinate and harmonise RES subsidy policies and measures to avoid creating an oversupply of power that leads to wholesale prices too low to trigger investments in an otherwise profitable low-carbon electricity capacity.

Onshore wind capacity has increased quickly in recent years. Norway has very good wind conditions and thus a remarkable potential for this technology. However, the growth in the wind sector depends on the certificate system or on other support, as the technology is not competitive at the current wholesale electricity prices. After 2021, wind power will be installed only if the market signals a need for further electricity production and if wind power is able to compete with hydropower. Offshore wind offers an even greater potential, but the technology needs to mature to become competitive.

The renewable energy share in heat and transport fuels is small. The installation of fossil heating in new buildings is already prohibited and a ban in existing buildings from 2020 is currently under discussion. To sustain the heating alternatives, several public support schemes provided by Enova, Innovation Norway, and some municipalities are in place. In general, the substitution of electric heating with other renewable heating systems as biomass or heat pumps will not have an impact on long-term GHG emissions, but will reduce peak load and make electricity available for the international trade.

The use of bioenergy has a large potential, but it has declined in the past few years. This is primarily because of the shutdown of capacity in the pulp and paper industry, which uses its waste wood for energy. On the one hand, the low electricity prices make bioenergy a less-attractive heating solution. On the other hand, the increased use of biofuels in the transport sector, stimulated by the higher biofuels sales obligation, could lead to a rise in demand and therefore in the value of biomass. The IEA welcomes the government's decision to raise the biofuels sales obligation to 20% from 2020 on.

Recommendations

The government of Norway should:

- ☐ Support the development of a harmonised regulatory framework and market instruments, such as the introduction of shorter products, that maximise the flexibility value of hydropower, especially as more interconnection capacity becomes available.
- ☐ Ensure fiscal conditions (e.g. the resource rent tax) do not discourage investment in hydropower maintenance and refurbishments.

References

Enova (2016), *Results and activities 2015*, Enova, Trondheim, http://viewer.zmags.com/publication/9513c0bc#/9513c0bc/1.

IEA (International Energy Agency) (2017), World Energy Balances - 2017 Preliminary edition, *www.iea.org/statistics/*.

IEA (2016), Renewables Information (database), www.iea.org/statistics/.

Ministry of Finance (2017), Skattesatser 2017, Oslo, www.regjeringen.no/no/tema/okonomi-og-budsjett/skatter-og-avgifter/skattesatser-2017/id2514837/.

Ministry of Finance (2016), Uendret skatt og bedre investeringsinsentiver for norsk vannkraft, Oslo, www.regjeringen.no/no/aktuelt/uendret-skatt-og-bedre-investeringsinsentiver-for-norsk-vannkraft/id2518140/.

MPE (Ministry of Petroleum and Energy) (2016), Kraft til endring — Energipolitikken mot 2030 [Power for Change – an Energy Policy towards 2030], Oslo, www.regjeringen.no/no/dokumenter/meld.-st.-25-20152016/id2482952/sec4.

MPE (2015), FACTS 2015 – Energy and Water Resources in Norway, MPE, Oslo, www.regjeringen.no/contentassets/fd89d9e2c39a4ac2b9c9a95bf156089a/facts_2015_energy_and_water_web.pdf.

NVE (the Norwegian Water Resources and Energy Directorate) and the Swedish Energy Agency (2016), The Norwegian-Swedish Electricity Certificate Market. Annual report 2015, NVE and the Swedish Energy Agency, Stockholm, Oslo, www.nve.no/Media/4750/elcertifikat-2015-en_web.pdf.

Pöyry (Pöyry Management Consultancy) (2016), Langsiktige konsekvenser av dagens vannkraftbeskattning, Pöyry, Oslo, www.energinorge.no/contentassets/1ac12b3d210d48c4afcca91066e9f335/langsiktige-konsekvenser-av-dagens-vannkraftbeskatning.pdf.

8. Energy technology research, development, and demonstration

Key data
(2015)

Government energy RD&D spending: NOK 2 471 million

Share of GDP: 0.12% (IEA median*: 0.028)

RD&D per capita: NOK 716

* Median of 16 IEA member countries for which 2015 data are available.

Overview

Research, development, and demonstration (RD&D) on energy and petroleum is one of the Norwegian government's priorities. Norway's public funding for energy and petroleum RD&D has multiple objectives. It should contribute to long-term value creation and a secure, cost-effective, and sustainable utilisation of Norway's energy and petroleum resources, strengthen the development of new technology and competence building, and contribute to an increased competitiveness in the energy and petroleum industry. The government's vision is to make Norway a global leader in green energy, and to develop and implement new solutions is a key element in fulfilling this ambition.

The Ministry of Education and Research is responsible for the basic research and co-ordination of the government's general RD&D policies, and individual ministries are responsible for funding RD&D within their sector. The Ministry of Petroleum and Energy (MPE) is thus in charge of Norway's policy for petroleum and energy RD&D. Almost all the MPE funding for energy research and development (R&D) is channelled to the Research Council of Norway (RCN), which administrates the national petroleum and energy R&D programmes. The MPE also funds energy technology development and demonstration through several other bodies, mainly Enova and Gassnova.

The RCN is the government's strategic and advisory body on R&D. It has a key role to finance and follow up R&D as well as to advise the government on policy. The RCN distributes close to 30% of public R&D spending in Norway, mainly to higher education, research institutes, and industry. Higher education is principally funded by the Ministry of Education and Research, but other ministries also fund specific institutes and industry. In addition to the ministries and RCN, industry and academia also participate in the design and review of high-level strategic plans, in developing programmes, and within individual projects. Publicly funded demonstration programmes and projects are administered by several public agencies.

In an effort to develop national RD&D strategies for the petroleum and the energy sector, the MPE launched the OG21 (Oil and Gas in the 21st century) strategy in 2001 and the Energi21 strategy in 2008. These strategies and the related major RD&D programmes are detailed below. The government also funds several other bodies that support energy technology development and demonstration, mainly Enova, Gassnova, and Innovation Norway.

Strategies

Norway has two major strategies for energy RD&D: OG21 for the petroleum sector and Energi21 for the energy sector (which includes carbon capture and storage [CCS)]. The strategies set the priorities for the distribution of the MPE RD&D funding. The strategies and their respective list of thematic priority areas are used also by the RCN to run the different petroleum and energy programmes. Co-ordination between OG21 and Energi21 is ensured by contact between the respective secretariats and also between the boards of the two strategies (see below).

OG21

The OG21 strategy was established on the initiative of the MPE in 2001. It aims to provide a unifying national technology strategy for the oil and gas industry. It also aims to contribute to an efficient and environmentally friendly value creation from the Norwegian continental shelf (NCS) for several generations, and to develop world-class petroleum expertise and industry enterprises. It has a board of directors, determined by the MPE, with members and observers drawn from industry, academia, and government departments (the MPE, the RCN, and the Norwegian Petroleum Directorate), and a Secretariat located in the RCN. The OG21 strategy and pertinent issues are discussed at the OG21 Forum at which all interested parties can contribute. Depending on circumstances, the strategy is reviewed every five years.

The OG21 strategy was last updated in 2016. It now includes cross-thematic topics such as digitalisation and barriers to technology implementation and adoption. The main priorities in the new strategy are reflected through the following four technology target areas:

- energy efficiency and environment
- exploration and increased recovery
- drilling, completions, and intervention
- production, processing, and transport.

To ensure a commitment from industry, follow-up groups are primarily led by oil and gas companies. The strategy constitutes the foundation of the roadmap for the necessary research and technology development in Norwegian oil and gas activities, and is implemented through the PETROMAKS 2 and DEMO 2000 programmes (see below).

Energi21

Energi21 was adopted in 2008 on the initiative of the MPE as the national RD&D strategy for the Norwegian energy sector. It is a strategic body for the RD&D and commercialisation of new energy technologies. The main purpose is to provide the authorities and the energy community with recommendations on the strategic priority areas for efforts to develop new environmentally friendly solutions in the energy sector. In October 2016, the mandate was expanded to also include the energy use in transport. It has an industry-led board, appointed by the MPE, with representatives from energy companies, technology suppliers, research communities, and the authorities. The Energi21 strategy documents are drawn up in co-operation and broad consultation with trade and industry, academia, and the relevant authorities. The strategy is implemented by the ENERGIX programme and the Centres for Environmentally Friendly Energy Research (FMEs).

Energi21 was revised in 2011 and again in 2014. A review is planned roughly every three years, with the next one in the first half of 2018. In the strategy report from 2014, the Energi21 board recommends a strong growth in public funding for RD&D within the following six areas:

- hydropower
- flexible energy systems
- solar power
- offshore wind power
- energy efficiency
- CCS.

These are the areas in which Norway is expected to enjoy competitive advantages in future energy markets, thanks to its natural energy resources, substantial technology and competence base, and widespread industrial experience. Among the six areas, the Energi21 board recommends devoting special attention to hydropower and flexible energy systems. These two areas represent the very foundation of Norway’s energy system and are critical for current as well as future value creation, both nationally and internationally.

In addition, the board stresses how important it is to maintain and continuously develop the competence platform that underpins all the energy-related thematic and technology areas.

Programmes and supporting bodies

The OG21 and Energi21 strategies are implemented through four main programmes and the centre schemes. The OG21 strategy is implemented through the PETROMAKS 2 and DEMO 2000 programmes, while the Energi21 strategy is implemented mainly through the ENERGIX programme and the FMEs. The CLIMIT programme has been set up for the RD&Din CCS.

The RCN ensures the co-ordination between the administrations of the different programmes. Co-operation between the programmes within each sector (i.e. energy sector/petroleum sector) is close, for example that between ENERGIX and the FMEs. There is also collaboration between the sector programmes – PETROMAKS 2 and ENERGIX have implemented a joint call for proposals directed at projects in the thematic interface between the two programmes. Moreover, the RCN, Enova, and Innovation Norway co-ordinate their activities through a mutual agreement.

Programmes

PETROMAKS 2

The PETROMAKS 2 programme started in 2013 and succeeds the PETROMAKS programme, which was established in 2004. The programme is to run for ten years and promotes knowledge creation and industrial development to enhance the value creation for society by ensuring the development and optimal management of Norwegian petroleum resources within an environmentally sustainable framework.

The programme supports both basic research and applied research to generate expertise and innovations that will lead to:

- A reduction of the environmental impact and level of risk related to petroleum activities on the NCS.
- Higher recovery rates from new and existing fields.
- More discoveries of oil and gas.
- More environmentally sound and cost-effective drilling and well technology.
- Cost-effective and energy-efficient production solutions for the NCS.
- Improved solutions in the areas of health, safety, and the work environment.
- Enhanced petroleum-related industrial development in Norway and abroad.
- Competence building and recruitment adapted to the needs of society and the industry.

Based on the revised OG21 Strategy, the programme will also support cross-disciplinary projects that include social sciences.

DEMO 2000

The DEMO 2000 programme was set up to help demonstrate and pilot specific projects, both to increase the value of the exploration and development of hydrocarbon resources on the NCS and to develop Norwegian products and services for the global offshore market. The supported projects are concentrated in focus areas of the OG21 strategy, which includes exploration and an improved hydrocarbon recovery.

In more detail, DEMO 2000 will implement pilot testing and demonstration of new technology with the aim to:

- Ensure the ongoing development of technology for the recovery of petroleum on the NCS to promote the optimal operational efficiency, reduce investment, and decrease emissions to the air and sea.
- Ensure that the Norwegian oil and gas industry can, through its use of technology tested and qualified under the DEMO 2000 programme, remain competitive nationally and internationally and thus safeguard the existing jobs and employment in Norway.
- Safeguard health and safety by reducing the risk of accidents and increasing the technical integrity of the equipment used to produce, process, and transport oil and gas on the NCS.

Since 2000, around 250 pilot and demonstration projects have been carried out at a total cost of around NOK 3 billion (Norwegian kroner), of which around NOK 750 million has been government funded, according to the RCN. DEMO 2000 may provide up to 25% of the costs associated with the piloting, demonstration, and/or qualification of the technology. The remaining costs are to be covered by the supplier industry and the participating petroleum company.

Both PETROMAKS 2 and DEMO 2000 attract supplementary funding from oil companies and contractors through the joint funding of projects. Several projects commence and develop in PETROMAKS and continue with the demonstration in DEMO 2000, although there is no forced dependence between the two programmes.

Research centres for petroleum activities (PETROSENTER)

Two petroleum research centres were established in 2013 because of the government's White Paper *An industry for the future – Norway's petroleum activities (*MPE, 2011*)*. The research centres are time limited (a maximum of eight years), and are characterised by broader objectives, a longer-term perspective, and a more-targeted focus to solve the identified challenges to exploit the Norwegian petroleum resources. The centres are also expected to stimulate researcher training in fields of importance to the user partners and to encourage the transfer of research-based knowledge and technology.

The centres must be co-funded by the host institution, research partners, user partners, and the RCN. The user partners are expected to participate actively in the governance, financing, and research activities at the centres. They must also conduct significant innovation activities of their own as well as be able to take advantage of the research results when they develop their activities.

The two centres are:

- the National Centre for Improved Oil Recovery (IOR Centre)
- the Research Centre for Arctic Petroleum Exploration (ARCEx).

ENERGIX

The ENERGIX programme was launched in 2013 and will run for ten years. It continues the activities of the Clean Energy for the Future (RENERGI) programme (2004-13). ENERGIX provides funding for research on renewable energy, the efficient use of energy, energy systems, energy policy, and energy in transport. This encompasses R&D based on technology, natural sciences, and social sciences.

ENERGIX is an important instrument to implement the Energi21 strategy. It is targeted towards Norwegian companies and research and educational institutions that can enhance long-term competence building to develop further the energy industry and related industries, such as the energy processing industry and the supplier industry.

The ENERGIX programme is designed to provide support for the long-term, sustainable restructuring of the energy system to accommodate a greater supply of renewable energy, improve the efficiency and flexibility, and facilitate closer energy integration with other European countries.

The programme is expected to help generate knowledge and cutting-edge solutions related to the following five primary targets:

- achieve a sustainable utilisation and efficient consumption of Norway's renewable energy resources.
- reduce the Norwegian and global emissions of greenhouse gases (GHGs).
- ensure Norway's security of energy supply.
- strengthen innovation in Norwegian trade and industry.
- develop Norwegian research communities.

In the 2016 White Paper to the Parliament on energy policy towards 2030 (MPE, 2016), the government proposes to develop further the instruments for the innovation phase between technology development and market introduction. One possibility considered is to adjust ENERGIX to support projects further along the innovation chain than today (i.e. support projects with higher technology readiness levels).

ENERGIX co-operates with Enova and Innovation Norway to address synergies and gaps between their activities and funding mechanisms and to ensure that these funding agencies are streamlined throughout the innovation chain. For 2017, the plan is to test a new instrument called PILOT-E that will increase the development and introduction of new energy technology in Norway.

PILOT-E is a financing tool for industry, set up by RCN (under the ENERGIX programme), Innovation Norway, and Enova. It aims to promote energy technology development through integrated projects that involve a broad range of participants from the research community, industry, and the public. It covers the whole project development from research to the testing of new concepts under real operating conditions. Funding is granted phase-by-phase, i.e. a PILOT-E project receives funding for the next phase after it has met the objectives and criteria for the preceding one. RCN and Innovation Norway allocated NOK 70 million for PILOT-E for a call (for emission-free sea transport) in 2016 and five projects were chosen. The total support from Enova will come later, as the projects reach their milestones.

CLIMIT

CLIMIT is the national programme for the RD&D of technologies for carbon capture, transport, and storage from power generation and industry. The programme covers both RCN's support programme for R&D (CLIMIT RD&D) and Gassnova's support programme for development and demonstration of technology for carbon capture and storage (CLIMIT Demo). It thus supports projects in all stages of the development chain up to commercialization. The programme is aimed at Norwegian companies, research institutions and universities, preferably in co-operation with international companies and research institutions, which can help accelerate CCS commercialization (see chapter on CCS).

CLIMIT supports the development of knowledge, technology and solutions that may in turn result in cost reductions and broad international proliferation of CCS. At the same time, CLIMIT will contribute to leverage national advantages and development of new technology and service concepts with international potential.

CLIMIT's objectives are to promote:

- lower costs and earlier international realisation of CCS
- CCS in Norwegian enterprises
- the realisation of the storage potential in the North Sea
- knowledge and expertise to close technology gaps and increase safety
- ground-breaking technologies and service concepts with international potential.

FMEs

The FME scheme is a long-term initiative designed to generate solutions to climate- and energy-related challenges, and to promote innovation and industrial development. The centres comprise dynamic research groups in close co-operation with a large number of user partners from the trade, industry, and the public sector, and in broad co-operation with international players. The user partners will take an active part in the centres' management, financing, and research activities. The FME scheme is administered by the RCN.

In early 2009, the MPE established eight technology-oriented FMEs. In 2011, three social-science-oriented FMEs were started. The eight FMEs from 2009 came to an end in 2016/2017. In May 2016, the RCN granted funding to eight new technology-oriented FMEs. From competing applications in response to a call for proposals, the centres were selected based on scientific merit, the potential for innovation and value creation, and the extent to which they fulfil the objective of the call.

Each new centre is guaranteed an annual allocation of NOK 15-25 million for up to eight years. The new FMEs will start in 2017. The centres will work to reduce GHG emissions in Norway and internationally, utilise energy more efficiently, and increase the production of renewable energy. Another important task is to disseminate the results of their research and contribute to a knowledge-based debate on environment-friendly energy. The new centres cover the areas of hydropower, smart grids, energy efficiency in trade and industry, environment-friendly transport, carbon dioxide (CO_2) management (CCS), solar cells, biofuels, and zero-emission urban zones.

The total annual allocation from the RCN to the 11 FME centres is NOK 190 million in 2017. The centres are co-financed by the host research institution and its research partners (up to 25%), the user/industry partners (at least 25%), and the RCN (up to 50%).

Monitoring and evaluation

The RCN has an extensive system for evaluations. Programmes and funding schemes are evaluated both halfway and after completion. The RCN also carries out subject-specific evaluations, e.g. of Norwegian RD&D in the energy or climate field, as well as institute evaluations and evaluations of political reforms.

In 2012, as the two largest R&D programmes in the energy field were about to conclude and new programmes were being established, the MPE carried out an evaluation of the programmes and the R&D system in the energy field as a whole. Similar evaluations can be carried out as needed.

The MPE, as well as other funding ministries, receive an annual report from the RCN with information about funding, budget allocations, activities, and results. A new system, common for all ministries, for target-oriented management of the RCN is under development. The system will include common targets and better key performance indicators that are less activity oriented and more result oriented. The Ministry of Education and Research is responsible for developing the new system, in co-operation with the other funding ministries.

Supporting bodies

Enova

Enova is the national agency to promote energy efficiency, renewable energy, new energy, and climate technology. It is owned by the MPE. It operates targeted programmes and support schemes and provides funding for projects that are close to market deployment. Enova focuses on launching investments in large-scale demonstration projects in industry, buildings, and transport. It covers up to 50% of investment costs in the projects. In recent years, project applications have ranged from less than NOK 1 million to more than NOK 1 billion. Enova's budget for 2016 was around NOK 3 billion.

In January 2015, Enova took over tasks, previously conducted by Transnova, that aimed to limit the emissions in the transport sector. This includes support for energy and climate technology related to both land and maritime transport. Electrification of and hydrogen use in transport are central, but also biofuels and biogas are promoted.

Enova, RCN, and Innovation Norway co-operate closely on promoting investments along the "innovation chain". Enova is also member of the Energi21 strategy board.

Innovation Norway

Innovation Norway is the government's most important instrument for the innovation and development of enterprises and industry in all the sectors, including energy. The programmes and services are intended to create more successful entrepreneurs, more enterprises with the capacity for growth, and more innovative business clusters. They aim to promote technology through international networking services, general entrepreneur advice services, and aid for third-party technology verification.

Specifically, Innovation Norway's environmental technology programme contributes to developing and testing green technology. The programme was launched in 2010, and its funding has increased from the initial NOK 140 million to NOK 465 million in 2016. For businesses, the programme facilitates carrying out pilot tests by reducing the associated financial risk.

Gassnova

The state enterprise Gassnova helps find solutions to ensure that the technology for capture, transport, and storage of CO_2 can be implemented and become an effective climate measure. Gassnova advices the authorities on CCS and, together with RCN, it funds the CLIMIT programme, through which it grants financial support to develop, demonstrate, and pilot CCS technologies.

Gassnova also manages the state's interest in the CO_2 Technology Centre Mongstad (TCM), which operates in the long-term and targeted development, testing, and qualification of technology for CO_2 capture. Moreover, Gassnova has experience from planning full-scale CCS projects. It is also active in the international dissemination of this experience (see chapter 5).

Public funding

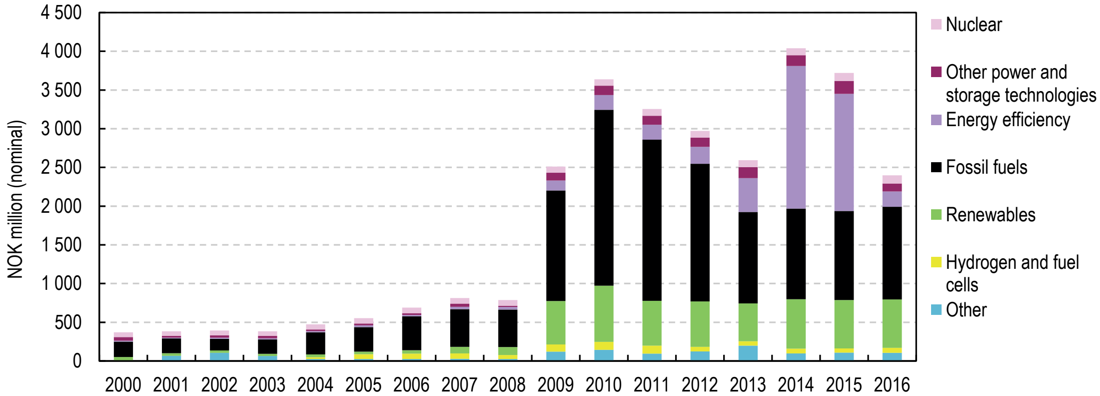
The government has dramatically increased spending on energy RD&D since late in the previous decade, in particular after the parliament's 2008 Climate Agreement. Although the annual government spending on energy RD&D averaged around NOK 540 million from 2000 to 2008, the average for the 2009-16 period was more than five times higher, NOK 2 800 million.

For 2009-12, the increase in supported efforts on CCS (shown in the fossil fuels category of Figure 8.1) focused specifically on the construction of the TCM. In 2014-15, a large-scale demonstration of industrial energy efficiency was funded. The funding of large individual demonstration projects also explains the relatively large year-on-year variation in funding levels this decade.

In the 2009-16 period, public funding for energy RD&D totalled NOK 25.2 billion. Fossil fuel projects, mostly CCS, received around half of the total (48.6%), whereas almost one-fifth was allocated to both renewable energy (19.2%) and energy efficiency (18.7%). The rest was spent on hydrogen and fuel cells (2.3%), nuclear energy (2.9%, including for the Organisation for Economic Co-operation and Development Halden reactor project), other power and storage (4%), and other cross-cutting research (4%).

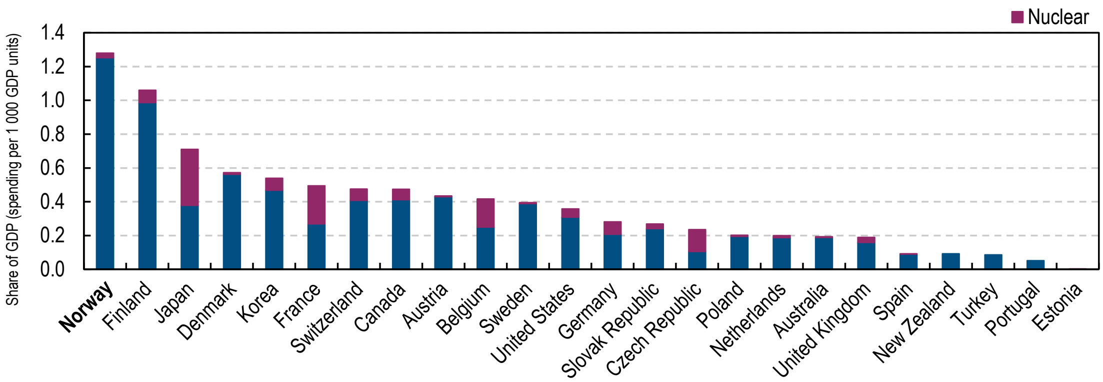
By international comparison, Norway's government spending on energy RD&D per gross domestic product (GDP) has been one of the highest, in 2014-15 the highest, among the International Energy Agency (IEA) member countries (Figure 8.2). In 2016, however, this share is set to decline significantly as funding for energy efficiency RD&D dropped but practically did not change for the other areas.

Figure 8.1 Government energy RD&D spending by category, 2009-16



Source: IEA (2016), *Energy Technology RD&D* (database), www.iea.org/statistics/.

Figure 8.2 Government energy RD&D spending as a ratio of GDP in the IEA member countries, 2014



Source: IEA (2016), *Energy Technology RD&D* (database), www.iea.org/statistics/.

International collaboration

International collaboration is a cross-cutting policy goal for Norwegian research, and energy research is closely tied to the international energy research community. Norway participates in a multilateral co-operation with the IEA, the European Union, and the Nordic countries. It also participates in Mission Innovation and has bilateral RD&D agreements with countries such as the United States and Brazil.

Norway participates in 21 of the IEA's Technology Collaboration Programmes (TCPs) (former Implementing Agreements), including end-use technologies, renewable energy, and petroleum. Norway (the MPE) is chairing the Gas and Oil Technologies TCP, and it (the RCN) is one of the Vice Chairs in the Renewable Energy Working Party.

Norway is a founding member of Nordic Energy Research, an institution under the Nordic Council of Ministers that aims to promote and extend regional co-operation in energy RD&D on topics such as energy market integration, sustainable energy, and energy efficiency.

Through the European Economic Area agreement, Norwegian research institutions and companies can participate fully in EU Horizon 2020 – the EU Framework Programme for Research and Innovation (2014-20). Energy is one of the priority thematic areas that focus on energy efficiency, low-carbon energy, and smart cities and communities, among others. So far in Horizon 2020, Norwegian energy research institutions and companies have succeeded quite well in the yearly calls for proposals.

Norway participates in the steering group for the EU Strategic Energy Technology Plan (the SET Plan). As part of the SET Plan, Norwegian research institutes are members of the European Energy Research Alliance, and Norwegian companies participate in several European Technology and Innovation Platforms, particularly those on CCS and electricity grids.

Norway has participated in Mission Innovation since the start of the initiative in November 2015. Today, 22 countries and the European Union participate in the initiative. Mission Innovation aims to reinvigorate and accelerate public and private global clean energy innovation with the objective to make clean energy widely affordable. Each participating country will seek to double its governmental and/or state-directed clean energy R&D investment over five years. New investments will be focused on transformational clean energy technology innovations that can be scalable to varying economic and energy market conditions that exist in the participating countries and in the broader world.

Assessment

Since the last in-depth review in 2011, Norway has continued to carry out energy RD&D at a high level of ambition. Parliament's 2008 Climate Agreement meant that government funding for energy RD&D increased rapidly and it has remained at an exceptionally high level over recent years, which makes Norway one of the leading countries in public spending on energy RD&D per GDP. This very positive state of affairs reflects a political commitment to respond to the new energy challenges. The IEA applauds the government for maintaining this high level of funding and encourages it to continue doing so.

In recent years, several energy RD&D programmes have faced an oversubscription from high-quality projects for funding, so the government should consider raising the funding level even further. This could be done in the context of Mission Innovation, which Norway joined from the start in late 2015. Mission Innovation requires increases in RD&D spending, which would be most efficiently and effectively done as part of the existing programmes. This would also enable the funding of more high-quality projects.

Norway has two strategies for R&D in the energy sector. Since 2001, the OG21 strategy for the petroleum sector has brought together public and private sector stakeholders and the long timeframe of the strategy has helped research institutions to plan their work constructively. Since 2008, the Energi 21 strategy has done the same in the non-petroleum sector.

The two strategies are implemented through a set of well-designed programmes. Finding the right balance between excellence in RD&D and addressing the challenges for Norway's energy policy is a task for which priority-setting and evaluation are critical. For this purpose, it is also essential that a transparent interaction between programme owners, funding agencies, and different strategy bodies is maintained.

Companies in Norway have the potential to deliver successfully in various areas of energy technology worldwide. As Norway's domestic energy system itself does not require or even facilitate the demonstration and implementation of all these technologies and services, to promote them is more a matter of innovation and technology policy than of energy policy, which needs to be considered so that programmes for RD&D are designed to unlock this potential for the export markets. Energi21 and OG21 give important inputs to these processes.

To bring ideas to the market often needs facilitation at certain points in the innovation chain. This is often challenging. A new promising approach to facilitate innovation is the PILOT-E financing tool designed to provide a seamless path from research to deployment. The IEA welcomes this initiative.

It is sometimes difficult to identify the impact of RD&D programmes and projects. Increased spending will also increase the need to measure output to justify public money. The IEA encourages that increases in productivity and reductions of GHG emissions are considered as key performance indicators.

International collaboration has continued to be a priority for Norway's energy RD&D policy. The country is well represented in the IEA's technology collaboration programmes and has been active within the EU Horizon 2020 framework programme, for example. The IEA encourages the government to promote a proactive engagement in the design of international programmes for RD&D and innovation (e.g. the next EU framework programme for research and technological development [RTD] and innovation, and the IEA technology collaboration programmes). The government should also communicate to stakeholders how they can make best use of these programmes.

Recommendations

The government of Norway should:

- ☐ Determine the amount of funding needed for Mission Innovation commitments and use the additional funding to increase the number of high-quality energy RD&D projects above the evaluation thresholds.
- ☐ Secure a seamless path for innovation from research to deployment. Build this on the existing well-designed instruments, which bring together academia and companies. In this respect, evaluate and investigate the potential related to the new PILOT-E instrument.
- ☐ Measure and document the output of RD&D programmes and projects to optimise their impact. For the key performance indicators, use increases in productivity and the reduction of GHG emissions.
- ☐ Engage proactively in the design of international programmes for RD&D and innovation (e.g. the next EU framework programme for RTD and innovation, and IEA technology collaboration programmes), and communicate to stakeholders how they can make best use of these programmes.

References

IEA (International Energy Agency) (2016), *Energy Technology RD&D* (database), www.iea.org/statistics/.

MPE (Ministry for Petroleum and Energy) (2011), *An Industry for the Future – Norway's Petroleum Activities* (Meld. St. 28, 2010–2011), MPE, Oslo, www.regjeringen.no/globalassets/upload/oed/petroleumsmeldingen_2011/oversettelse/2011-06_white-paper-on-petro-activities.pdf.

Further reading

Research Council of Norway website, www.forskningsradet.no.

ANNEX A: Organisation of the review

REVIEW CRITERIA

The Shared Goals, which were adopted by the International Energy Agency (IEA) Ministers at their 4 June 1993 meeting in Paris, provide the evaluation criteria for the in-depth reviews conducted by the IEA. The Shared Goals are presented in Annex D.

REVIEW TEAM

The IEA in-depth review team visited Norway from 14 to 18 November 2016. The team met with government officials, energy suppliers, interest groups, and other organisations. This report was drafted on the basis of the review team's preliminary assessment of the country's energy policy and information on subsequent policy developments from the government and private sector sources. The members of the team were:

IEA member countries

Ms Florence Tordjman, France (team leader)

Ms Laura Antonini, Switzerland

Dr Andreas Indinger, Austria

Mr David Lerch, Germany

Ms Annemieke Schouten, the Netherlands

International Energy Agency

Mr Aad van Bohemen

Mr Matthew Wittenstein

Mr Miika Tommila

The review team is grateful for the co-operation and assistance of the many people it met throughout the visit. Thanks to their kind hospitality, openness, and willingness to share information, the visit was highly informative, productive, and enjoyable. The team expresses its gratitude to Secretary General Elisabeth Berge and the staff of the Ministry of Petroleum and Energy. In particular, the team thanks Ms Eli Jensen, Mr Knut Mansika, Ms Inger Ostensen and Ms Sadiya K. Jama for their professionalism displayed throughout the review process.

Miika Tommila managed the review and drafted the report, with the exception of chapter 5 (CCS, drafted by Thomas Berly) and chapter 6 (electricity, drafted by Matthew Wittenstein). Oskar Kvarnström drafted the case study on E-mobility in the energy efficiency chapter and, together with Jiyeon Lim, the supply and demand sections of the report.

The report was prepared under the guidance of Aad van Bohemen, Head of Energy Policy and Security Division. Helpful comments and updates were provided by the following IEA staff: Emanuele Bianco, Toril Bosoni, Rebecca Gaghen, Christina Hood, Volker Kraayvanger, Caroline Lee, Juho Lipponen, Cuauhtémoc López-Bassols, Brian Motherwell, Simon Mueller, Keisuke Sadamori, and Laszlo Varro.

Oskar Kvarnström and Jiyeon Lim prepared the figures and Bertrand Sadin prepared the maps. Roberta Quadrelli and Rémi Gigoux provided support on the statistics. Therese Walsh managed the editing process, and Astrid Dumond and Katie Russell managed the production process.

ORGANISATIONS VISITED

Center for International Climate Research (CICERO)

Energy Norway

Enova

Federation of Norwegian Industries

Gassnova

Ministry of Climate and Environment

Ministry of Foreign Affairs

Ministry of Local Government and Modernisation

Ministry of Petroleum and Energy

Ministry of Transport and Communications

Naturvernforbundet (Friends of the Earth Norway)

Nord Pool

Norwegian Oil and Gas Association

Norwegian Petroleum Directorate

Research Council of Norway

Norwegian Water Resources and Energy Directorate

Statkraft

Statnett

Statoil

ANNEX B: Energy balances and key statistical data

Energy balances and key statistical data

Unit: Mtoe

SUPPLY		1973	1990	2000	2010	2013	2014	2015
TOTAL PRODUCTION		**8.06**	**119.47**	**228.02**	**207.58**	**193.94**	**196.04**	**208.11**
Coal		0.29	0.20	0.42	1.30	1.25	1.12	0.74
Peat		-	-	-	-	-	-	-
Oil		1.51	83.66	167.75	99.37	84.36	86.69	91.66
Natural gas		-	24.14	46.27	95.18	95.58	94.96	102.10
Biofuels and w aste[1]		-	1.03	1.36	1.55	1.52	1.32	1.43
Nuclear		-	-	-	-	-	-	-
Hydro		6.27	10.42	12.20	10.04	11.02	11.65	11.86
Wind		-	-	0.00	0.08	0.16	0.19	0.22
Geothermal		-	-	-	-	-	-	-
Solar/other[2]		-	0.02	0.02	0.06	0.06	0.10	0.10
TOTAL NET IMPORTS[3]		**5.82**	**-96.55**	**-201.47**	**-173.69**	**-161.37**	**-168.72**	**-178.00**
Coal	Exports	0.09	0.17	0.39	1.14	1.39	1.08	0.75
	Imports	0.67	0.84	0.99	0.76	0.72	0.82	0.76
	Net imports	0.58	0.67	0.60	-0.38	-0.67	-0.26	0.00
Oil	Exports	3.55	77.25	161.62	91.79	76.35	82.03	85.97
	Imports	10.13	4.43	4.49	5.95	6.66	5.45	6.49
	Int'l marine and aviation bunkers	-0.90	-0.86	-1.18	-0.82	-0.85	-0.65	-0.69
	Net imports	5.68	-73.69	-158.31	-86.65	-70.54	-77.23	-80.16
Natural Gas	Exports	-	22.17	42.13	87.47	89.83	90.03	96.74
	Imports	-	-	-	-	-	-	0.01
	Net imports	-	-22.17	-42.13	-87.47	-89.83	-90.03	-96.73
Electricity	Exports	0.45	1.40	1.77	0.61	1.30	1.89	1.89
	Imports	0.01	0.03	0.13	1.26	0.87	0.55	0.63
	Net imports	-0.45	-1.37	-1.64	0.65	-0.43	-1.34	-1.26
TOTAL STOCK CHANGES		**0.41**	**-1.85**	**-0.39**	**0.02**	**0.04**	**0.49**	**-0.50**
TOTAL SUPPLY (TPES)[4]		**14.29**	**21.07**	**26.17**	**33.91**	**32.61**	**27.80**	**29.62**
Coal		0.91	0.86	1.05	0.76	0.78	0.85	0.82
Peat		-	-	-	-	-	-	-
Oil		7.56	8.13	9.03	12.86	13.66	9.97	10.90
Natural gas		-	1.98	4.14	7.75	5.73	4.94	5.39
Biofuels and w aste[1]		-	1.03	1.37	1.70	1.62	1.45	1.59
Nuclear		-	-	-	-	-	-	-
Hydro		6.27	10.42	12.20	10.04	11.02	11.65	11.86
Wind		-	-	0.00	0.08	0.16	0.19	0.22
Geothermal		-	-	-	-	-	-	-
Solar/other[2]		-	0.02	0.02	0.06	0.06	0.10	0.10
Electricity trade[5]		-0.45	-1.37	-1.64	0.65	-0.43	-1.34	-1.26
Shares in TPES (%)								
Coal		*6.4*	*4.1*	*4.0*	*2.3*	*2.4*	*3.1*	*2.8*
Peat		-	-	-	-	-	-	-
Oil		*52.9*	*38.6*	*34.5*	*37.9*	*41.9*	*35.9*	*36.8*
Natural gas		-	*9.4*	*15.8*	*22.9*	*17.6*	*17.8*	*18.2*
Biofuels and waste[1]		-	*4.9*	*5.2*	*5.0*	*5.0*	*5.2*	*5.4*
Nuclear		-	-	-	-	-	-	-
Hydro		*43.9*	*49.5*	*46.6*	*29.6*	*33.8*	*41.9*	*40.0*
Wind		-	-	-	*0.2*	*0.5*	*0.7*	*0.7*
Geothermal		-	-	-	-	-	-	-
Solar/other[2]		-	*0.1*	*0.1*	*0.2*	*0.2*	*0.4*	*0.3*
Electricity trade[5]		*-3.1*	*-6.5*	*-6.3*	*1.9*	*-1.3*	*-4.8*	*-4.3*

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Unit: Mtoe

DEMAND							
FINAL CONSUMPTION	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015**
TFC	**13.36**	**17.44**	**19.80**	**21.32**	**20.68**	**20.17**	**20.55**
Coal	0.82	0.78	0.95	0.59	0.61	0.62	0.61
Peat	-	-	-	-	-	-	-
Oil	7.31	7.36	7.51	8.55	8.07	7.94	8.05
Natural gas	-	-	0.59	0.74	0.91	0.95	0.97
Biofuels and waste[1]	-	0.90	1.20	1.30	1.06	0.88	0.96
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	-	-	-
Electricity	5.23	8.33	9.42	9.76	9.61	9.38	9.53
Heat	-	0.07	0.13	0.38	0.42	0.40	0.43
Shares in TFC (%)							
Coal	*6.2*	*4.4*	*4.8*	*2.8*	*3.0*	*3.1*	*3.0*
Peat	-	-	-	-	-	-	-
Oil	*54.7*	*42.2*	*37.9*	*40.1*	*39.0*	*39.4*	*39.2*
Natural gas	-	-	*3.0*	*3.5*	*4.4*	*4.7*	*4.7*
Biofuels and waste [1]	-	*5.2*	*6.1*	*6.1*	*5.1*	*4.4*	*4.7*
Geothermal	-	-	-	-	-	-	-
Solar/other [2]	-	-	-	-	-	-	-
Electricity	*39.1*	*47.8*	*47.6*	*45.8*	*46.5*	*46.5*	*46.4*
Heat	-	*0.4*	*0.6*	*1.8*	*2.0*	*2.0*	*2.1*
TOTAL INDUSTRY[6]	**6.95**	**7.87**	**9.03**	**8.33**	**8.11**	**8.11**	**8.28**
Coal	0.76	0.77	0.95	0.59	0.61	0.62	0.61
Peat	-	-	-	-	-	-	-
Oil	2.99	2.77	2.43	2.79	2.61	2.58	2.67
Natural gas	-	-	0.59	0.64	0.75	0.78	0.81
Biofuels and waste[1]	-	0.38	0.60	0.43	0.36	0.25	0.27
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	-	-	-
Electricity	3.20	3.94	4.44	3.83	3.73	3.82	3.88
Heat	-	0.02	0.02	0.04	0.05	0.05	0.05
Shares in total industry (%)							
Coal	*10.9*	*9.7*	*10.5*	*7.1*	*7.6*	*7.7*	*7.3*
Peat	-	-	-	-	-	-	-
Oil	*43.0*	*35.2*	*27.0*	*33.5*	*32.2*	*31.9*	*32.3*
Natural gas	-	-	*6.5*	*7.7*	*9.3*	*9.6*	*9.7*
Biofuels and waste [1]	-	*4.9*	*6.6*	*5.2*	*4.5*	*3.1*	*3.2*
Geothermal	-	-	-	-	-	-	-
Solar/other [2]	-	-	-	-	-	-	-
Electricity	*46.0*	*50.1*	*49.1*	*46.0*	*46.0*	*47.2*	*46.8*
Heat	-	*0.2*	*0.2*	*0.5*	*0.6*	*0.6*	*0.6*
TRANSPORT[4]	**2.30**	**3.41**	**4.06**	**4.86**	**4.79**	**4.82**	**4.94**
OTHER[7]	**4.12**	**6.15**	**6.72**	**8.14**	**7.79**	**7.24**	**7.33**
Coal	0.06	0.01	0.00	-	-	-	-
Peat	-	-	-	-	-	-	-
Oil	2.07	1.24	1.07	1.13	0.97	0.85	0.78
Natural gas	-	-	0.00	0.05	0.05	0.05	0.05
Biofuels and waste[1]	-	0.52	0.60	0.75	0.57	0.50	0.54
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	-	-	-	-	-	-
Electricity	1.98	4.33	4.93	5.87	5.82	5.49	5.57
Heat	-	0.06	0.11	0.34	0.37	0.35	0.39
Shares in other (%)							
Coal	*1.6*	*0.1*	-	-	-	-	-
Peat	-	-	-	-	-	-	-
Oil	*50.2*	*20.2*	*15.9*	*13.9*	*12.5*	*11.7*	*10.6*
Natural gas	-	-	-	*0.6*	*0.7*	*0.6*	*0.6*
Biofuels and waste [1]	-	*8.4*	*9.0*	*9.2*	*7.4*	*6.9*	*7.4*
Geothermal	-	-	-	-	-	-	-
Solar/other [2]	-	-	-	-	-	-	-
Electricity	*48.2*	*70.4*	*73.4*	*72.1*	*74.7*	*75.8*	*76.1*
Heat	-	*0.9*	*1.6*	*4.2*	*4.8*	*4.9*	*5.3*

Unit: Mtoe

DEMAND							
ENERGY TRANSFORMATION AND LOSSES	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015**
ELECTRICITY GENERATION[8]							
Input (Mtoe)	6.31	10.58	12.42	11.41	12.12	12.85	13.11
Output (Mtoe)	6.28	10.46	12.26	10.60	11.48	12.15	12.38
Output (TWh)	73.03	121.61	142.51	123.24	133.44	141.23	143.92
Output Shares (%)							
Coal	-	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*	*0.1*
Peat	-	-	-	-	-	-	-
Oil	*0.2*	-	-	-	-	-	-
Natural gas	-	-	*0.1*	*3.9*	*1.8*	*1.8*	*1.8*
Biofuels and waste [1]	-	*0.2*	*0.2*	*0.4*	*0.4*	*0.3*	*0.3*
Nuclear	-	-	-	-	-	-	-
Hydro	*99.8*	*99.6*	*99.5*	*94.7*	*96.0*	*95.9*	*95.8*
Wind	-	-	-	*0.7*	*1.4*	*1.6*	*1.7*
Geothermal	-	-	-	-	-	-	-
Solar/other [2]	-	*0.1*	-	-	..	..	-
TOTAL LOSSES	**0.89**	**3.78**	**5.27**	**6.16**	**5.69**	**6.03**	**6.80**
of which:							
Electricity and heat generation[9]	0.03	0.07	0.06	0.45	0.26	0.38	0.39
Other transformation	0.12	0.05	0.05	-0.33	-0.37	-0.36	-0.32
Own use and transmission/distribution losses[10]	0.73	3.67	5.15	6.04	5.80	6.01	6.73
Statistical Differences	**0.05**	**-0.15**	**1.10**	**6.42**	**6.24**	**1.60**	**2.28**
INDICATORS	**1973**	**1990**	**2000**	**2010**	**2013**	**2014**	**2015**
GDP (billion 2010 USD)	145.55	255.70	367.06	428.53	449.01	457.63	465.00
Population (millions)	3.96	4.24	4.49	4.89	5.08	5.14	5.19
TPES/GDP (toe/1000 USD)[11]	0.10	0.08	0.07	0.08	0.07	0.06	0.06
Energy production/TPES	0.56	5.67	8.71	6.12	5.95	7.05	7.03
Per capita TPES (toe/capita)	3.61	4.97	5.83	6.94	6.42	5.41	5.71
Oil supply/GDP (toe/1000 USD)[11]	0.05	0.03	0.02	0.03	0.03	0.02	0.02
TFC/GDP (toe/1000 USD)[11]	0.09	0.07	0.05	0.05	0.05	0.04	0.04
Per capita TFC (toe/capita)	3.37	4.11	4.41	4.36	4.07	3.93	3.96
CO_2 emissions from fuel combustion ($MtCO_2$)[12]	23.4	27.5	31.9	37.5	35.1	35.4	36.7
CO_2 emissions from bunkers ($MtCO_2$)[12]	2.8	2.7	3.7	2.5	2.6	2.0	2.1
GROWTH RATES (% per year)	**73-90**	**90-00**	**00-10**	**10-12**	**12-13**	**13-14**	**14-15**
TPES	2.3	2.2	2.6	-6.5	10.0	-14.7	6.5
Coal	-0.3	2.0	-3.2	3.6	-5.4	9.7	-3.4
Peat	-	-	-	-	-	-	-
Oil	0.4	1.1	3.6	-4.5	16.6	-27.0	9.4
Natural gas	-	7.7	6.5	-23.0	24.8	-13.9	9.1
Biofuels and waste[1]	-	2.8	2.2	-0.3	-4.3	-10.7	9.6
Nuclear	-	-	-	-	-	-	-
Hydro	3.0	1.6	-1.9	10.2	-9.6	5.7	1.8
Wind	-	-	38.2	32.3	21.8	17.9	13.1
Geothermal	-	-	-	-	-	-	-
Solar/other[2]	-	1.0	11.4	-37.8	166.7	54.7	4.0
TFC	1.6	1.3	0.7	-1.9	0.7	-2.5	1.9
Electricity consumption	2.8	1.2	0.4	-1.2	0.8	-2.4	1.6
Energy production	17.2	6.7	-0.9	-1.1	-4.4	1.1	6.2
Net oil imports	..	..	..	..	..	..	..
GDP	3.4	3.7	1.6	1.9	1.0	1.9	1.6
TPES/GDP	-1.0	-1.4	1.0	-8.2	8.8	-16.4	4.9
TFC/GDP	-1.7	-2.3	-0.8	-3.7	-0.2	-4.3	0.2

0 is negligible, - is nil, .. is not available, x is not applicable. Please note: rounding may cause totals to differ from the sum of the elements.

Footnotes to energy balances and key statistical data

1. Biofuels and waste comprises solid biofuels, liquid biofuels, biogases, industrial waste and municipal waste. Data are often based on partial surveys and may not be comparable between countries.
2. Other includes tide, wave and ambient heat used in heat pumps.
3. In addition to coal, oil, natural gas and electricity, total net imports also include peat, biofuels and waste and trade of heat.
4. Excludes international marine bunkers and international aviation bunkers.
5. Total supply of electricity represents net trade. A negative number in the share of TPES indicates that exports are greater than imports.
6. Industry includes non-energy use.
7. Other includes residential, commercial and public services, agriculture/forestry, fishing and other non-specified.
8. Inputs to electricity generation include inputs to electricity, CHP and heat plants. Output refers only to electricity generation.
9. Losses arising in the production of electricity and heat at main activity producer utilities and autoproducers. For non-fossil fuel electricity generation, theoretical losses are shown based on plant efficiencies of approximately 33% for nuclear and solar thermal, 10% for geothermal and 100% for hydro, wind and solar photovoltaic.
10. Data on "losses" for forecast years often include large statistical differences covering differences between expected supply and demand and mostly do not reflect real expectations on transformation gains and losses.
11. Toe per thousand US dollars at 2010 prices and exchange rates.
12. "CO_2 emissions from fuel combustion" have been estimated using the IPCC Tier I Sectoral Approach from the *2006 IPCC Guidelines.* In accordance with the IPCC methodology, emissions from international marine and aviation bunkers are not included in national totals.

ANNEX C: International Energy Agency “Shared Goals”

The member countries* of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants. In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

1. Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

2. Energy systems should have the ability to respond promptly and flexibly to energy emergencies. In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

3. The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision-makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

4. More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

5. Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

6. Continued research, development and market deployment of new and improved energy technologies make a critical contribution to achieving the objectives outlined above. Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-member countries, should be encouraged.

7. Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the

extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

8. Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

9. Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

(The Shared Goals were adopted by IEA Ministers at the meeting of 4 June 1993 Paris, France.)

* Australia, Austria, Belgium, Canada, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Poland, Portugal, the Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, the United States.

ANNEX D: Glossary and list of abbreviations

In this report, abbreviations and acronyms are substituted for a number of terms used within the International Energy Agency. While these terms generally have been written out on first mention, this glossary provides a quick and central reference for the abbreviations used.

Acronyms and abbreviations

aFRR	automatic Frequency Restoration Reserves
APA	awards in predefined areas
BEV	battery electric vehicle
CAIDI	customer average interruption duration index
CAIFI	customer average interruption frequency index
CCS	carbon capture and storage
CENS	costs of energy not supplied
CER	certified emission reductions
CHP	combined heat and power
CO_2	carbon dioxide
CSLF	Carbon Sequestration Leadership Forum
CTAIDI	customer total average interruption index
DSO	distribution system operators
ECCSE	European Carbon Dioxide Capture and Storage Laboratory
EEA	European Economic Area
ETS	Emissions Trading Scheme
EU	European Union
EU-ETS	EU Emissions Trading Scheme
EV	electric vehicle
FEED	front-end engineering design
FME	Centres for Environmentally Friendly Energy Research
GDP	gross domestic product
GHG	greenhouse gases
HFC	hydrofluorocarbon
IEA	International Energy Agency
IEA29	29 members of the IEA
ICE	internal combustion engine
IOR	improved oil recovery
LNG	liquefied natural gas
LPG	liquid petroleum gas
MPE	Ministry of Petroleum and Energy
Nasdaq	National Association of Securities Dealers Automated Quotations
NCCS	Norwegian CCS Research Centre

NCS	Norwegian Continental Shelf
NOK	Norwegion kroner
NO_x	nitrogen oxides
NPD	Norwegian Petroleum Directorate
NSBT	North Sea Basin Taskforce
NVE	Norges Vassdrags- og Energidirektorat (Norwegian Water Resources and Energy Directorate
OECD	Organisation for Economic Co-operation and Development
OU	ownership unbundling
PETROSAM	Programme on Social Science Research related to the Petroleum Sector
PFC	perfluorocarbon
PHEV	plug-in hybrid electric vehicles
PM	particulate matter
PPP	purchasing power parity
PSA	Petroleum Safety Authority Norway
RCN	Research Council of Norway
RD&D	research, development, and demonstration
RES	renewable energy sources
RTD	research and technological development
SAIDI	system average interruption duration index
SAIFI	system average interruption frequency index
SDFI	State's Direct Financial Interest
SF_6	sulphur hexafluoride
SSB	Statistisk sentralbyrå (Statistics Norway)
TCM	Technology Centre Mongstad
TCP	Technology Collaboration Programmes
TFC	total final consumption
TOI	Institute for Transport Economics
TPES	total primary energy supply
TSO	transmission system operator
UNFCCC	United Nations Framework Convention on Climate Change
USD	United Sates dollars
VRE	variable renewable energy

Units of measurement

b/d	barrels per day
bcm	billion cubic metres
g	gram
GW	gigawatt

GWh	gigawatt hour
kb/d	thousand barrels per day
km	kilometre
km^2	square kilometre
kWh	kilowatt hour
m^3	cubic metre
mb	million barrels
mb/d	million barrels per day
mcm	million cubic metres
min	minutes
MJ	megajoule
Mt	million tonnes
$MtCO_2$	million tonnes of carbon dioxide
$MtCO_2$-eq	million tonnes of carbon dioxide-equivalent
Mtoe	million tonnes of oil-equivalent
MW	megawatt
MWh	megawatt hour
Pa	Pascal
PJ	petajoule
toe	tonne of oil-equivalent
TWh	terawatt hour
W	watt

IEA Publications,
International Energy Agency
Website: www.iea.org
Contact information: www.iea.org/aboutus/contactus
Typeset in France and Printed in France by IEA, May 2017
Cover design: IEA. Photo credits: © PhotoObsession.

IEA/OECD possible corrigenda on: www.oecd.org/about/publishing/corrigenda.htm

The paper used has been produced respecting
PEFC's ecological, social and ethical standards

ENERGY POLICIES OF IEA COUNTRIES

Norway

2017 Review

As one of the world's largest energy exporters, Norway advances the energy security of consuming countries. And at the same time, as a global advocate for climate change mitigation, Norway is committed to environmental sustainability and climate policy.

The latest review of Norway's energy policies by the International Energy Agency finds that the country continues to manage its significant hydrocarbon resources and revenues in a sustainable way, and remains a reliable supplier of oil and gas. But as the world looks to cut its reliance on fossil fuels, Norway's government should also consider measures to prepare for a future with lower oil and gas revenues.

Norway's large hydropower generation is another valuable energy asset particularly at a time when European electricity markets are integrating and variable renewable energy generation is growing. More cross-border connections are coming online and will help realise the full potential of hydropower for balancing variations in demand and supply in the regional market. This will also improve electricity security in Norway in times of low hydropower availability. This review looks at how market-based investments in low-carbon generating capacity can be encouraged by changes in taxation and subsidy systems.

In order to meet its ambitious targets to reduce greenhouse gas emissions, this review finds that Norway needs to step up efforts at home. The IEA encourages the government to spell out more in detail how the emissions reduction targets will be met. There is a major potential to do so in transportation, oil and gas production and manufacturing. In this context, a high level of public spending on energy RD&D and strong efforts to develop carbon capture and storage are very welcome.