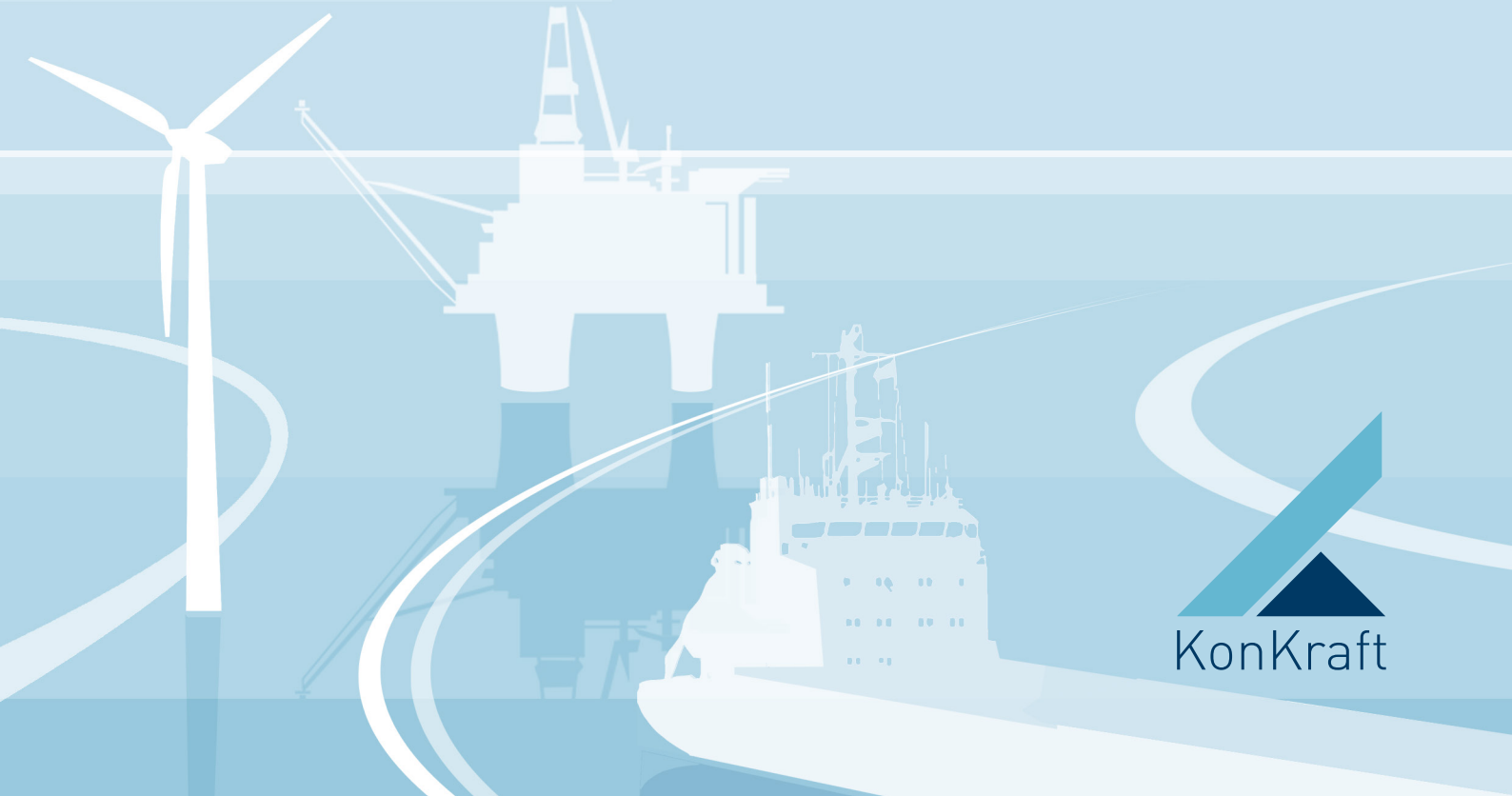
KonKraft report 2020-1

THE ENERGY INDUSTRY OF TOMORROW ON THE NORWEGIAN CONTINENTAL SHELF

CLIMATE STRATEGY TOWARDS AND 2030 2050



KonKraft

KONKRAFT IN BRIEF

KonKraft is a collaboration arena for the Norwegian Oil and Gas Association, the Federation of Norwegian Industries, the Norwegian Shipowners Association, the Norwegian Confederation of Trade Unions (LO), and LO members the United Federation of Trade Unions and the Norwegian Union of Industry and Energy Workers (Industry Energy).

This arena serves as an agenda-setter for national strategies in the petroleum sector, and works to maintain the competitiveness of the Norwegian continental shelf (NCS), so that Norway remains an attractive area for investment by the Norwegian and international oil and gas industry – including suppliers and the maritime sector.

The council is KonKraft's supreme body. In addition comes an executive committee and a secretariat responsible for ongoing activities and day-to-day operations.

Norsk olje&gass

Norsk Industri

Norges Rederiforbund
Norwegian Shipowners' Association

Fellesforbundet

INDUSTRI ENERGI

MAIN GOAL

-40%
in 2030

Near zero
in 2050

The oil and gas industry in Norway will reduce its absolute greenhouse gas emissions by 40 per cent in 2030 compared with 2005, and will further reduce emissions to near zero in 2050.

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SUMMARY

The world community faces a number of fundamental challenges which must be overcome in the 21st century. Of the 17 sustainable development goals identified by the UN, some the most crucial include combating global warming, poverty and biodiversity loss as well as providing affordable and sustainable energy for all. An integrated approach must be taken to these goals to ensure that one is not achieved at the expense of another.

Global warming ranks among the biggest challenges facing the world today. Anthropogenic emissions of greenhouse gases (GHGs) must be sharply reduced over coming decades in order to limit the heating, and this will require substantial changes for countries, industries and each individual. At the same time, adequate energy supplies must be secured for billions of people.

NORWAY'S OIL AND GAS INDUSTRY IS SETTING ITSELF AMBITIOUS GOALS FOR EMISSION CUTS

The expertise and technological innovativeness in the Norwegian petroleum industry, at operators, suppliers and the maritime sector, are part of the solution to the global challenges of the 21st century. They will contribute to meeting the Paris agreement's targets and the UN sustainable development goals.

Long-term efforts to reduce GHG emissions have ensured that oil and gas production in Norway has one of the lowest carbon footprints in the world.

Given the challenges facing the world, this is nevertheless not enough. The Norwegian petroleum industry sees the need for a change of pace in the work to reduce global warming, and is therefore setting the following targets for emission cuts from its own operations:

The oil and gas industry in Norway will reduce its absolute greenhouse gas emissions by 40 per cent in 2030 compared with 2005, and reduce them further to near zero in 2050.[1]

A 40 per cent drop in emissions by 2030 represents an absolute reduction of 5.4 million tonnes of CO_2 equivalent (CO_2e) in that year compared with 2005. That corresponds to 10 per cent of Norway's total emissions in 2018.[2] In addition to working for absolute cuts related to its own operations, the Norwegian oil and gas industry will seek to reduce emissions from associated maritime activities.

To realise these goals, the industry will work to build a culture where good ideas are encouraged, picked up and adopted. Oil and gas produced with a low GHG footprint in Norway will have a competitive advantage in the future, and its ambitious climate targets will therefore help the petroleum sector to continue creating major value for Norwegian society.

1 This goal embraces all emissions from oil and gas operations on the NCS as well as total emissions from the oil and gas processing plants at Kårstø, Kollsnes, Nyhamna, Melkøya and Sture.

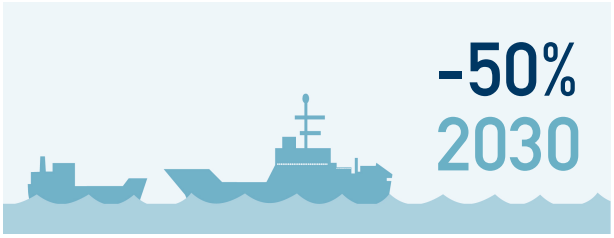
2 Norway's GHG emissions in 2018 totalled 52 million tonnes of CO_2 (Statistics Norway, 2019).

-40% in 2030

By 2030, absolute GHG emissions from Norway's oil and gas industry will be down by 40 per cent from the 2005 figure.

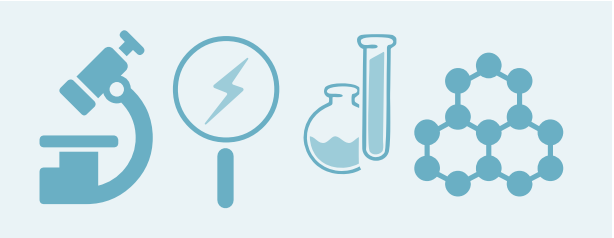
Near zero in 2050

By 2050, the oil and gas industry will have reduced its GHG emissions to near zero.



Together with ship and rig owners, the Norwegian oil and gas industry will be a driver in ensuring that vessel categories involved in offshore maritime activities contribute actively to achieving the goal, set in the government's action plan for green shipping, of a 50 per cent cut in emissions from domestic maritime transport and fishing.

The Norwegian Shipowners Association, the Federation of Norwegian Industries, Norwegian Oil and Gas and the unions will establish a collaboration forum to work for emission cuts in offshore maritime activities. During 2020, these industries will jointly establish specific quantitative targets for emission reductions by 2030.

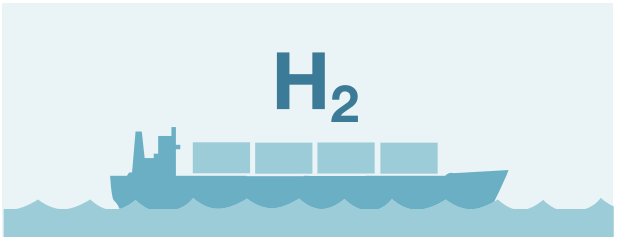


Work will be pursued by the oil and gas sector in Norway to secure a further increase in research on and development of low- and zero-emission solutions.

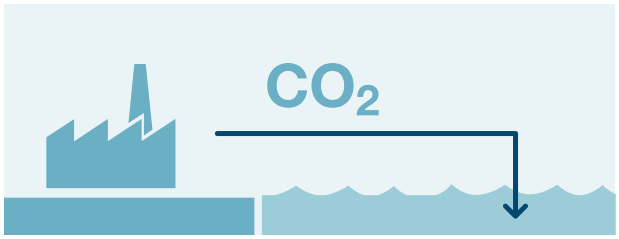
The industry will take the initiative to establish a forum for promoting better coordination between oil and gas companies, suppliers and academia to encourage the development of low- and zero-emission technology.

A FORWARD-LOOKING ENERGY INDUSTRY WHICH GIVES GLOBAL EMISSION CUTS

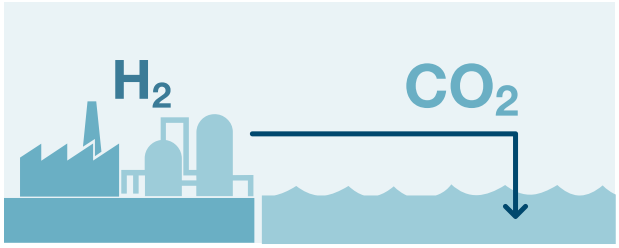
In addition to cutting emissions from its own operations and associated offshore maritime activities, the Norwegian oil and gas industry will gradually create a new and forward-looking energy industry on the NCS. This will include offshore wind power, hydrogen, and carbon capture and storage (CCS) projects which facilitate large emission reductions in Norway, Europe and the rest of the world. That lays the basis for further value creation and jobs in an industry with great expertise and technological innovativeness on the way towards a future zero-emission society. The industry will work to realise the following ambitions.



Hydrogen demonstrated as a fuel in offshore shipping by 2025.

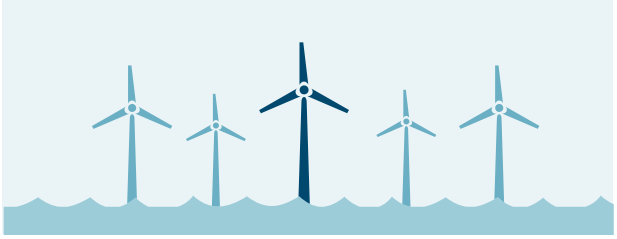


At least five European industrial companies use hydrogen from Norwegian natural gas with CCS in their production by 2030. At least two gas-fired power stations in Europe use hydrogen as fuel by 2030.



Two carbon capture plants in Norway (Norcem Heidelberg cement in Brevik and Fortum energy recovery at Klemetsrud) and the Northern Lights project on carbon transport infrastructure and storage on the NCS are in operation by 2024.

CO_2 is transported for storage on the NCS from at least five European industrial companies by 2030.



Further development of Norway's strong position in renewable energy from offshore wind power.

FOLLOWING UP THE CLIMATE GOALS

Achieving the goals and ambitions defined in this climate strategy calls for an extensive and long-term commitment to the development of low-emission technology. That relates to such aspects as electrification, enhanced energy efficiency, low- and zero-emission fuel, CCS and offshore wind power. Norwegian low- and zero-emission technology which is exported to the rest of the world will also make an important contribution to reaching global climate targets.

Predictable operating parameters which promote innovation will be crucial for implementing this change and for the industry's long-term commitments to low- and zero-emission technology.

The climate strategy and goals have been developed by KonKraft through a task force with broad representation from member companies in Norwegian Oil and Gas, the Federation of Norwegian Industries and the Norwegian Shipowners Association as well as representatives from the LO, the United Federation of Trade Unions and Industry Energy. The strategy is intended to give a clear signal of the road staked out by the industry in a world where the Paris agreement's goals must be achieved.

KonKraft's partners will closely monitor work on realising the targets in the climate strategy. Events are moving swiftly, and the strategy and goals will be regularly assessed to take account of developments in technology, politics and market conditions. An updated climate strategy with the ambition of achieving additional emission cuts will therefore be presented no later than 2025.

> The oil and gas industry will work for further development of Norway's strong position in renewable energy from offshore wind power.

> The climate strategy is intended to give a clear signal of the road staked out by the industry in a world where the Paris agreement's goals must be achieved.

1 CLIMATE GOALS FOR 2030 AND 2050

The expertise and technological innovativeness of the Norwegian oil and gas industry will form part of the solution to the global challenges of the 21st century, and help to attain the Paris agreement's targets and the UN's sustainable development goals. Absolute GHG emissions from Norway's petroleum sector will be 40 per cent lower in 2030 than they were in 2005, and will be reduced to near zero by 2050. The industry will also help to ensure cuts to GHG emissions from associated maritime activities. Specific quantitative targets for emission reductions by 2030 are due to be established in 2020.

In addition to cutting emissions from its own operations and the maritime sector, the Norwegian oil and gas industry will gradually create a new and forward-looking energy industry on the NCS. This will include offshore wind power, hydrogen, and CCS projects, which facilitate large emission reductions in Europe and the rest of the world. Work on realising the targets in the climate strategy will be closely monitored. Events are moving swiftly, and an updated climate strategy for the oil and gas industry in Norway will be presented no later than 2025.

1.1 GHG emissions down by 40 per cent in 2030

The oil and gas sector in Norway will work over the coming decade to achieve an absolute emission reduction of 40 per cent from 2005, which is the base year for cuts in the EU emissions trading system (EU ETS). [3] This means the industry is to cut the annual amount of GHG it releases to no more than 8.1 million tonnes of CO_2e in 2030. That goal covers total emissions from petroleum operations on the NCS as well as from the oil and gas processing plants at Kårstø, Kollsnes, Nyhamna, Melkøya and Sture. A substantial contribution will thereby be made to reducing Norway's national GHG emissions.

A goal of absolute emission cuts differs significantly from the targets set in the industry's earlier roadmap for emission-reducing measures. Cutting absolute emissions by 40 per cent calls for a big change in the industry over a 10-year period, and an intensification of efforts to develop and implement low- and zero-emission solutions through greater energy efficiency, electrification, low- and zero-emission fuels such as hydrogen, ammonia and biofuels, and CCS.

Close collaboration between operators, suppliers, shipping companies, research institutes, academia and the government will be crucial for success.

3 EC (2019) – EU Emissions Trading System

FIGURE 1: THE NORWEGIAN OIL AND GAS INDUSTRY'S TARGET FOR EMISSION REDUCTIONS BY 2030.

1.2 Near zero emissions from the oil and gas industry in Norway by 2050

The amount of GHG released by the oil and gas industry in Norway will be near zero in 2050. A number of countries, sectors and companies have set themselves the target of achieving net zero emissions, and the European Commission is expected to present proposals in March 2020 on setting a legally binding objective of net zero emissions for the EU by 2050.[4] The industry will set itself a goal in line with this, as illustrated in figure 2.

4 EC (2019) – Communication on the European Green Deal

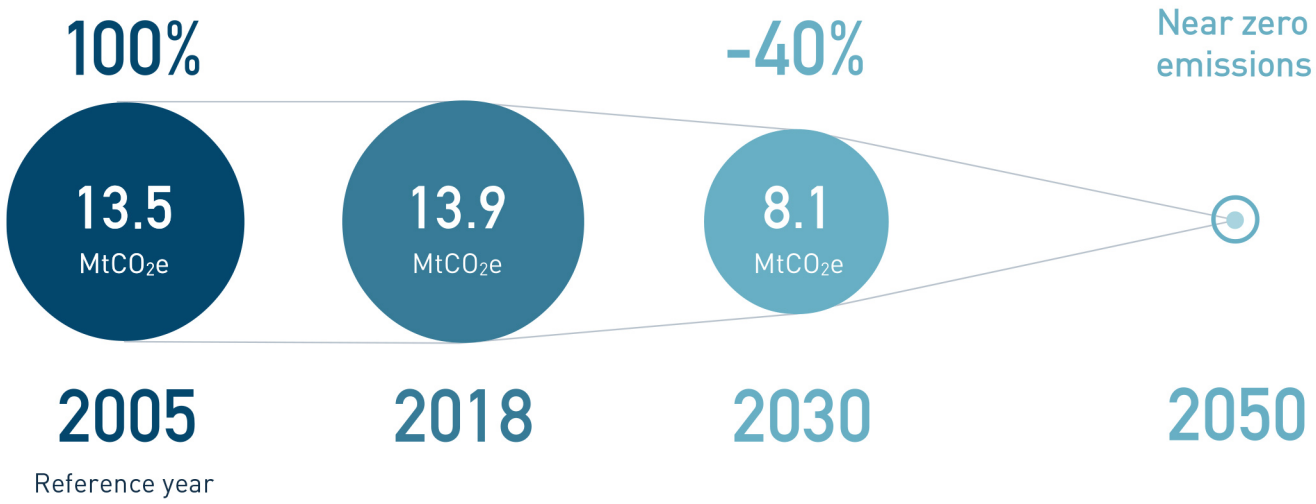


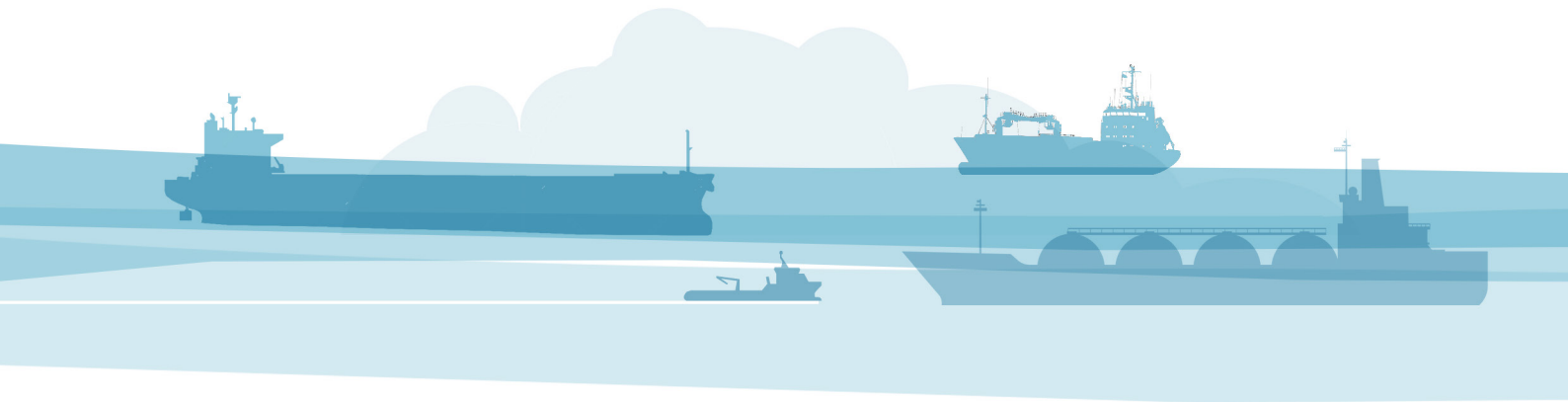
FIGURE 2: THE OIL AND GAS INDUSTRY'S TARGET FOR EMISSION REDUCTIONS IN NORWAY BY 2050.

1.3 The industry will contribute to emission cuts in offshore maritime activities

In addition to working for absolute cuts related to its own operations, the Norwegian oil and gas industry will help to ensure reductions in GHG emissions from associated maritime activities. The operator companies have substantial opportunities to influence emissions and technological choices in the offshore maritime sector through their procurement of such services, and the industry is accordingly setting itself the following targets.

- Together with ship and rig owners, the Norwegian oil and gas industry will be a driver in ensuring that vessel categories involved in offshore maritime activities contribute actively to achieving the goal, set in the government's action plan for green shipping, of a 50 per cent cut in emissions from domestic maritime transport and fishing.

- The Norwegian Shipowners Association, the Federation of Norwegian Industries, Norwegian Oil and Gas and the unions will establish a collaboration forum to work for emission cuts in offshore maritime activities. During 2020, these industries will jointly establish specific quantitative targets for emission reductions by 2030.

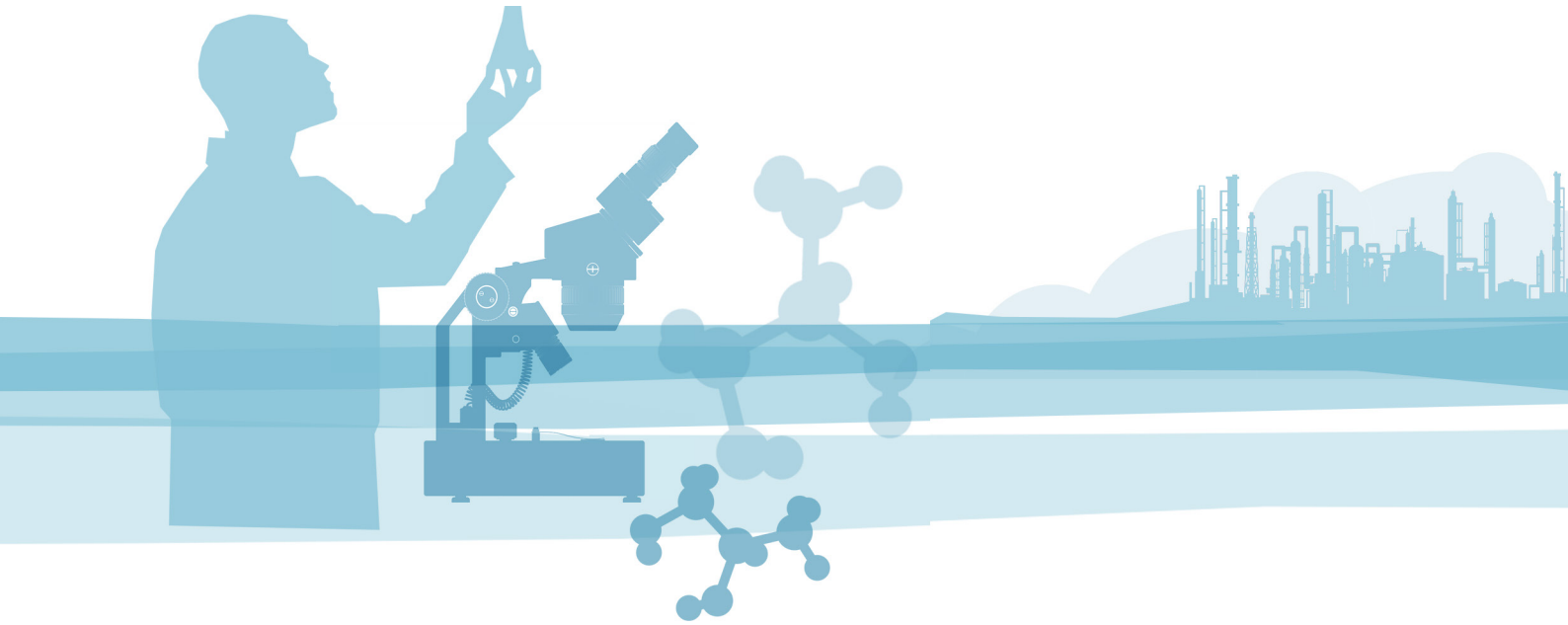


1.4 Intensified research on and development of low- and zero-emission solutions

The oil and gas sector in Norway will work to achieve a further increase in research on and development of low- and zero-emission solutions. It already contributes to strengthening the commitment to such work through establishing, supporting and participating in initiatives like the LowEmission Research Centre, the Norwegian CCS Research Centre and Compacts2. Very important efforts are also being made through research programmes such as Petromaks 2, Demo 2000, EnergiX and Climit as well as other research centres for environment-friendly energy. In addition, many of the companies in the industry have established internal goals for research on and development of emission-reducing solutions.

Giving high priority to developing and implementing new solutions which reduce GHG emissions is crucial if the industry's climate goals for 2030 and 2050 are to be met. The oil and gas sector in Norway will therefore work to ensure a further increase in the R&D funds devoted by the industry to developing low- and zero-emission solutions.

Good results from R&D efforts are best achieved through a collaboration between the industry, academia and the government. The industry will take the initiative to establish a forum for promoting better coordination between oil and gas companies, suppliers and academia to encourage the development of low- and zero-emission technology.



1.5 A forward-looking energy industry on the NCS which yields big emission cuts

Oil and gas companies, suppliers and shipping companies will gradually create a new and forward-looking energy industry on the NCS, including hydrogen, CCS projects, and renewable energy from offshore wind power, which facilitates large emission reductions in Europe and the rest of the world.

Over the coming decade, the industry will work to realise projects for CCS facilities in Norway, the demonstration of hydrogen as a fuel in offshore shipping, and the use of this gas for electricity generation.

Good wind resources on the NCS, combined with Norway's strong position in maritime, offshore and land-based industrial sectors, mean that offshore wind power has all it needs to become a large and important new Norwegian industry. The oil and gas sector will work to ensure that this strong position is further developed and that Norway takes a leading role in developing floating wind farms as well as securing larger market shares for fixed offshore wind power.

> Over the coming decade, the industry will work to realise projects for CCS facilities and hydrogen production from natural gas.

1.6 Following up the climate strategy

The overall climate goals in this strategy are set for 2030 and 2050. This means that the KonKraft partners in Norwegian Oil and Gas, the Federation of Norwegian Industries, the Norwegian Shipowners Association, the LO, the United Federation of Trade Unions and Industry Energy will closely monitor the work of reaching these targets. A committee will be appointed to meet regularly in order to follow up the status of developments in relation to the goals.

This committee will publish an annual report to present the status of emission-reducing measures, technological progress towards low- and zero-emission solutions, and the export of these from Norway to the rest of the world.

Events are moving swiftly, and the climate strategy and goals will be adjusted in the future to take account of developments in technology, politics and market conditions. A revised strategy will therefore be presented no later than 2025.

Until the next update, the KonKraft partners will work to clarify measures and goals even further.

The climate strategy and goals will be adjusted in the future to take account of developments in technology, politics and market conditions.

2 EMISSION-REDUCING TECHNOLOGY

Although petroleum produced in Norway has a low emission intensity compared with most other countries, the oil and gas industry accounts for about a quarter of total Norwegian GHG emissions. Most of the quantity released derives from gas turbines used to provide power and heat.

In order to realise the goals of a 40 per cent cut by 2030 and a continued reduction to near zero by 2050, efforts must be made to implement and further develop solutions for reducing emissions in a number of areas.

Electrification through connection to the power grid or the use of new renewable generating capacity offshore will be particularly important. But reducing emissions by enhancing energy efficiency, limiting flaring and cold venting, adopting low- and zero-emission fuels such as hydrogen, ammonia and biofuel, and CCS will also play key roles in reaching the climate strategy's goals.

In close collaboration with the supplier industry, the oil and gas companies are working to develop, test and apply a number of technologies and solutions which will help to reduce emissions from petroleum production both in Norway and internationally.

2.1 Emission sources

The oil and gas industry accounted for more than a quarter of total Norwegian GHG emissions in 2018.[5] Figure 3 presents an overview of developments from 2005 to 2018, covering total emissions from activities on the NCS and from the oil and gas processing facilities at Kårstø, Kollsnes, Nyhamna, Melkøya and Sture. In addition come emissions from maritime operations.

Combined with energy efficiency improvements and measures for flaring, electrification has been the most important source of emission cuts by Norway's oil and gas industry so far.

GHG emissions from the petroleum sector in Norway totalled 13.9 million tonnes of CO_2e in 2018. The bulk of this amount came from gas turbines generating electricity and providing mechanical power and heat offshore and at the processing plants on land. Energy production by offshore and onshore turbines accounted for more than 84 per cent of total emissions from Norway's oil and gas production in 2018. Internal combustion engines on platforms and mobile facilities accounted for a further six per cent of emissions from the industry.

5 Norwegian Environment Agency (2019) – Norske utslipp av klimagasser

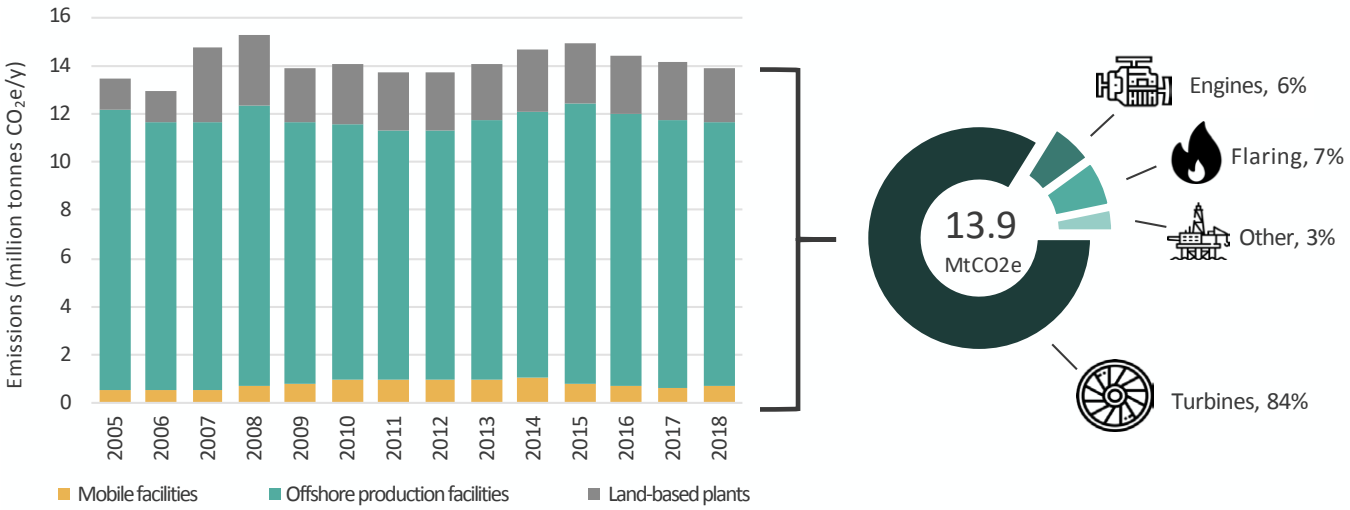


FIGURE 3: GHG EMISSIONS FROM THE NORWEGIAN OIL AND GAS SECTOR IN 2005-18. Sources: EEH, Statistics Norway, Endrava

Apart from power and heat supply, flaring represents the biggest source of GHG emissions and accounts for about seven per cent of the total.

Since 1990, the industry has worked purposefully to reduce emissions from flaring through better operation, maintenance and technical solutions, such as enclosed flares. Flaring is done to a limited extent, pursuant to the provisions of the Petroleum Act, and is only permitted for safety reasons. That makes it tough to eliminate emissions from this source entirely.

Other sources, such as cold venting and fugitive emissions, account for a minor share of the GHG released from the NCS. Since these primarily comprise methane, a far more powerful GHG than CO_2, the industry will continue to pay great attention to reducing their release even further.

Gas turbines offshore and at the land plants accounted for more than 84 per cent of total emissions from Norway's oil and gas production in 2018.

2.2 Electrification

Electrification will be a crucial measure for cutting emissions and achieving the ambitious climate goals set by the industry for 2030 and 2050. Supplying electricity by cable from shore is assessed for all new developments and major modification projects on the NCS. Continued development of solutions for electrification could also make this possible for more fields and plants, and it is being studied at present by both government and companies.

Applying an integrated perspective which takes account of the need for competitive power costs by land-based and offshore industries is important when assessing electrification of facilities on the NCS and the development of offshore wind power.

A positive power balance in Norway is important for industry and the nation. Grid operator Statnett estimates that an extensive electrification of sectors which currently utilise fossil fuels could increase consumption by 30-50 terawatt-hours. Facilitating such a switch to electricity may mean that a large part of this growth could occur before 2040.[6] It will be very important to ensure sufficient additional generating capacity to meet higher demand, given requirements for national security of supply as well as industrial power costs and value creation.

Innovative solutions, such as local generation of renewable electricity from offshore wind power, could contribute both to emission reductions on the NCS and to exciting new industrial developments in Norway. An important example of such local renewable energy production is Equinor's commitment to floating wind power in the Tampen area of the North Sea. See box 1. Technology development in this project could contribute to positive lessons for offshore wind power on the NCS and to the development of a supplier chain for floating wind turbines with a big international potential.

Big synergies exist between the petroleum sector and offshore floating and fixed wind power. Kværner's expertise with concrete structures, for example, has helped it to win the contract for 11 concrete hulls to carry floating wind turbines in the Hywind Tampen project. And Aibel and ABB have jointly developed competitive solutions for the conversion platforms being used to an ever growing extent by the European offshore wind power sector.

6 Statnett (2019) – Et elektrisk Norge – fra fossilt til strøm

HYWIND TAMPEN – FLOATING WIND POWER CUTS OFFSHORE EMISSIONS

Hywind Tampen is a floating wind farm to be developed on the NCS in order to supply two oil fields – Gullfaks and Snorre – with renewable energy. This project is being pursued for Equinor with support from Enova and the Business Fund for Nitrogen Oxides. Replacing power generated by gas turbines will reduce GHG emissions by about 200 000 tonnes of CO_2e per annum. Ranked as a world first, the project will be important in further development of technology and solutions for offshore wind power and renewable electricity supplies on oil and gas installations at sea.

Illustration from Equinor

BOX 1: HYWIND TAMPEN – FLOATING WIND POWER CUTS OFFSHORE EMISSIONS.

2.3 Enhancing energy efficiency

The industry continuously pursues measures to improve energy efficiency and reduce flaring, and the effect of these added up to roughly 1.9 million CO_2e in avoided emissions annually in 2018 compared with 2007. Flaring reductions and energy efficiency gains helped to over-fulfil KonKraft's 2020 goal four years early. Further measures to make more efficient use of energy will also be important for achieving the emission targets in the new climate strategy. Energy requirements on installations and fields change over their commercial life. Continuous efforts to identify possible measures which provide energy-efficient production are important for reducing emissions. Two particularly important priority areas for future research in this area are energy-efficient processing and more effective reservoir management.

A substantial potential also exists for improving energy efficiency through more efficient gas-turbine operation. Combined-cycle technology which merges gas-fired and steam power generation makes it possible to match efficiencies at land-based power stations. That could cut emissions by more than 20 per cent from turbines when implemented for offshore power generation. This technology was introduced in the late 1990s, but developing more compact combined cycle plants with smaller size and lower weight would make installation on additional offshore facilities technically feasible. See box 2.

> **Continuous efforts to identify measures which provide more efficient production are important for reducing emissions.**

Battery-based hybrid solutions similar to those seen in vehicles are increasingly being adopted today on service and supply ships and drilling rigs. That could yield substantial energy savings and emission cuts in the maritime segment of the industry. An electric-powered drilling rig is already operating on the Valhall field, and the *West Mira* hybrid rig began working for Wintershall Dea on the Bergknapp wildcat in November 2019.[7] Implementation and further development of these technologies will contribute to additional emission reductions.

7 Petro (2019) – West Mira

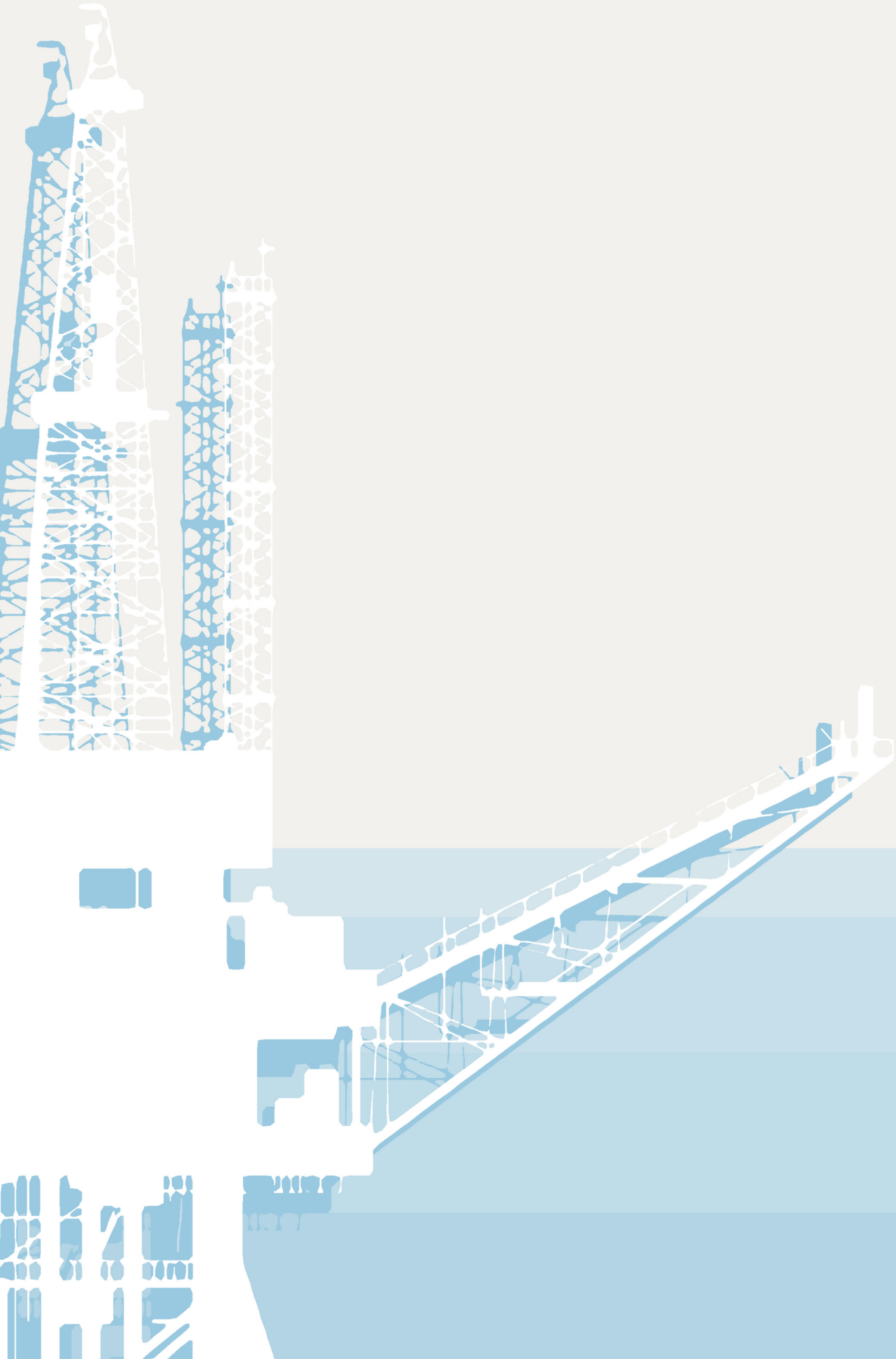
COMPACT COMBINED-CYCLE POWER PLANT TO MAKE OFFSHORE GAS TURBINES MORE EFFICIENT

Steam cycle systems in combined-cycle power plants exploit waste heat from gas turbine exhaust gases to generate electricity. That can make power supply on platforms more efficient. The system is now used in most new onshore gas-fired power stations, and has been adopted on three NCS fields so far. Available solutions have been heavy and complex as well as very bulky, which limits how many offshore installations can use them.

Scientists at Sintef are developing lighter and more compact systems through the Compacts2 project[8] for implementation on new and existing production facilities. This work builds on earlier experience from conventional combined-cycle power stations. The technology could increase power-generation efficiency and thereby cut GHG emissions from gas turbines by more than 20 per cent.

8 Sintef (2019) – COMPACTS2

BOX 2: COMPACT COMBINED-CYCLE POWER PLANT TO MAKE OFFSHORE GAS TURBINES MORE EFFICIENT.



2.4 Reduced emissions from flaring, cold venting and fugitive sources

Flaring, cold venting and fugitive sources account for about 10 per cent of total GHG emissions. Better maintenance and more stable production through increased use of electric subsea solutions help to cut flaring-related emissions when shutting down and starting up offshore facilities. Emissions from flaring can be further reduced if more platforms adopt technological solutions such as recovering flare gas without a pilot flame. Eliminating all emissions from flaring will nevertheless be tough because of safety considerations.

The industry studied emissions of non-methane volatile organic compounds (nmVOC) and methane from cold venting in 2016. This work showed that the amounts released were smaller than originally calculated, and contributed to a better and more detailed overview of emission sources and possible measures for reducing them.

Some of the smaller sources, such as fugitive emissions from small leaks in connections or valves at process plants, are tougher to eliminate. Better detection of fugitive sources and improved maintenance practices could help to cut these emissions further.

> Emissions from flaring can be further reduced if more platforms adopt new technological solutions.

2.5 Reducing emissions from offshore maritime activities

About 1.9 million tonnes of CO_2 were released by offshore maritime activities in Norway during 2017. They derived from drilling rigs, supply ships, flotels, anchorhandlers, shuttle tankers and so forth.

A number of measures have been implemented to achieve reductions. Emissions from offshore supply ships have fallen by more than 10 per cent in recent years, thanks to a modern, energy-efficient fleet, operational measures and upgrades. A number of vessels now run on liquefied natural gas (LNG) rather than more emission-intensive conventional fuels, and have installed batteries to optimise engine load. Increased awareness, knowledge, weather routing and planning – called "green operation" or the "fuel race" – have also helped to cut the quantities released.

Shuttle tankers are special carriers used to ship oil from offshore fields to refineries in Norway and abroad. Most sail to other countries and are then regarded as an international shipping operation. Shuttle tankers able to run on LNG and capture VOCs are under construction in 2020.

Drilling rigs working on the NCS comprise moored and dynamically positioned (DP) semisubmersible units and jack-ups. Substantial opportunities are available to reduce their emissions through upgrading.

Emphasis is being given to maintaining and intensifying the positive trend for vessel categories related to offshore maritime operations. This sector is characterised in Norway by a great willingness to innovate and improve.

A number of technical and operational measures could contribute to further emission reductions related to offshore maritime activities.

> A number of different measures for more effective collaboration could help to reduce emissions from maritime activities.

- **Operational measures:** Weather routing, optimised logistics, level of utilisation, good planning, slower steaming, and dialogue between ship and platform.

- **Standardisation and collaboration:** Establishing common standards for equipment and solutions related to emission reductions, such as infrastructure for power from shore, would lower abatement costs for the industry. These could also be reduced if operators and ship/rig owners share best practice for enhancing energy efficiency and cutting emissions.

- **Batteries:** Generator loads could be improved by using reserve power from batteries. The latter have been installed on 47 supply ships and 13 other offshore vessels since 2011.

- **Power from shore:** This provides better local air quality and reduces GHG emissions, assuming access to clean electricity.

- **Optimised newbuildings:** The potential is greatest for new vessels, where environment-friendly machinery and equipment can be extensively adopted. Optimising main dimensions and hull shape for dominant sea and wind conditions could substantially reduce energy consumption and emissions.

- **LNG:** A total of 25 offshore vessels currently run on LNG. The climate effect of using this instead of conventional fuel is positive, and can be further strengthened by gradually replacing fossil LNG with biogas which is climate neutral or negative.

- **Low- and zero-emission fuels:** New fuels such as hydrogen and ammonia emit no GHG in use but can involve substantial emissions in the production phase. These products must only be used if they are produced with clean electricity or CCS solutions to eliminate the release of GHG. An adequate supply network for low- and zero-emission fuels will need to be established at ports and bases, and could also offer opportunities for cutting emissions from other vessel types.

The operator companies in the petroleum sector possess substantial opportunities to influence emissions and technology choices in offshore maritime activities through the procurement of such services. Good collaboration between operator companies, rig owners, shipping companies and the supplier sector will be important for improving energy efficiency and reducing GHG emissions.

Several different measures for more effective collaboration could contribute to emission reductions.

- **Contract formulation:** Long-term contracts strengthen incentives to invest in climate measures on vessels with a lengthy pay-back time. New mechanisms for risk-sharing between operator company and vessel owner could also contribute to emission cuts.

- **Common industry requirements:** Common climate and environmental standards in the industry can reduce a shipping company's risk when investing in long-term climate measures. Extending these requirements to other national markets could help to cut risk even further for vessel segments which operate internationally.

- **Identifying emissions:** Requiring that GHG emissions are identified by assignment or vessel could make it easier for the players to see the emission effect of different choices. Another option is a certification scheme for vessels or shipowners which can be used by the operator companies when putting assignments out to tender.

Through establishing a collaboration forum, the Norwegian Shipowners Association, the Federation of Norwegian Industries, Norwegian Oil and Gas and the unions will work to meet the targets for offshore maritime activities. The industries will establish specific quantitative goals for 2030 in the course of 2020.

2.6 Low- and zero-emission fuels

Low- and zero-emission fuels can also be used to cut the amount of GHG released from offshore power supply. Hydrogen, ammonia and biofuels are the most relevant alternatives to existing fuels.

Hydrogen and ammonia can be used as fuel by converting gas turbines or by using fuel cells. The latter are currently too heavy and bulky to permit offshore use, but further technological progress could make them an important solution for emission reduction – particularly where power from shore is not feasible. Hydrogen can be produced either locally or on land for transport to the platforms. Producing hydrogen and ammonia from natural gas with CCS or by electrolysis using renewable electricity could provide a source of offshore energy with very low emissions. Biofuels can be used in existing gas turbines and engines almost without modification. The emission cuts attainable with biofuel depend on its origin, but most types provide a substantial reduction when replacing fossil fuels.

Low- and zero-emission fuels are particularly important for achieving big emission reductions in the maritime sector, where only energy-dense products such as biogas, hydrogen and ammonia can deliver the power a ship requires. Hydrogen-powered offshore supply ships based on zero-emission fuel are already under development.

Equinor has entered into an agreement with shipping company Eidesvik Offshore on converting the *Viking Energy* supply ship to run for long distances on pure ammonia, with no GHG emissions. This vessel will deliver to installations on the NCS, and the project will investigate whether the technology can provide 100 per cent emission-free operation.

2.7 Carbon capture and storage

The bulk of the oil and gas industry's GHG emissions in Norway take the form of CO_2. Implementing CCS offers a big potential, since all existing and planned Norwegian carbon storage capacity is located on the NCS. Capturing CO_2 on platforms is more difficult to implement, because the required facilities are bulky, but current work on developing concepts for compact CCS holds out the possibility that such technology can also be adopted offshore in the longer term.

COMPACT PLANTS FROM AKER SOLUTIONS AND COMPACT CARBON CAPTURE

Systems for carbon capture have been developed for land plants, where weight and volume optimisation are not a limiting factor. They have therefore been too large and heavy for use on platforms, with their tight space and load restrictions.

Both Aker Solutions and Compact Carbon Capture are now developing standardised plants which are substantially smaller and lighter than existing solutions for capturing CO_2. This could make installing the technology to capture CO_2 from gas turbines on offshore facilities technically feasible in the future. According to the suppliers, the new plants could cut power supply emissions on an installation by more than 80 per cent. Since gas turbines are a common solution in the global petroleum industry, similar technology could also be implemented in other countries. That offers the potential for substantial emission cuts in oil and gas production, at gas-fired power stations on land and in industry.

BOX 3: COMPACT PLANTS FROM AKER SOLUTIONS AND COMPACT CARBON CAPTURE

Sources: AkerSolutions (2019) and Compact Carbon Capture (2019)

2.8 Research and development

Some emission-reduction measures in the oil and gas industry use mature technology and proven concepts. But a large proportion of the remaining cuts require the adoption of new technological solutions. R&D work is therefore an important priority area for further development of low- and zero-emission technologies in oil and gas production.

Norway's Petromaks 2 and Demo 2000 programmes give emphasis and priority to enhancing energy efficiency and low-emission solutions. Establishing the LowEmission Research Centre in 2019 was a very important step towards further necessary collaboration over speeding up development of low- and zero-emission technologies.

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NORWAY'S LOWEMISSION RESEARCH CENTRE

The LowEmission Research Centre was established in June 2019 by the Research Council of Norway. Its job is to coordinate the development of new technologies and concepts for offshore energy systems, more efficient energy use, and the integration of renewable power-generation technology for implementation on the NCS. The centre aims to help achieve a 40 per cent emission reduction from petroleum production by 2030 and near zero emissions by 2050.

Funding for the centre is provided via the Research Council's Petrosenter programme, with contributions from the industry. Its partners include a large number of representatives from operator companies, the supplier industry, Sintef and the Norwegian University of Science and Technology (NTNU), the government and associated research institutions abroad (see the overview below). The centre will educate 19 PhD/post-doctoral candidates and 30 MSc students, and aims to generate a total of 26 spin-off research projects as well as more than 70 scientific papers. Its expertise will be shared with scientists, industry, society, politicians and the general public, and thereby help decision-makers in shaping emission policies for the Norwegian oil and gas industry.

BOX 4: NORWAY'S LOWEMISSION RESEARCH CENTRE

3 A FORWARD-LOOKING ENERGY INDUSTRY ON THE NCS GIVES GLOBAL EMISSION REDUCTIONS

Expertise and experience from operators, suppliers and the shipping sector in Norway will be utilised in gradually creating a new and forward-looking Norwegian energy industry which facilitates major emission cuts at home, in Europe and in the rest of the world. Developing new value chains in offshore wind power, hydrogen and CCS means that the NCS and Norwegian onshore plants can play an important role in reducing GHG emissions. Combined with the goals for cuts in Norway, this will lay the basis for further value creation and jobs on the way towards a future zero-emission society.

3.1 Carbon capture and storage

The Norwegian government has long been a global driver for CCS solutions, and supports technology development and international collaboration in a number of arenas. Research institutions and a broad range of businesses and industry in Norway have built up world-leading expertise on CCS over many years.

Since its opening in 2012, the Technology Centre Mongstad (TCM) has played a key role nationally and globally in developing carbon capture technologies. Companies can utilise the TCM to test and verify different methods for capturing and treating CO_2. Its use for research as well as commercial testing contributes to building up Norway's world-leading carbon capture expertise.

The Norwegian oil and gas industry has acquired particular expertise and experience where carbon storage is concerned. Such technology has been used in full scale on both the Sleipner and Snøhvit fields since 1996 and 2007 respectively, with a total of 25 million tonnes of CO_2 injected for secure storage in geological formations beneath the seabed.

CCS HAS A BIG ROLE IN REACHING GLOBAL CLIMATE TARGETS

Developing CCS solutions will be important for reaching ambitious targets in Norway, Europe and globally. World demand for energy is rising, and CCS will be crucial in reducing emissions from energy production and industrial processes based on fossil fuels.

Industries also release CO_2 as a consequence of their actual production process and of heat requirements which cannot easily be replaced by renewable sources. In addition, CCS can be used to realise negative emissions – in combination, for example, with bioenergy (bioCCS).

The significance of CCS for reaching global climate goals has been emphasised by such bodies as the International Energy Agency (IEA). [9]

9 IEA (2019) – The Role of CO_2 Storage

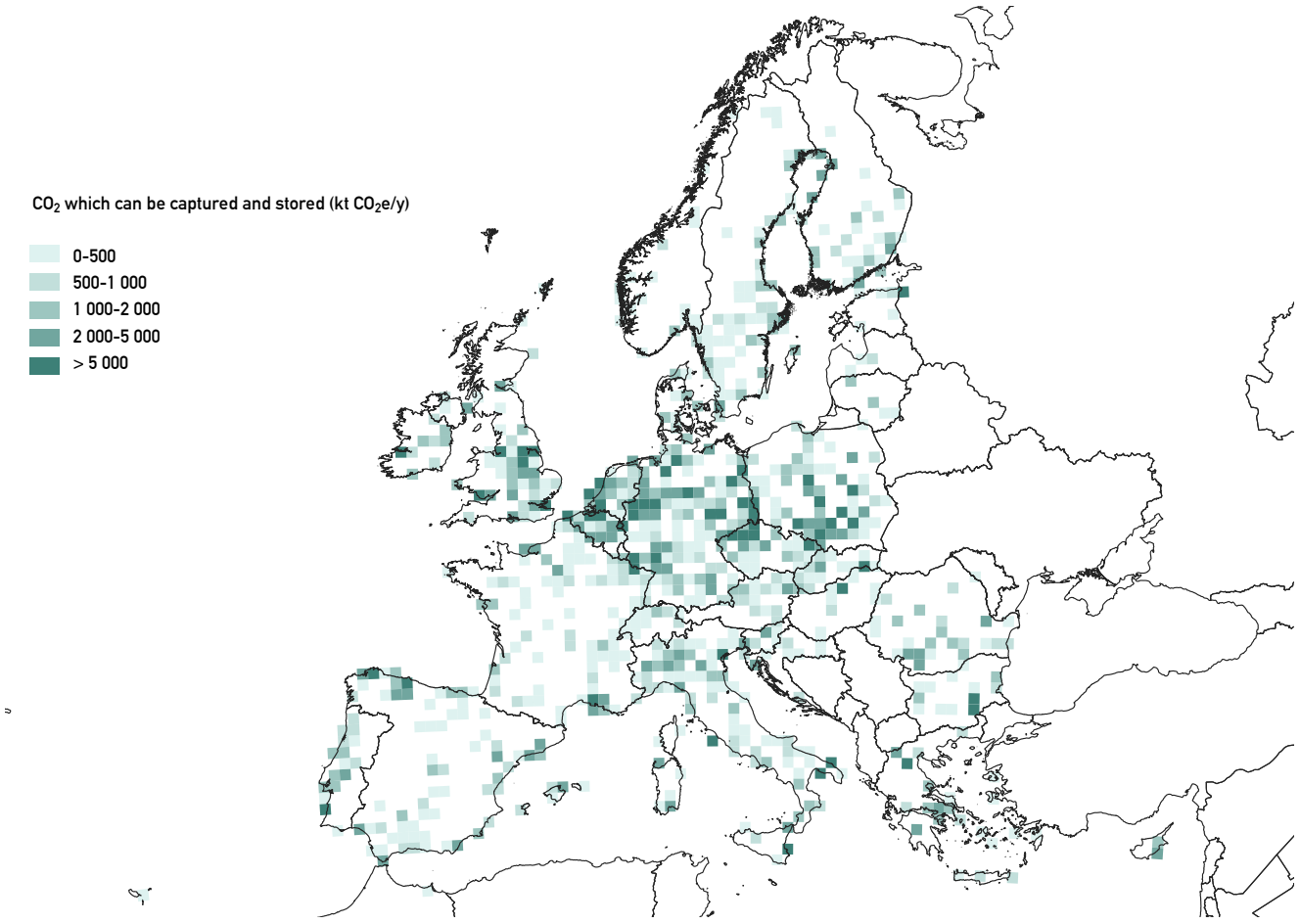


FIGURE 4: CAPTURABLE CO_2 EMISSIONS IN EUROPE.

Source: Endrava

The potential in Europe is substantial. CO_2 released from electricity generation, heating, industry and waste incineration represents about half of all European GHG emissions. A study by the Endrava and Carbon Limits companies estimates that 50-60 per cent of this can be captured with CCS technology which will soon become available.

CCS therefore represents a major opportunity for emission reductions in Europe if the necessary parameters and support schemes are developed, and Norway ought to be a driver in achieving this. Many of the emissions are located in central and northern Europe, and will be relevant for storage beneath the North Sea. See figure 4.

NORWEGIAN INDUSTRY IS PURSUING LARGE-SCALE CCS PROJECTS

Industry in Norway is heavily involved in the current development of the world's first full-scale value chain for CCS from industrial processes and waste handling.

The carbon capture project at Norcem Heidelberg's cement plant in Brevik will be the first of its kind in the world, capturing some 400 000 tonnes of CO_2 per annum. That corresponds to roughly half the plant's total emissions. Cement production accounts for about five per cent of all CO_2 released globally. Some two-thirds of these emissions relate to splitting the limestone raw material into lime and CO_2, with the rest derived from fuel for heating the process. The solutions being developed and implemented in Brevik will be an important step towards realising big global cuts in GHG emissions from producing the cement on which the world depends.

CCS is also being developed for Fortum's energy recovery plant at Klemetsrud in Oslo, with a capture facility intended to reduce emissions by 400 000 tonnes of CO_2 per annum. The solutions planned there are also under evaluation for a number of other waste incineration plants in Norway. More than 400 such facilities are found in the EU, and currently account for about two per cent of total EU emissions.[10] The GHG they release is expected to rise in the future through stricter regulations for waste deposition. Well-functioning systems for CCS from waste incineration plants could therefore yield big emission reductions in the EU.

A transport and storage solution for CO_2 captured at Norcem Brevik and Fortum Klemetsrud is being developed by Northern Lights, a collaboration project between the Equinor, Shell and Total energy companies. It covers carbon transport, handling and permanent storage in a geological formation beneath the northern North Sea. That includes a land-based facility for reception, intermediate storage and export in Øygarden local authority near Bergen, a pipeline and umbilical to an injection well, and a suitable formation for injecting and permanently storing CO_2.

Norway's full-scale CCS projects will be highly significant for the feasibility of capturing and storing CO_2 emissions from other large point sources on land. Work is underway in the Prosess21 programme to evaluate the potential for CCS in Norwegian land-based industry. [11]

Northern Lights is being planned for an annual storage capacity of 1.5 million tonnes of CO_2 in phase one, rising to five million tonnes in phase two. This Norwegian commitment is the first of its kind internationally where the value chain includes carbon capture from the energy, processing and waste treatment sectors, maritime transport of CO_2, and storage in a suitable geological formation beneath the North Sea. The opportunity to send captured CO_2 by sea provides a flexible solution for both Norwegian and European industry wishing to deposit CO_2 off Norway, and represents the first step towards a central carbon store on the NCS.

10 Endrava (2019) based on 2019 data from the Confederation of European Waste-to-Energy Plants (Cewep).

11 Read more about Prosess21 here.

SWEDEN'S PREEM WANTS TO ACHIEVE NEGATIVE EMISSIONS BY USING CCS

Preem is one of the biggest oil refiners in the Nordic area and meets half of Sweden's requirements for refined petroleum products. With ambitions of cutting a substantial proportion of its own emissions by 2040, it is one of the companies which has signed a letter of intent with the Northern Lights project.

In February 2019, Preem launched a project to study opportunities for carbon capture at Lysekil in collaboration with Sintef, Equinor, Aker Solutions and Chalmers University of Technology. The aim is to build a full-scale plant by 2025 which can capture up to 500 000 tonnes of CO_2 per annum – corresponding to 30 per cent of total emissions – for subsequent transport to and storage off Norway.

This CCS project is Preem's first step towards net zero emissions. Over time, the company aims to refine a larger proportion of bioproducts, where the CCS plant and infrastructure will make it possible to achieve negative emissions.

Lysekil, Sweden

BOX 5: SWEDEN'S PREEM WANTS TO ACHIEVE NEGATIVE EMISSIONS BY USING CCS

Source: Preem (2019) and Sintef (2019)

In September 2019, Equinor signed letters of intent on behalf of Northern Lights with seven international industrial companies which have the potential to capture and store some four million tonnes of CO_2 per annum. Among these signatories is Preem, one of the largest oil refiners in the Nordic area (see box 5). Northern Lights is also in discussion with more than 20 other interested industrial companies. An overview of these is provided in figure 5. A well was spudded on the storage formation in December 2019, and plans call for injection of CO_2 from Norcem Brevik and Fortum Klemetsrud to begin by 2024.

A Sintef study[12] in 2018 estimated that such value chains could potentially create 30-40 000 new jobs in Norway by 2050, and safeguard existing industrial employment given that the EU aims to achieve net zero emissions in 2050.

International collaboration is important for developing and implementing new technology to reduce emissions. A number of energy and petroleum companies have established the Oil and Gas Climate Initiative (OGCI) precisely to unify technological forces and knowledge. See box 6.

12 Sintef (2018) - Industrielle muligheter og arbeidsplasser ved storskala CO_2-håndtering i Norge

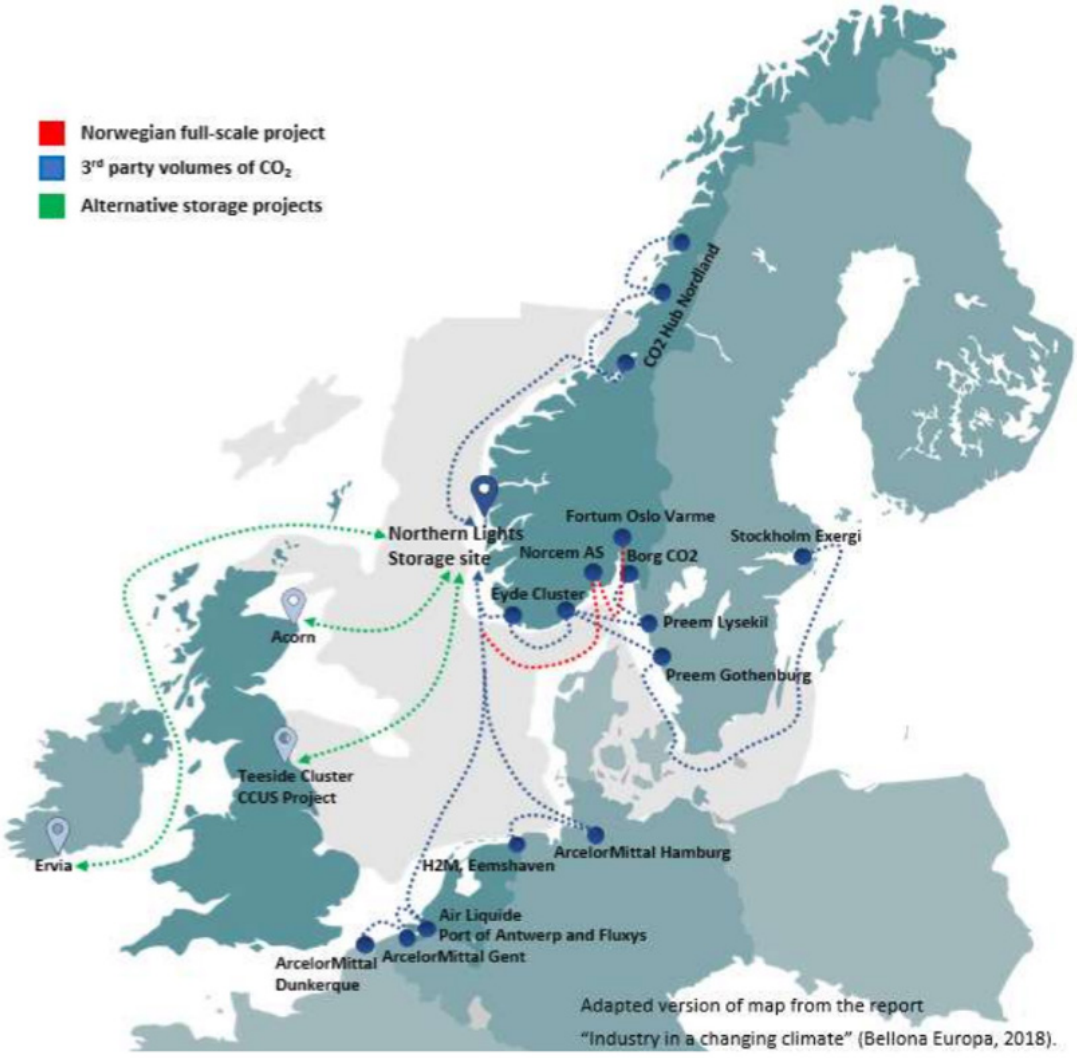


FIGURE 5: PARTNERS IN THE EUROPEAN "PROJECT OF COMMON INTEREST" APPLICATION FOR NORTHERN LIGHTS, APPROVED BY THE EU IN 2019.

Source: Northern Lights

OIL AND GAS CLIMATE INITIATIVE

The Oil and Gas Climate Initiative (OGCI) is being taken by the petroleum industry to speed up the development of low-emission solutions in connection with the goals set in the Paris agreement. It has secured backing from Equinor, Shell, ENI, Repsol and nine other oil and gas companies. The OGCI invests in R&D with low-emission solutions, among them carbon capture, utilisation and storage (CCUS). Its investments include the following projects.

Net Zero Teesside: This CCUS project based in the Teesside area of north-east England is establishing a cluster of carbon-intensive companies with the aim of reducing GHG emissions related to the whole value chain from production to consumption of oil and gas up to 2030. Its goal is to capture six million tonnes of CO_2 per annum, equivalent to emissions from the energy consumption of two million UK households.

Wabash Valley Resources: A project for low-emission hydrogen and ammonia production in the USA to be used for transport, industry and agriculture. It includes the capture and storage of 1.65 million tonnes of CO_2 per annum.

Svante Inc: A supplier of second-generation CCS technology, which has collaboration projects with energy and cement facilities in North America and Europe.

BOX 6: OIL AND GAS CLIMATE INITIATIVE

COMMITMENT MUST BE MADE TO CCS VALUE CHAINS IN NORWAY

Maintaining a commitment to developing CCS value chains in Norway could help to build an important new industry on the NCS. An investment decision for the Norwegian full-scale CCS projects is planned by the end of 2020. The oil and gas industry in Norway will work to achieve the following.

- Two carbon capture facilities in Norway – Norcem Heidelberg cement at Brevik and Fortum energy recovery at Klemetsrud – and the Northern Lights carbon transport infrastructure and NCS storage to be operational by 2024.
- CO_2 sent for storage on the NCS from at least five industrial companies in several countries by 2030.

The future market for carbon capture plants in Europe and the rebe st of the world is regarded as substantial, and the supplier industry expects to be able to deliver several dozen such facilities by 2030.

3.2 Hydrogen

PRODUCING HYDROGEN FROM NATURAL GAS WITH CCS WILL GIVE BIG EMISSION CUTS

In a somewhat longer perspective, consumption of natural gas without CCS will fall significantly from today's level in the EU, given its goal of net zero emissions by 2050. A big demand will simultaneously arise to find alternative low-emission energy carriers to replace current natural gas consumption by the industrial, heating and transport sectors, along with flexible load balancing on a scale which meets power generation needs.

Hydrogen produced from natural gas with CCS could be crucial in meeting this requirement. Some 90-95 per cent of the CO_2 content in natural gas can be captured and stored, which gives hydrogen combustion a very low carbon footprint. The EU report on *A Clean Planet for All* describes hydrogen as a potentially important solution for achieving net zero emissions. [13]

Producing hydrogen from natural gas with CCS has a big potential for safeguarding sales of Norway's natural gas resources in the longer term while simultaneously helping to simplify the EU's transition to a low-emission society by offering a very low-emission energy carrier which can replace fossil fuels across several sectors. Converting today's natural gas exports to hydrogen with CCS would yield about 22.5 million tonnes of this commodity per annum. [14]

Norway has centres of industrial and research expertise on pipeline transport, CCS and steam reforming of natural gas.

The oil and gas industry in Norway is already engaged in various projects which offer opportunities to adopt hydrogen produced from natural gas with CCS. Equinor is involved in major programmes assessing the use of hydrogen from natural gas in electricity generation, industrial processes, transport and heat production.
See boxes 7-10.

European industry also sees opportunities for using hydrogen to cut its GHG emissions. ThyssenKrupp Steel Europe, for example, runs Germany's largest steel mill at Duisburg. This releases some 4.7 million tonnes of CO_2e per annum, equivalent to nine per cent of Norway's total GHG emissions. Steelmaking involves burning coal in a reduction process. Reducing its emissions will therefore be tough without making major changes to production processes or adopting CCS.

Equinor is now collaborating with ThyssenKrupp to find a solution which replaces coal with hydrogen, produced from natural gas with CCS, as the reducing agent in steelmaking. Storing the captured CO_2 in the future Northern Lights facility beneath the NCS is being assessed. Europe has more than 60 other major steel mills where CCS could contribute to big future emission cuts at a European level.

13 EC (2018) A Clean Planet for All

14 Thema Consulting Group (2019) - Systemvirkninger og næringsperspektiver ved hydrogen

AMBITIONS FOR HYDROGEN FROM NATURAL GAS WITH CCS

The oil and gas industry in Norway will work for:

- hydrogen as a fuel being demonstrated in offshore shipping by 2025
- at least two European gas-fired power stations using hydrogen as fuel by 2030
- at least five European industrial companies using hydrogen produced from Norwegian natural gas with CCS in their production by 2030.

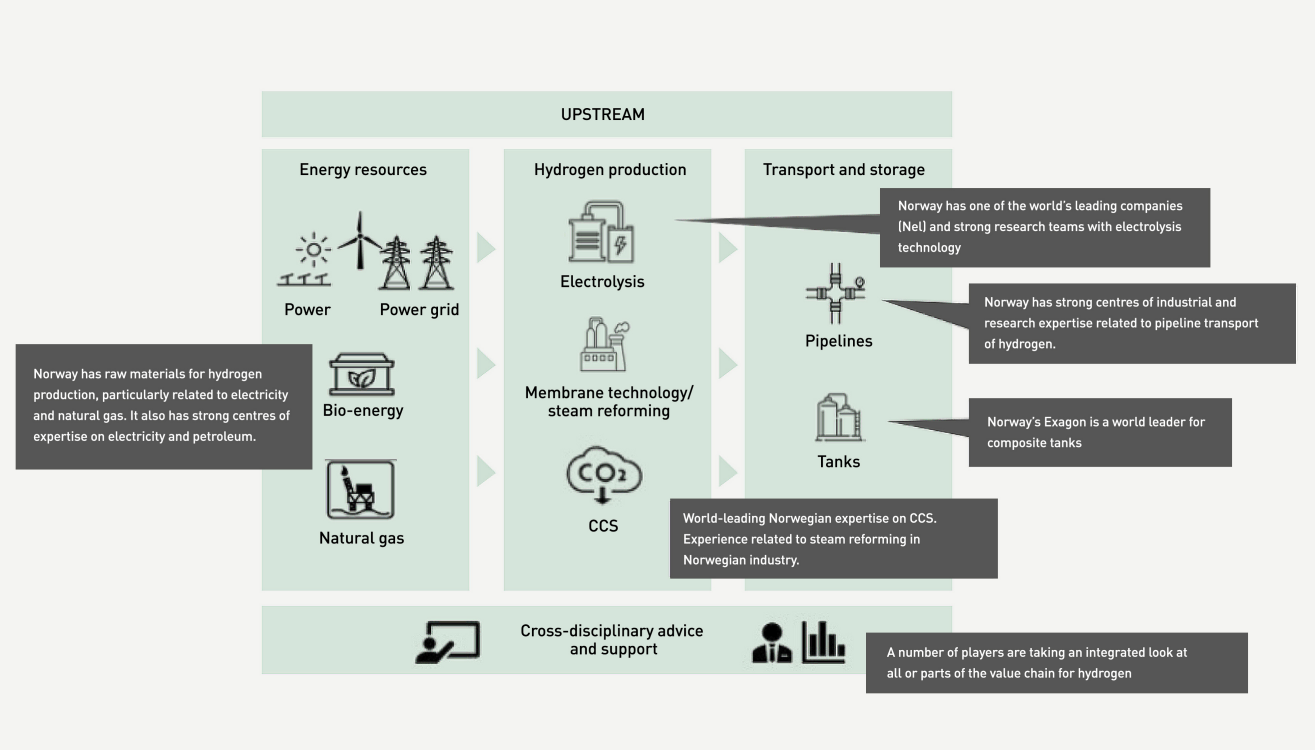


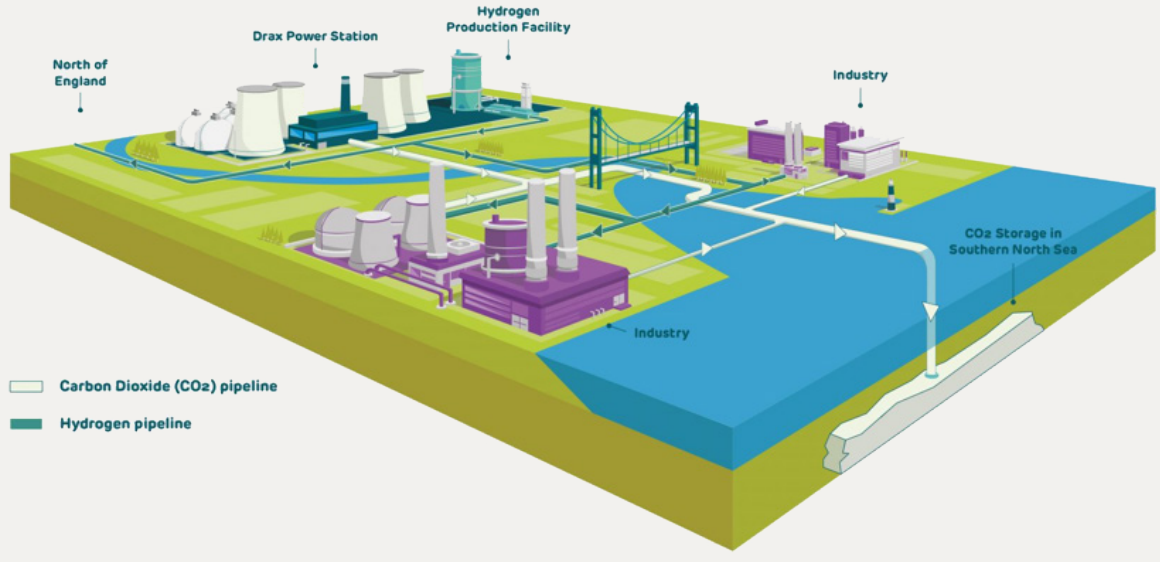
FIGURE 6: NORWAY IS WELL PLACED TO TAKE A GLOBAL LEAD ON PRODUCING HYDROGEN FROM NATURAL GAS WITH CCS AND BY ELECTROLYSIS.

Source: Thema Consulting Group (2019)

HYDROGEN FOR INDUSTRIAL PROCESSES

The UK is working to establish the world's first zero-emission industrial cluster. A collaboration has been established between the Drax Group, National Grid Ventures and Equinor to help realise this goal in the industry-intensive Humber region. This will be done through using hydrogen as an energy source for industry, electricity generation, heating and transport in the region, with a large-scale CCUS plant.

As part of the project, plans call for the construction of a large-scale demonstration plant for hydrogen production at the Drax facility in the mid-2020s. The companies are also planning to build the world's first carbon-negative power station to generate electricity by burning biomass combined with CCS.

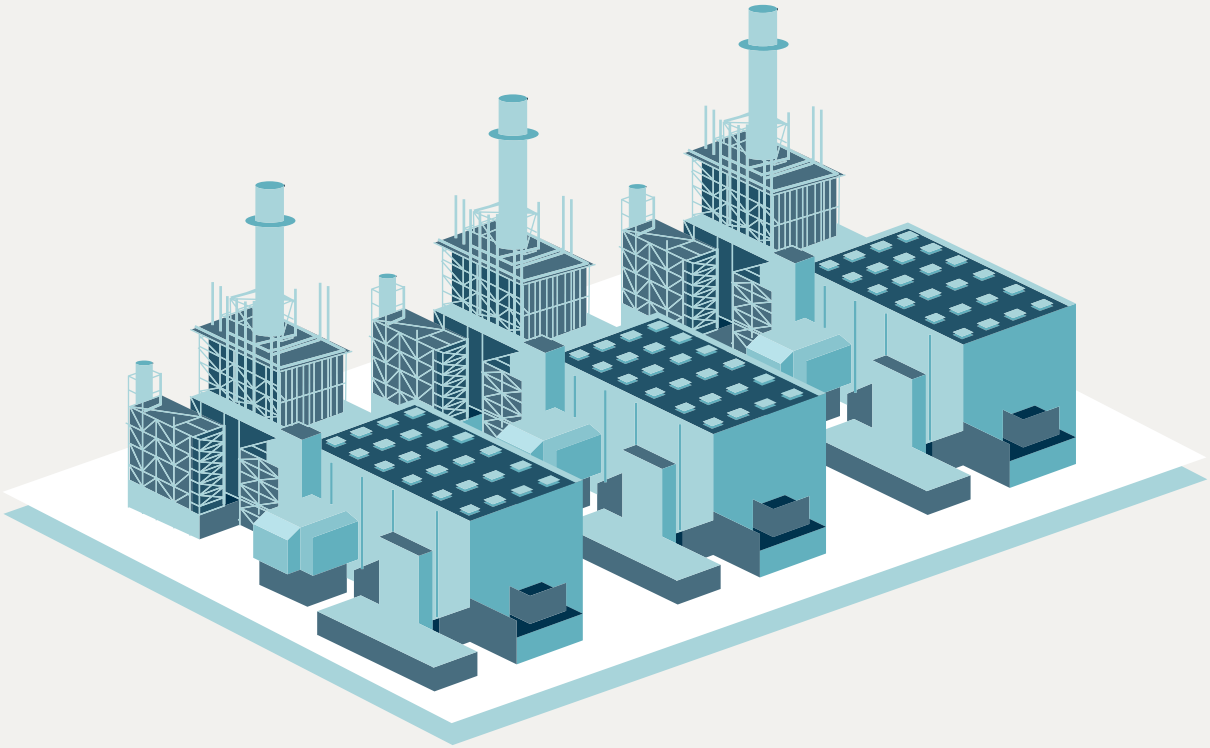


Plans for the Humber region industrial cluster with net zero emissions, www.zerocarbonhumber.co.uk

HYDROGEN ELECTRICITY GENERATION

Participants in the H2M consortium – Vattenfall, Equinor and Gasunie – are studying opportunities for converting a Dutch gas-fired power station to hydrogen operation. The letter of intent also involves investigating the creation of a large-scale value chain for hydrogen production combined with carbon capture, transport and permanent storage. Possible business models for such a combination will also be investigated.

Each of the three combined gas/steam turbines at the Magnum power station has a capacity of 440 megawatts and releases about 1.3 million tonnes of CO_2 per annum. The project initially plans to convert one of these units to hydrogen operation. If realised for all three units, this could reduce annual CO_2 emissions by four million tonnes.



Vattenfall's Magnum gas-fired power station in the Netherlands is being assessed for conversion to run on hydrogen.

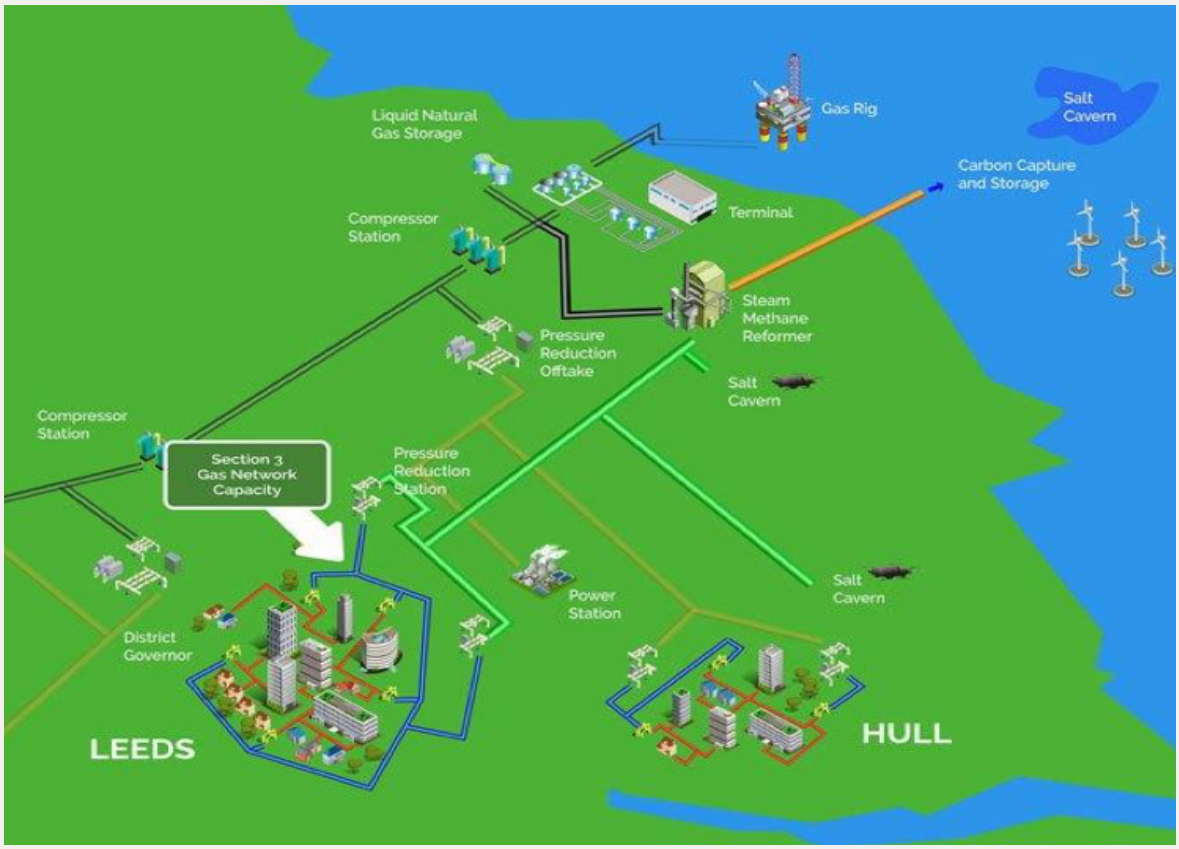
Source: Equinor (2017)

BOX 8: HYDROGEN FOR ELECTRICITY GENERATION

HYDROGEN FOR HEAT

The H21 study by Cadent, Equinor and Northern Gas Networks has assessed the possible conversion of the UK's existing gas distribution network for hydrogen delivery. These companies are investigating opportunities to achieve big emission cuts by replacing the natural gas used today for household heating and cooking with hydrogen produced from steam reforming of natural gas with CCS.

In its first phase, the study is directed at decarbonising heating for 3.7 million households and 40 000 companies in northern England by 2034, with the ambition of expanding by a further 12 million households in 2050. The starting point is producing low-emission hydrogen from natural gas with CCS, planned to take place in a facility with a capacity of 12 gigawatts.



Concept for a full-scale value chain for hydrogen from natural gas with CCS.

HYDROGEN IN MARITIME TRANSPORT

Much work is being done to develop concepts for using hydrogen in Norway's maritime sector. A consortium comprising BKK, Equinor, Air Liquide, Norled, Wilhelmsen, Viking Cruises, NorSea Group, Norce and NCE Maritime Cleantech is receiving support for a Pilot-E project concentrated on developing value chains for hydrogen to be used in the maritime sector. The artist's impression below shows a hydrogen ferry being developed for Norled in cooperation with LMG Marin and Westcon Power & Automation.

Hydrogen-fuelled ferry.

BOX 10: HYDROGEN IN MARITIME TRANSPORT

3.3 Offshore wind power

OFFSHORE WIND POWER WILL HAVE A KEY PLACE IN SUPPLYING RENEWABLE ENERGY FOR THE WORLD

Offshore floating and fixed wind power will play an important role in tomorrow's energy system. Europe has taken a lead in developing the technology, with big projects in the UK, Germany and Denmark. Such developments are also being stepped up sharply in Asia and the USA.[15] According to the IEA's sustainable development scenario, the global market for offshore wind power will grow by more than 13 per cent per annum. That would result in a combined installed capacity of 560 GW by 2040. This will meet five per cent of world electricity consumption from an investment in the order of USD 1 000 billion. The International Renewable Energy Agency (Irena) also believes the market for offshore wind power will increase substantially over the next three decades, to a total installed capacity of 228 GW in 2030 and almost 1 000 GW in 2050.[16]

How much actually gets developed will depend on such factors as cost levels, technological progress and the competitive position of offshore wind power compared with other energy sources. Also significant will be employment opportunities, conflict levels and environmental impacts.

The European Commission has presented its proposals for a European Green Deal, which aims to make the EU climate-neutral in 2050.[17] An important component is harnessing the full potential of offshore wind power in Europe. Several hundred GW from this source are incorporated in the commission's scenarios for net zero emissions by 2050.[18] Offshore wind farms also have a big potential for the electrification of offshore oil and gas installations, offshore hydrogen production, energy supplies to ships and rigs, and a range of other applications in areas such as aquaculture on the open sea.

Offshore wind power employed more than 1 600 people in Norway during 2017 and created NOK 3.9 billion in value.[19] This is expected to increase in the future. Pure oil and gas companies will become broad energy enterprises, while suppliers to the petroleum sector increase their involvement in renewables. Equinor, for example, has ambitions to invest in the order of NOK 100 billion in new renewable energy up to 2030. [20] Kværner's strategy is to grow in renewable activities alongside its

15 IEA (2019) - World Energy Outlook 2019 and Norwep (2018) - Global Offshore Wind Market Report 2018

16 Irena (2019) – FUTURE OF WIND Deployment, investment, technology, grid integration and socio-economic aspects. A Global Energy Transformation paper. October 2019.

17 EC (2019) – European Green Deal

18 EC (2018) – A Clean Planet for All

19 Menon (2018) - Kartlegging av omsetning, sysselsetting, eksport og utenlandsomsetning i fornybarnæringen i Norge 2017.

20 Equinor (2017) – Fra oljeselskap til bredt energiselskap and E24 (2019) – Equinor foran skjema om fornybar energi

21 Kværner (2019) – Kværners kontrakt for Hywind Tampen er et viktig strategisk gjennombrudd

existing involvement in oil and gas,[21] while Aker Solutions has unveiled a plan to derive almost half its turnover from renewable energy and what the company considers "low-carbon solutions" by 2030.[22] Renewables now account for 40 per cent of Aibel's order backlog, compared with less than five per cent a year ago.

Floating wind power has a big value creation potential in Norway. In a report on the value creation potential of developing a Norwegian-based floating wind turbine industry,[23] Menon Economics assumes a base scenario for this sector with a global capacity of 60-140 GW in 2050. Its calculations indicate that industry based in Norway could take up to 20 per cent of the world market. Assuming that the latter will reach 140 GW in 2050, this corresponds to a value creation of NOK 117 billion and a cumulative employment effect of 128 400 work-years over three decades.

Local production of renewable energy from offshore wind power could contribute to both reductions in petroleum industry emissions on the NCS and exciting new industrial development in Norway. An important example of such local renewable energy production is Equinor's commitment to floating wind power in the Tampen area. Technology development in this project could contribute to positive learning effects with this energy source on the NCS and to the development of a value chain for floating wind power which could have a big potential internationally.

COMMITMENT TO RENEWABLE OFFSHORE WIND POWER IN NORWAY MUST CONTINUE

Good wind resources on the NCS, combined with Norway's strong position in maritime, offshore and land-based industrial sectors, mean that offshore wind power has all it needs to become a large and important new Norwegian industry.

In the future, Norway could potentially export large quantities of renewable energy generated on the NCS to Europe, and the oil and gas industry will work to ensure that the strong Norwegian position in renewable offshore wind power continues to be developed.

22 Aker Solutions (2019) – Aker Solutions targets growth in low carbon and renewable energy

23 Menon (2019) – Verdiskapingspotensialet knyttet til utviklingen av en norskbasert industri innen flytende havvind.

4 PREDICTABLE AND INNOVATION-PROMOTING PARAMETERS

Achieving the targets set in this climate strategy calls for far-reaching changes to the oil and gas industry in Norway.

Predictable operating parameters which make it possible to take a long-term perspective on investment in Norway and government instruments which encourage the implementation of efficient climate measures will be very important contributions to this transformation.

4.1 Predictable and innovation-promoting parameters

Achieving the climate targets requires that the companies approach their operations in Norway in a long-term perspective. Stable and predictable operating parameters which encourage innovation and a continuation of today's tax regime will safeguard continued competitiveness for the industry.

This is very important in order to provide the security needed for undertaking long-term climate and technology investments related to petroleum production, CCS, hydrogen from natural gas and offshore wind power.

4.2 Today's support schemes must be maintained and strengthened

Government instruments represent an important source of support when the industry aims to achieve such ambitious goals as a 40 per cent emission reduction in 2030 and near zero emissions in 2050. The industry regards the schemes below as particularly important for the continued development of low- and zero-emission solutions.

ENOVA

It is important to strengthen Enova and give it the opportunity to support technology developments which reduce GHG emissions and energy consumption.

The adaptations being made offshore involve substantial risk and additional costs, often greater than for land-based industry. This means new technology or solutions need several demonstrations before being regarded as qualified for use offshore. Securing cost cuts from learning is essential, and risk mitigation through a sufficient number of projects to reduce costs will be needed.

BUSINESS FUND FOR NITROGEN OXIDES

The NO_x fund was established within the framework of the environmental agreement on these gases in 2008, and is a voluntary scheme between a number of industry organisations and the government,

represented by the Ministry of Climate and the Environment. It functions as an instrument for cutting NO_x emissions in order to fulfil Norway's obligations under the Gothenburg protocol[24] and EU directive 2016/2284.[25]

Through its grants to support emission-reducing technologies and conversions, the fund has contributed to a substantial cut in NO_x emissions since 2008. Measures adopted in offshore petroleum operations related to these gases often have a further positive effect by also reducing the amount of CO_2 released. The present environmental agreement with the government runs to 2025. To secure continued reductions in NO_x emissions in line with Norway's international obligations, the industry recommends that it be extended until 2030. Work on this should begin immediately in order to ensure predictability when planning measures for the period.

RESEARCH AND DEVELOPMENT PROGRAMMES

Norway's system to determine the strategy for and conduct of research in the petroleum sector has functioned extremely well. The national OG21 strategy defines the direction and gives guidance, while funds are allocated through the Petromaks 2 and Demo 2000 programmes. Along with Climit, these should be returned to their 2019 funding level and further strengthened towards 2030. The tax incentive scheme for R&D is very important for many companies. The LowEmission Research Centre should be maintained, and EnergiX continue to receive support for hydrogen-related research.

FACILITATING ELECTRIFICATION WHERE SENSIBLE IN AN OVERALL PERSPECTIVE

It is important that assessments related to electrifying oil and gas installations in Norway and developing offshore wind power are made on the basis of an overall perspective, where the needs of land-based and offshore industries for competitive power costs are met.

NORWEGIAN ENERGY PARTNERS (NORWEP) AND INTERNATIONAL SALES AND MARKETING

Norwep has been established to support Norwegian suppliers in the renewable and petroleum energy sectors when identifying relevant projects and markets globally for deliveries from Norway. This organisation is functioning well and forms part of the Norwegian system of government instruments, but is distinguished by the fact that the industry participates actively in its financing and organisation. Through its work, Norwep will contribute to value creation and employment in Norway and thereby strengthen the Norwegian supplier industry. Norwep reports that international interest in emission-reducing technology and solutions is being recorded for the first time in a number of markets.

The Norwegian Export Credit Guarantee Agency (Giek) and Export Credit Norway are key providers of guarantees and credits respectively for foreign trade, and have made important contributions to the international success of Norwegian companies.

24 Norwegian Environment Agency - Nitrogenoksid

25 Directive (EU) 2016/2284 of the European Parliament and of the Council of 14 December 2016 on the reduction of national emissions of certain atmospheric pollutants.

4.3 Value chains for CCS and hydrogen

Developing and implementing technology and solutions for hydrogen and CCS call for a commitment both by the oil and gas industry and by the government. The following decisions and activities are very important in ensuring the achievement of the goals.

- Taking an investment decision in 2020 for the two carbon capture facilities at Klemetsrud and Brevik as well as the Northern Lights project on carbon transport and storage.
- Continuing the commitment to developing new-generation technology and projects which reduce CCS costs in both large and small facilities.
- Committing to research, development and demonstration projects for hydrogen from natural gas with CCS.
- Ensuring that pilot and demonstration projects related to hydrogen from natural gas with CCS are covered by the petroleum tax regime.
- Strengthening collaboration with European players in order to boost CCS and hydrogen as an energy carrier.

4.4 A fund for CO_2 measures could contribute to further emission reductions

Establishing a fund for CO_2 measures could support faster implementation of plans which provide further absolute emission reductions on top of the targets set. It could be used to help finance climate measures which fall outside existing support schemes. Reference is made in that context to the good experience with the NO_x fund.

APPENDICES

The oil and gas industry's role in the low-emission society

The world community faces a number of fundamental challenges which must be overcome in the 21st century. Of the 17 sustainable development goals identified by the UN, some the most crucial include combating global warming, poverty and biodiversity loss as well as providing affordable and sustainable energy for all. An integrated approach must be taken to these goals to ensure that one is not achieved at the expense of another. The global amount of anthropogenic GHG must be reduced, and fossil fuels are clearly the largest source of today's emissions. On the other hand, demand for cheap energy is rising as a result of global population growth at the same time as billions of people must be lifted out of poverty.

World oil and gas consumption in 2050 will be sharply reduced from current levels in virtually all the scenarios referenced by the UN Inter-governmental Panel on Climate Change (IPCC) as being in line with a goal of limiting global warming to 1.5°C. At the same time, no scenario phases out petroleum entirely. Emissions from residual oil and gas production in 2050 must therefore be as low as possible, and eliminated or substantially reduced when these commodities are used.

PARIS AGREEMENT AND THE EU

The Paris agreement represents the central global framework for reducing GHG emissions. Its goal is to limit global warming in the 21st century to 2°C compared with the pre-industrial temperature, but it also strives towards limiting the rise even further, to just 1.5°C. A report published by the IPCC in the autumn of 2018, which pointed to the differences and the importance of holding warming to only 1.5°C rather than 2°C, has increased support for a stronger effort by the world's nations to combat climate change.

With an ambition to be the world leader for reducing GHG emissions, the EU has a goal of cutting the amounts released by a minimum of 40 per cent in 2030 and 80-95 per cent in 2050 when compared with 1990. Growing political commitment to achieving faster reductions means that the EU is now assessing cuts of 50-55 per cent by 2030 and net zero emissions by 2050. The latter would mean some GHG continues to be released, but that this must be offset through biological or technical CCS.

Norway is collaborating closely with the EU on cutting GHG emissions, and has targets enshrined in law for 2030 and 2050 which reflect the European goals. An increase in the EU ambitions would therefore probably also lead to a future rise in the Norwegian targets.

NATURAL GAS FROM NORWAY IS IMPORTANT FOR THE EU'S CLIMATE GOALS

Replacing coal with natural gas in the European electricity sector will be important in the short and medium terms for cutting the EU's GHG emissions. Power generation based on coal accounts for a substantial proportion of EU emissions, and shifting from this fuel to gas would permit big cuts to be achieved quickly. Norwegian natural gas exported by pipeline also has a low climate footprint compared with other EU gas imports.

Renewable sources such as wind, solar and other solutions account for a growing share of electricity output. Natural gas consumption for generating power is expected to decline, but gas-fired power stations are nevertheless expected to play an important role in balancing variable solar and wind power output.

EU climate scenarios for 2050, published by the European Commission in *A Clean Planet for All* in 2018, [26] provide indications about the consequences which a target of net zero emissions would have for the energy mix in Europe. Figure 7 shows the commission's estimates for various energy carriers used in the EU under different scenarios for 2050. The column on the far right presents an estimated energy mix associated with a goal of net zero emissions in 2050.

As the figure shows, the fossil-fuel share of energy consumption falls from just over 70 per cent in 2016 to about 15 per cent in 2050. The bulk of the latter represents feedstock in industrial processes or in other non-energy applications. CCS is identified as important for cutting residual emissions from industry and for achieving possible negative emissions in the form of bioenergy with carbon capture.

A goal of net zero emissions in 2050 means the amount of GHG released by natural gas consumption must be substantially reduced – through processing to emission-free hydrogen combined with CCS, for example.

26 EC (2018) – A Clean Planet for All

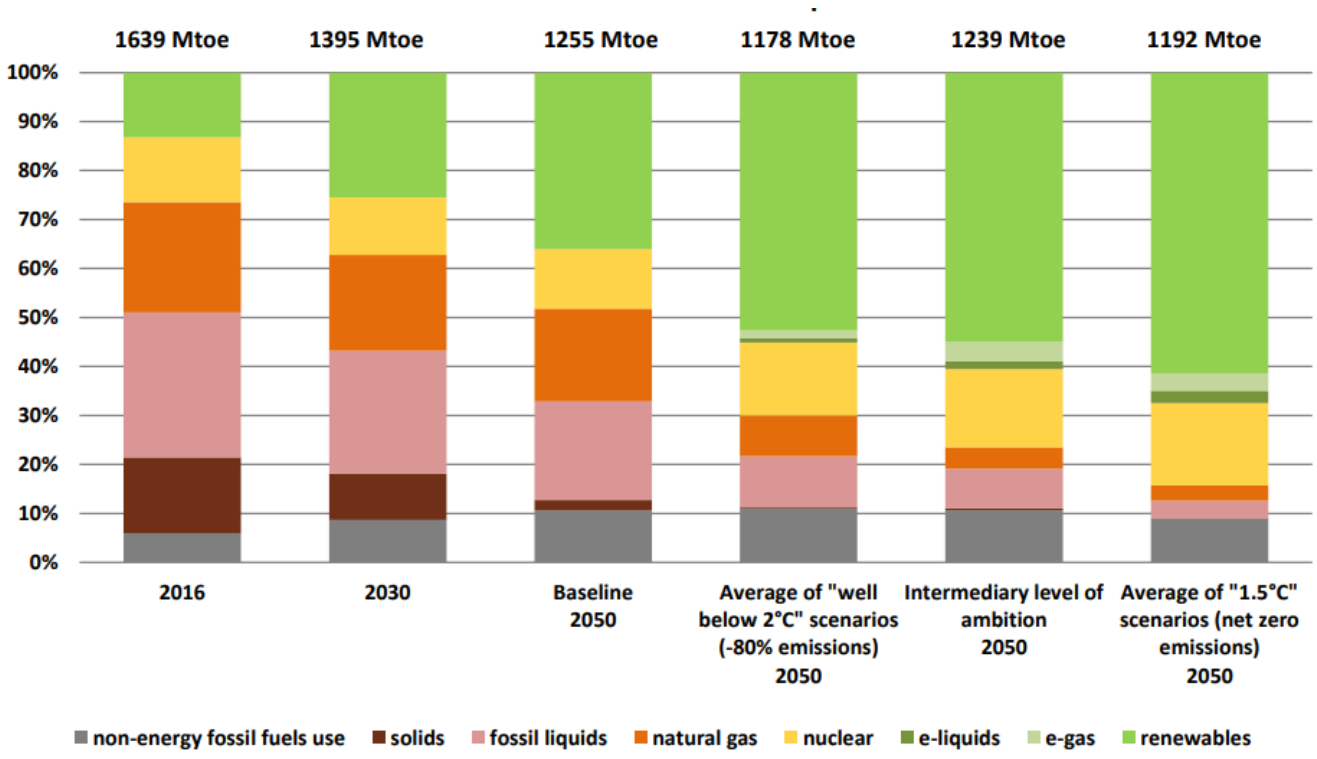


FIGURE 7: GROSS EU ENERGY CONSUMPTION IN 2016, 2030 AND FOR VARIOUS SCENARIOS IN 2050. Source: EC (2018)

DEMAND FOR OIL AND GAS IN 2050

Predicting how demand for different energy sources will develop over the next 30 years is difficult. Various scenarios and projections yield differing results related to varying expectations of technological progress as well as national and international politics.

The IPCC's 1.5°C report[27] emphasised that a goal of net zero emissions in 2050 involves a radical transformation of the global energy system. At the same time, it gives no clear answer on how such a restructuring will happen and what the world's energy mix will be in 30 years. The report refers to a number of research-based scenarios, and the global consumption of oil and gas is expected to be substantially reduced in most scenarios which keep warming to only 1.5°C. Most scenarios assume extensive use of CCS, and that combining this with bioenergy will be a potentially important measure for achieving negative emissions.

A GROWING SHARE OF PETROLEUM USED AS INDUSTRIAL FEEDSTOCK

In addition to playing a key role in the global energy system, oil and gas are important input factors in many different industrial processes. As shown in figure 8, about 11 per cent of the world's total annual petroleum production is used as feedstock. The great bulk goes to industry (10 per cent), while a small one per cent gets consumed in other sectors.

Many products in daily use are wholly or partly made from petroleum, including composites and plastics in cars, aircraft, textiles, shoes, computers, skis, kayaks and bicycles. Even though a growing number of countries are restricting single-use plastic products, overall demand for items composed of plastic materials is rising globally in line with increasing prosperity.

27 IPCC (2018) - Mitigation Pathways Compatible with 1.5°C in the Context of Sustainable Development

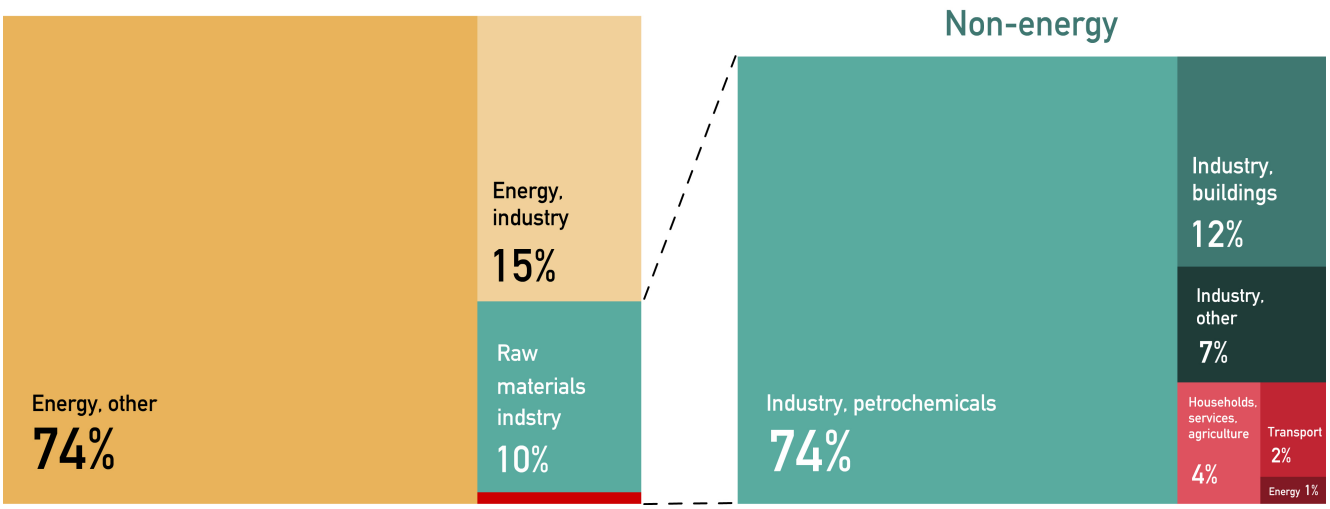


FIGURE 8: CONSUMPTION OF OIL AND GAS FOR ENERGY PURPOSES AND AS INDUSTRIAL FEEDSTOCK.

Source: Endrava (2019), based on figures from the IEA for 2017.

In addition to plastics and composites, the petrochemicals industry uses hydrocarbons from oil and gas in many other everyday products – including a lot of cosmetics, pharmaceuticals, paints and adhesives, for example. Natural gas is also utilised in the production of artificial fertilisers and therefore forms an important part of the global value chain for food production.

The heaviest oil fractions, such as bitumen, are used to manufacture asphalt for road surfacing, important building materials and waterproofing roofs. Other oil-based products are utilised across sectors, such as lubricants for rotating machinery and solvents. With an expected decline in petroleum consumption for heat and power and growing global demand for petrochemicals, the proportion of oil and gas output used as feedstock is likely to continue growing. Figure 9 presents various projections for the proportion of overall global oil and gas production used for non-energy purposes. As this shows, most scenarios indicate an increase.

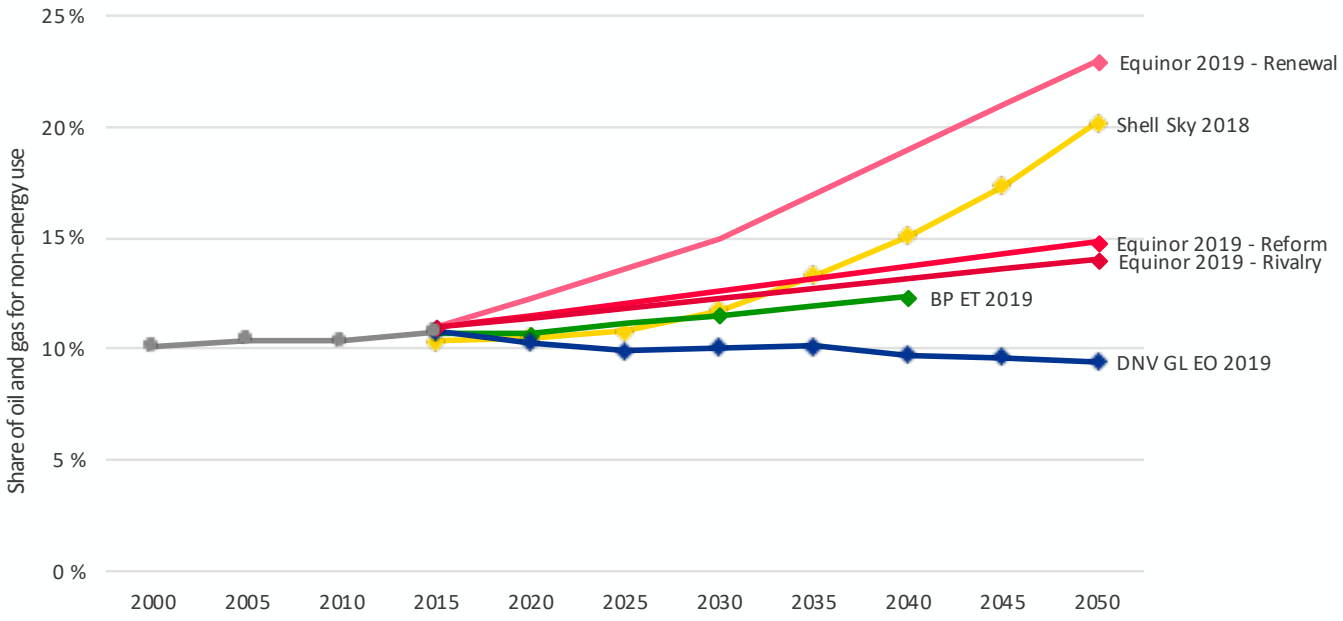


FIGURE 9: SHARE OF OVERALL OIL AND GAS DEMAND USED FOR NON-ENERGY PURPOSES.
Source: Endrava (2019), based on figures from Equinor (2019), Shell (2018), BP (2019) and DNV GL (2019)

The oil and gas industry in Norway

Employment, value creation and revenues for society in the form of taxes and direct ownership make the oil and gas industry a very important part of the Norwegian economy. Furthermore, only about half the overall petroleum resources on the NCS are estimated to have been recovered. Thanks to strict regulation and long-term efforts to develop and implement emission-reducing technologies, GHG emissions from Norwegian oil and gas production are among the lowest in the world.

OIL AND GAS PRODUCED IN NORWAY HAVE A LOW CLIMATE FOOTPRINT

Norway's petroleum output has one of the world's lowest climate footprints. As figure 10 shows, an average of eight kilograms of CO_2e is released per unit of oil equivalent (oe) in Norway, which is far below the emission intensity in most other large petroleum-producing regions. Norwegian oil and gas production is subject to one of the world's most stringent tax regimes aimed at encouraging emission reductions and technology development. The CO_2 tax was introduced on the NCS as early as 1991, and the industry is also part of the EU ETS.

A KEY SOURCE OF JOBS AND REVENUES FOR SOCIETY

The oil and gas sector is one of Norway's biggest industries in terms of jobs, value creation and revenues for society. It employs 180 000 people directly or indirectly,[28] and the overall net cash flow from petroleum operations to the government is estimated at NOK 251 billion in 2018 and NOK 263 billion in 2019.[29]

28 Norwegian Oil and Gas employment figures.

29 Norwegian Petroleum (2019) – The goverment´s revenues

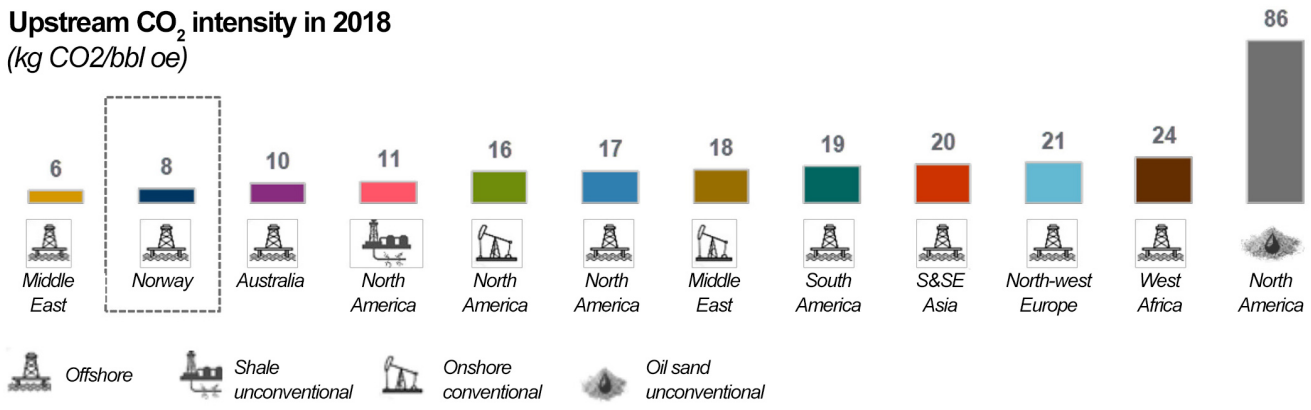


FIGURE 10: PRODUCTION AND EXPORT REVENUES FROM OIL AND GAS OPERATIONS IN NORWAY, 2018.

Source:Rystad Energy (2019)

Foreign sales of Norwegian petroleum, which totalled NOK 534 billion in 2018, account for about half the country's overall commodity exports. And the supplier industry makes the second largest contribution to these exports, with an international turnover of NOK 100 billion in 2017. [30]

From a global perspective, Norway is a relatively small player in the oil market and meets only two per cent of total world demand. Norwegian natural gas accounts for about three per cent of world demand for this commodity. Pipeline gas from Norway is particularly important in the EU, meeting roughly 25 per cent of its overall gas consumption.

SUBSTANTIAL OIL AND GAS RESOURCES REMAIN ON THE NCS

As shown in figure 12, about half the total oil and gas resources in the Norwegian economic zone were estimated to have been produced at the end of 2018. That means some 8.3 billion standard cubic metres of oe remain.[31] The potential for continued production is accordingly still substantial.

30 Rystad Energy (2018) – Internasjonal omsetning fra norske oljeserviceselskaper

31 Norwegian Petroleum Directorate (2010) (2019) – Resource report - discoveries and fields 2019

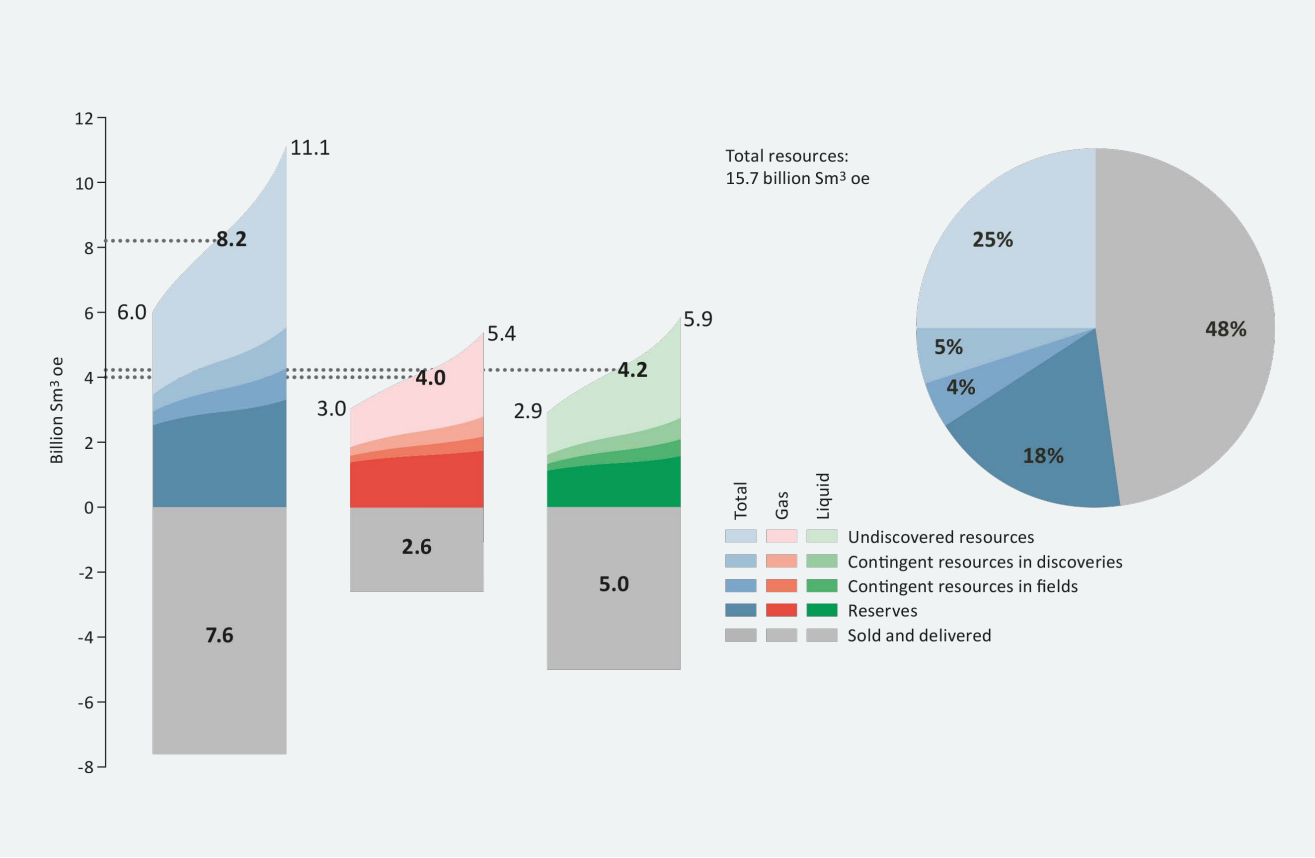


FIGURE 11: PRODUCTION HISTORY AND FORECASTS UP TO 2030.

Source: Norwegian Petroleum Directorate, 2019

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