THE ENERGY INDUSTRY OF TOMORROW ON THE NCS

CLIMATE STRATEGY TOWARDS 2030 AND 2050

STATUS REPORT 2022

KonKraft

ABOUT KONKRAFT

KonKraft is a collaboration arena for Offshore Norway, the Federation of Norwegian Industries (NI), the Norwegian Shipowners Association (RF), the Confederation of Norwegian Enterprise (NHO) and the Norwegian Confederation of Trade Unions (LO), together with two LO members – the United Federation of Trade Unions and the Norwegian Union of Industry and Energy Workers (Industry Energy).

Its role is to be an agenda-setter on national strategies for Norway's petroleum sector and to work on maintaining the competitiveness of the Norwegian continental shelf (NCS), so that the country remains an attractive investment target for the domestic and international oil and gas sector, including supplier companies and the maritime industry.

The council is KonKraft's topmost body. In addition, it has an executive committee and a secretariat, which is responsible for ongoing activities and day-to-day operations.

OFFSHORE NORGE Norsk Industri Norges Rederiforbund Norwegian Shipowners' Association NHO LO Fellesforbundet INDUSTRI ENERGI

CONTENTS

SUMMARY

The Norwegian oil and gas industry will do its part of the job in ensuring that Norway and the world reach their emission goals by mid-century.

With some of the lowest petroleum production emissions globally, Norway's oil and gas sector has set ambitious targets for further reductions. In 2020, KonKraft adopted a climate strategy to reduce greenhouse gas (GHG) emissions from this industry by 40 per cent in 2030 and to near zero by 2050. Its future follow-up of efforts to attain the 2030 goal will be based on the target of an absolute 50 per cent cut set by the Storting (parliament) when considering temporary changes to the Petroleum Tax Act. In parallel with reducing emissions from today's petroleum activities, a new and forward-looking energy industry will be built up on the NCS which includes offshore wind power, hydrogen, and carbon capture and storage (CCS). This report provides a update for 2022 on the status of KonKraft's work to reach the ambitious goals specified in the climate strategy.

Emissions from petroleum operations declined by eight per cent from 2020 to 2021, reaching a level of 12 million tonnes of CO_2 equivalent (CO_2e), and were thereby down by 11 per cent compared with 2005.

The reduction in 2021 primarily reflected a production shutdown at the Hammerfest LNG plant on Melkøya, and is expected to be reversed somewhat in 2022. From 2023, however, emissions are set to decline more rapidly as sanctioned reduction measures are implemented. Realising electrification projects takes time, and the big cuts will emerge gradually up to 2030. See figure 1.

About 50 per cent of Norway's petroleum industry emissions can be cut by 2030.

An updated review of emission-reducing measures at various stages of maturation by operator companies on the NCS shows that achieving the target cut of 50 per cent by 2030 is possible, but that predictable operating parameters and strengthened support programmes will be crucial. Cancellation or postponement of planned power-from-shore projects would make it very difficult to reach the 2030 climate target.

Players in the oil and gas sector are working intensively to identify and mature emission reduction projects, and the number of such measures sanctioned and matured has increased sharply – from 22 per cent of the portfolio in 2020 to 56 per cent in 2021. One reason why a number of the climate measures have matured considerably or been sanctioned is the temporary tax changes introduced in order to maintain the level of activity during the coronavirus pandemic. Roughly half the overall potential for emission reductions comprise measures still at an early stage.

Electrification through power from shore could eliminate nine per cent of today's overall Norwegian emissions by 2030 and is the most important measure for reaching the industry's ambitious climate goals.

Extending electrification offshore is an effective climate measure and provides genuine emission cuts in global terms. It has an energy efficiency effect in that natural gas can be used more efficiently in alternative applications when exported to Europe, while also displacing European imports of other gas with a higher carbon footprint.

Access to new renewable energy is crucial for meeting the climate goals.

Given today's sanctioned and planned power-from-shore projects, electricity demand from the oil and gas industry is expected to roughly double in 2030 from today's level of about nine terawatt-hours (TWh). Stable supplies of renewable power at competitive prices are a precondition for many electrification measures in Norwegian industry, and are an important competitive advantage in the energy transition. To ensure continued competitive prices in the Norwegian electricity market, capacity for generating renewable power must be increased.

Other types of emission-reduction measures also make a mark in the climate transition.

Energy efficiency enhancements and reduced flaring play important roles for goal attainment. The operator companies on the NCS work continuously to identify and initiate such measures, which can often yield quicker emission cuts than electrification projects. Many companies are actively pursuing research and development (R&D) with new technologies, such as carbon capture on installations, qualifying carbon storage sites, compact combined cycle plants, and using hydrogen or ammonia for offshore power generation. These technologies are expected to be more relevant in the long term, but how far they can provide emission reductions by 2030 is uncertain.

Players on the NCS are working actively to reduce emissions from maritime operations by enhancing energy efficiency, optimising operations and new technologies.

In addition to reducing emissions related to petroleum operations on the NCS and at land plants, the industry will cooperate with ship and rig owners in being a driver for achieving a 50 per cent emission cut by 2030 from vessel categories involved in offshore maritime operations, in line with Norway's action plan for green

FIGURE 01 UPDATED OPPORTUNITY SPACE IN MARCH 2022.
Emissions (million tonnes CO_2e/y)

Source: Konkraft

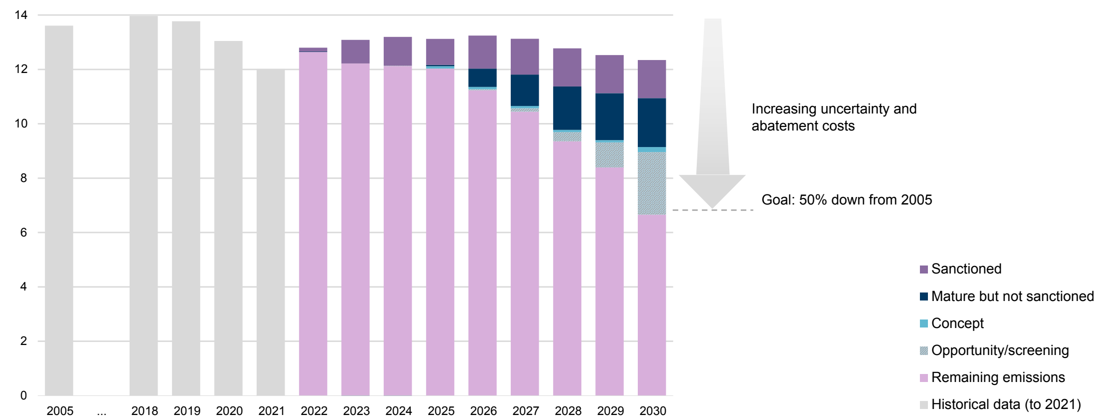


Figure: Updated opportunity space in March 2022 with projections for emissions and the estimated effect of large sanctioned climate measures and measures under assessment. The projections also include planned new field developments and cessations, which means that the total effect of emission-reduction measures at the various levels of maturity varies somewhat over time.

shipping. Many operator companies, as well as rig and ship owners, have set ambitious climate goals related to their own operations and have already achieved good results. Securing accurate figures for the overall status and development of emissions from maritime operations is difficult. Preliminary estimates show annual CO_2 emissions of roughly 2.1 million tonnes in 2021. While the model for estimated emissions in 2019-21 is activity based, it does not pick up measures to enhance energy efficiency. The KonKraft partners will prioritise securing better figures in the future.

Operator companies and suppliers lead the way in developing new low- and zero-emission technologies for a forward-looking energy industry on the NCS.

KonKraft's climate strategy also embraces ambitious targets for building up new value chains with such low- and zero-emission technologies as offshore wind, hydrogen and CCS on the NCS. The Norway Energy Hub describes a plan for industrialising new value chains on the NCS which contribute to the energy transition. It represents an invitation from Equinor to a national collaboration on, and concretising of, what is required to create new green value chains and continue developing Norway's position as an energy nation on the basis of its energy resources, expertise and capital.

Predictable operating parameters and strengthened support programmes will be important for reaching KonKraft's ambitious climate goals.

KonKraft's climate strategy gives players in Norway's oil and gas industry a set of very ambitious goals to work towards. To reach these targets, it is important that operating parameters in Norway provide for an effective development of industry policy and long-term perspectives for industrial players. These parameters must encourage technology development, innovation and scaling up. KonKraft would particularly emphasise the importance of establishing a CO_2 fund for reducing GHG emissions on the NCS, facilitating a rapid build-up of sufficient renewable power generation to ensure competitive prices for NCS electrification, and ensuring operating parameters which support a large-scale Norwegian commitment to offshore wind in line with the government's recently announced ambition to award areas for 30 gigawatts (GW) of such output by 2040. [1]

1 Government press release (2022), Ambitious offshore wind initiative.

> To reach these targets, it is important that operating parameters in Norway provide for an effective development of industry policy and long-term perspectives for industrial players

1

BACKGROUND

1.1 Global GHG emissions must be reduced, and the Norwegian petroleum industry accepts its responsibility

Immediate cuts in GHGs are needed in every sector to fulfil the Paris agreement, and the Norwegian oil and gas industry will do its part of the job in ensuring that Norway and the world reach their emission goals by the middle of this century. The latest part-report[2] from the UN's International Panel on Climate Change notes that, if planetary warming is to be limited to 1.5°C, global GHG emissions must peak before 2025 and be reduced by 43 per cent in 2030 and 84 per cent in 2050 compared with 2019. As Norway's largest industry, the oil and gas sector has a great social responsibility. It currently releases more than 12 million tonnes of CO_2 per annum and thereby contributes a substantial proportion of Norway's GHG emissions. These emissions are to be reduced while the industry produces energy as well as helping to maintain value creation, jobs and income for the welfare state. Norwegian oil and gas production has one of the lowest carbon footprints in the world, and this will get even smaller if the goals in KonKraft's global strategy are reached. A united petroleum industry in Norway set a target in 2020 of cutting emissions to near zero by 2050.

Predictable operating parameters and strengthened support programmes will be crucial for the industry's ability to implement its commitment to such low- and zero-emission technologies as CCS, hydrogen and offshore wind. Licensing and application processes should be reviewed, and government administrative capacity must be strengthened to reduce lead times. The expertise and technological innovativeness of the petroleum industry are crucial for putting in place the technologies required, which will also provide big emission reductions far beyond Norway's oil and gas sector and help to reach the targets set in the Paris agreement.

1.2 KonKraft's original climate strategy and raising the emission target

The KonKraft partnership developed *The energy industry of tomorrow on the Norwegian continental shelf. Climate strategy towards 2030 and 2050* in 2020 as the industry's commitment to reaching national and global climate goals. Preparing and following up a common climate strategy demonstrates the willingness of the players to adapt, and their ambitions for realising a low-emission society.

The main targets in the original climate strategy were:

- The Norwegian petroleum sector will reduce its absolute GHG emissions in 2030 by 40 per cent compared with 2005, and continue cutting them to near zero in 2050.
- Together with shipping companies and rig owners, the Norwegian petroleum sector will be a driver for vessels involved in offshore maritime activities to make an active contribution to achieving the goal set in the government's action plan on green shipping, which involves a 50 per cent emission reduction by 2030 in domestic maritime transport and fishing

2 Working Group III contribution to the IPCC sixth assessment report (AR6). Summary for policymakers.

In order to realise these goals, the industry is working to foster a culture which encourages and shares good ideas so that they can be widely adopted and the best solutions for reducing GHG emissions can be collectively identified. In addition to cutting emissions from its own operations and from associated offshore maritime activities, Norway's oil and gas sector has ambitions of gradually creating a new and forward-looking energy industry on the NCS. Developing new value chains includes a commitment to offshore wind, hydrogen and CCS projects which facilitate major emission reductions in Norway, Europe and the rest of the world. A more detailed description of goals and ambitions for new value chains on the NCS is provided in chapter 4. The need for changes to operating parameters and support programmes in order to realise emission reductions in the petroleum industry and succeed with new value chains is described in chapter 5.

After KonKraft adopted and published its climate strategy in January 2020, the Storting asked the government – through a petition resolution in connection with the temporary amendments to the petroleum tax regime – to present a plan together with the industry on how the oil and gas sector could reduce its GHG emissions by 50 per cent in 2030. The Storting called attention to the government's involvement in allowing the instruments in the climate strategy to be utilised, but specified that the goals should be even more ambitious than those already adopted in the KonKraft strategy.

The KonKraft partners are paying close attention to the work of realising the goals in the climate strategy. KonKraft's original goal of reducing the oil and gas industry's absolute GHG emissions by 40 per cent in 2030 received great support from the players when it was established in 2020. The review with the companies as part of the work on this year's status report shows that a number of them have an explicit goal of a 50 per cent emission reduction by 2030, and the ambitions of the companies are thereby in line with the government target. Given the government's raising of the goal and the increased level of ambition at the companies, KonKraft's continued follow-up of progress towards meeting the 2030 objective will be based on the more ambitious goal of a 50 per cent absolute emission reduction. Predictable policies, attractive operating parameters, collaboration with the authorities and a strengthening of support programmes will be important for reaching the higher target.

To ensure adequate follow-up of the climate strategy, KonKraft prepares an annual status report which presents progress towards the goals through an analysis of the opportunity space across the operator companies, based on planned and potential emission-reduction measures and innovative projects for new value chains. This report is the second since the climate strategy was launched in 2020. The annual updating provides new insight on the opportunity space, developments in the sector and proposals for further improvements in the petroleum industry's climate work within the framework of the KonKraft collaboration.

1.3 Key political guidelines for the climate strategy

The non-socialist coalition under Erna Solberg presented a White Paper in 2021 on *Energy for work – long-term value creation from Norwegian energy resources*. This calls attention to the goal of reducing GHG emissions from oil and gas production on the NCS by 50 per cent in 2030 compared with 2005. It notes in part that, to achieve this, measures must be implemented at an abatement cost substantially higher than NOK 2 000 per tonne of CO_2. Furthermore, the White Paper emphasises that a large part of the possible costs must be covered by the government through the state's direct financial interest (SDFI) and tax deductions. It also calls attention to the importance of R&D activities which help to lower emission reduction costs in the oil and gas industry, including such initiatives as the LowEmission Centre.

In its *Hurdal platform* for 2021-25, the centre-left government under Labour's Jonas Gahr Støre makes it clear that the petroleum sector will be further developed and that provision will be made for a continued high level of activity on the NCS.

Furthermore, the government will continue its collaboration with the industry to ensure that emissions from offshore oil and gas production are reduced by 50 per cent in 2030 and reach near zero in 2050. The platform maintains the previous government's plans to increase the cost of carbon, comprising CO_2 tax and the emission allowance price, to NOK 2 000 per tonne up to 2030 and to ensure continued electrification on the NCS. However, the latter will be fuelled as far as possible from offshore wind and other renewable power generated offshore.

The government wants to ensure a stable level of activity on the NCS, with increased involvement by industries related to CCS, hydrogen, offshore wind, aquaculture and mineral recovery. Among political signals in the platform, the following are significant for new value chains.

- **Offshore wind power:** The government will make provision for a large-scale commitment to offshore wind through an ambitious national strategy for this sector, which includes a commitment to the Norwegian supplier industry, good regulations, and developing a power grid on the NCS. In addition, the government will set production targets for offshore wind in 2030.
- **Hydrogen:** The government will help to build up a continuous value chain for hydrogen, where production, distribution and utilisation are developed in parallel, and set a target for annual production of blue and green hydrogen in 2030, as well as assessing the establishment of a state-owned hydrogen company. In addition, the government will make long-term capital available where this can play a crucial role in achieving new industrial commitments in Norway – with hydrogen, for example.
- **CCS:** The government will develop a robust value chain for CCS in Norway, with the goal of having at least two full-scale capture plants and one storage facility operational in the North Sea. Expertise acquired will benefit Norwegian industry, society and business.
- **Seabed minerals:** The government will increase the mapping of mineral resources both on land and offshore, with particular emphasis on mineral deposits which could play a big role in the green shift – such as rare earths. In addition, the government will make long-term capital available where this can play a crucial role in achieving new industrial commitments in Norway – in the mineral sector, for example.

The government will continue its collaboration with the industry to ensure that emissions from offshore oil and gas production are reduced by 50 per cent in 2030 and reach near zero in 2050

The Hurdal platform also presents ambitions and guidelines on reducing GHG emissions in the maritime sector. Requirements will be set by the government for reduced emissions from the offshore fleet, including subcontractors. These requirements will be formulated to secure step-by-step phasing-in of best available technology and make provision for technological progress by Norwegian centres of expertise. From 2025, the government will require low-emissions solutions on offshore supply ships and zero emissions from 2030. In order to support the development of such solutions in the maritime sector, the government will present a green transition package for climate-friendly ship conversions. It will also ensure a substantial increase in the development of infrastructure for climate-friendly heavy transport and ships by 2025, with a charging and filling infrastructure for renewables along the coast.

A supplement to the White Paper on *Energy for work*, [3] published by the government in April 2022, continues to back the ambitions for new value chains and green industry expansion in Norway. Furthermore, it supports stable oil and gas production while GHG emissions on the NCS are to be reduced. The government proposes clarifications to the guidelines on plans for development and operation and installation and operation (PDO/PIO), which will require that uncertainty analyses for new developments include financial climate risk assessments based on a break-even price which conforms to global emission developments in line with the goals of the Paris agreement and the 1.5°C target. In addition, the government wants the consideration of all new PDOs to include assessments of the climate effect of production and combustion emissions. Following the supplementary White Paper, the government has also introduced a goal of awarding acreage off Norway for wind power generation equivalent to 30 GW by 2040. [4]

1.4 Energy and industry policy platform from labour and industry for good solutions to common challenges

Norway is an energy and industry nation with a well-developed and virtually emission-free electricity generation system, where the energy sector in a broad sense accounts for a significant part of national value creation, employment and export-oriented activities. It is therefore in Norway's own interests to take the lead on developments and to position itself in relevant areas. A commitment can contribute to future Norwegian exports, jobs and value creation.

Employers and unions in Norway have a tradition of collaborating to find good solutions for common challenges, the individual workplace and operating parameters which safeguard employment and lay the basis for creating new jobs. Work done by the NHO, the LO, Industry Energy, the United Federation of Trade Unions, the Electrician and IT Workers Union, the NI, Norwegian Oil and Gas (now Offshore Norway), Energy Norway and Nelfo on a report concerning a common energy and industry policy platform, published in 2021, rested on the governments' climate goals and aimed to unite the interests of labour and business.[5]
This report presents important proposals on a common energy and industry policy platform for use in relevant political processes, based on both ambitious climate goals and an aggressive industrial commitment.
The organisations concerned are keen that Norway continues to develop its positions and advantages in energy, industry and associated areas of expertise. Dilemmas and conflicts of interest must then be addressed wisely and aggressively. This is best done by having an unambiguous direction and clear ambitions, with operating parameters which integrate energy, climate and industry policy. Collaboration between the parties in the labour market and the government will be crucial in creating the foundation for broad political compromises and reduced conflict in the time to come.

3 Report no 11 (2021-2022) to the Storting. Link: Energi til arbeid – langsiktig verdiskaping fra norske energiressurser. (preliminary edition).
4 Government press release (2022), Ambitious offshore wind initiative..
5 ww.nho.no Felles Energi- og industripolitisk plattform

The Norwegian petroleum industry will be a driving force in achieving the following specific ambitions up to 2030.

- Continue to develop employment and value creation from the petroleum industry, and contribute to this becoming an engine for developing new export solutions such as offshore wind and CCS. The NCS is already among the areas of the world with the lowest production emissions. The aim is to meet the Storting's request for a 50 per cent cut in emissions from petroleum operations in 2030, but achieving that depends primarily on power from shore.

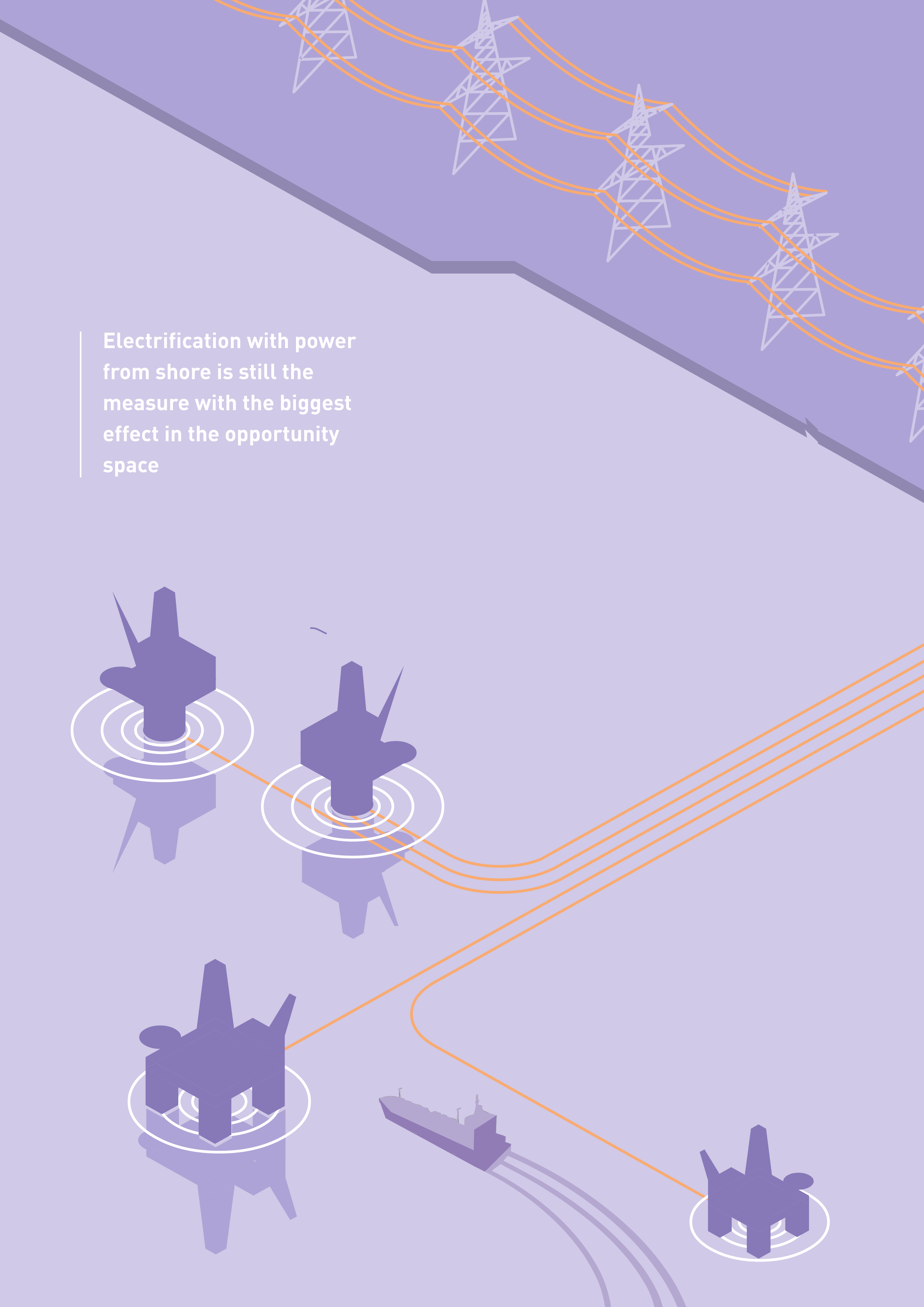
- Scale up CCS as a crucial climate technology for industry and energy recovery in Norway and Europe. That calls for further roll-out of CCS as the solution for a number of point emission sources in Norwegian industry, and for more European capture facilities to tie into storage on the NCS.

- Large-scale production of hydrogen and ammonia for the climate transition in Norway's own industry and transport sectors, and as an export solution. Opportunities for green and blue hydrogen must be interlinked, and infrastructure development is crucial.

- Construct a value chain for offshore wind, where Norway establishes a competitive supplier industry and takes a share of this market. Key goals in the short term are establishing a learning arena on Utsira North, and developing Southern North Sea II and a power grid in the North Sea.

> The world's energy systems are changing fast, and a strong global trend is more electrification. The parameters for this development are set by ever clearer and more ambitious climate goals

Electrification with power from shore is still the measure with the biggest effect in the opportunity space



2

REDUCED EMISSIONS FROM OPERATIONS ON THE NCS

This year's status report shows that emissions from petroleum operations on the NCS can be reduced by 50 per cent in 2030. Electrification utilising power from shore and increased supplies of renewable energy are necessary measures for ensuring that the petroleum industry and Norway reach the climate goals for 2030. Although the overall opportunity space is at the same level as last year, the cancellation or postponement of planned power-from-shore projects could make it difficult to reach the 2030 climate goal.

2.1 Status and progress for emission reductions in 2022

The opportunity space for emission reductions at March 2022 shows a total potential of about 50 per cent in 2030 compared with 2005. An important part of the work on the annual status reports is to identify the opportunity space and progress towards the 2030 goal for the NCS and the onshore plants. On behalf of Offshore Norway, Endrava has developed an updated opportunity space from the ground up towards 2030, based on collating the potential for GHG reductions from sanctioned and non-sanctioned measures at March 2022. The analysis rests on a review with all operators on the NCS in February 2022, and also takes account of the climate goals set by the companies, their emission forecasts, planned new field developments and cessation on existing fields. Figure 2 presents the opportunity space illustrated as the overall effect of the measures. The latter are categorised by level of maturity:

- sanctioned – the investment decision has been made but the measure is not operational yet (most mature)
- mature but not sanctioned – the technical details are being clarified and the measure is approaching an investment decision
- concept – conceptual studies are under way, and the measure is approaching a decision on implementation
- opportunity/screening – opportunities for the measure are being developed and assessed at a preliminary level (great uncertainty).

With a potential of 51 per cent by 2030, the opportunity space for emission reductions in this year's status update is at roughly the same level as in the one conducted in early 2021. CO_2e released by the oil and gas industry amounted to 12 million tonnes in 2021 and represented roughly a quarter of Norway's overall emissions. The figures cover total emissions from operations on the NCS as well as from the Kårstø, Kollsnes, Nyhamna, Melkøya and Sture onshore petroleum plants. Emissions from petroleum operations declined by almost eight per cent from 2020 to 2021, and a little over five per cent from 2019 to 2020. The changes primarily reflect the shutdown at Melkøya in September 2020. Emissions in 2022 are expected to return to a slightly higher level on the basis of sanctioned activities and the planned start-up at Melkøya in May 2022. From 2023, emissions are expected to decline sharply towards 2030.

All operator companies on the NCS and at the onshore plants have project portfolios with emission-reduction measures for each facility. These portfolios are matured over time, with the companies choosing technologies and calculating emission reductions and time lines for the project on the basis of what is technically feasible and financially profitable. The proposed increases in the CO_2 price up to 2030 will help to strengthen the profitability of emission-reducing measures. Those with an acceptable abatement cost and low complexity take first priority, and many of the reduction measures fall into the sanctioned or mature categories. Measures in the opportunity/screening phase are often more complex and have a higher abatement cost. This category accounts for just under half the opportunity space in 2030, and the companies depend on predictable and competitive operating parameters to implement the measures and realise the emission cuts.

2.1.1 Developments from 2021 to 2022

Many operator companies have worked to mature the measures reported in connection with last year's status report, and a number of these have therefore been sanctioned or are due to be so in 2022. The number of sanctioned and mature measures increased sharply, from 22 per cent of the portfolio in 2020 to 56 per cent in 2021. See the trend in figure 3. The emission-reduction potential for individual measures has been adjusted because of changes to the base

FIGURE 02 UPDATED OPPORTUNITY SPACE IN MARCH 2022.
Emissions (million tonnes CO_2e/y)

Source: Konkraft

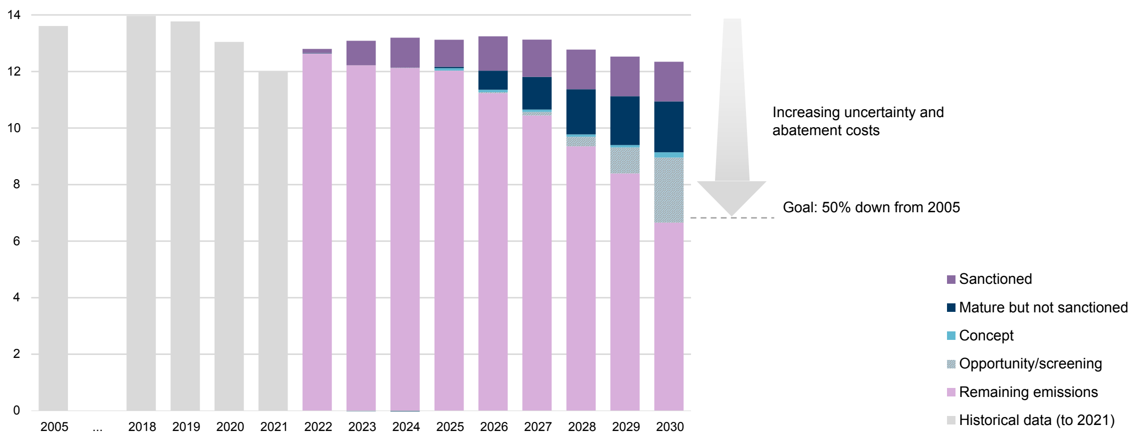


Figure: Updated opportunity space in March 2022 with projections for emissions and the estimated effect of large sanctioned climate measures and measures under assessment. The projections also include planned new field developments and cessations, which means that the total effect of emission-reduction measures at the various levels of maturity varies somewhat over time.

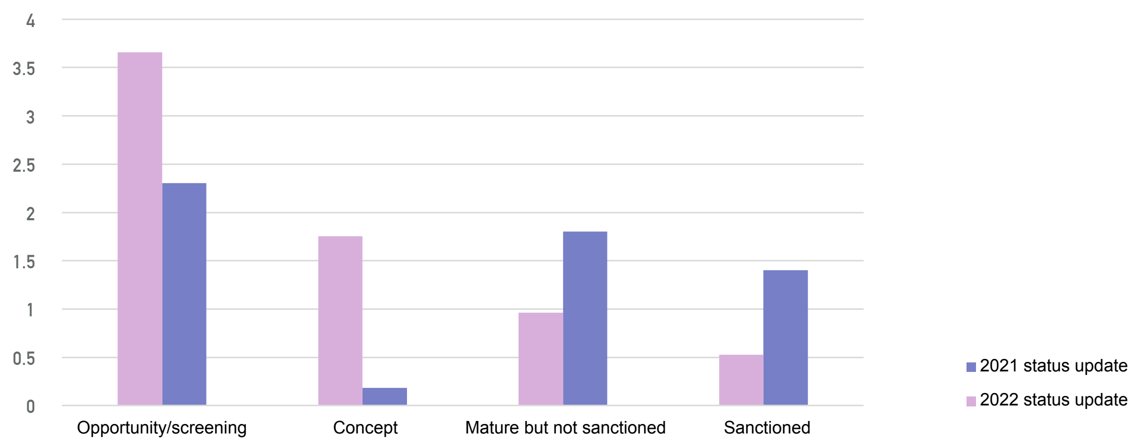
data and the availability of more precise information. Projects at the opportunity/screening stage still represent a substantial proportion of the reduction potential to 2030. One reason why a number of the climate measures have matured considerably or been sanctioned is the temporary amendments to the petroleum tax regime introduced to maintain activity in the industry during the coronavirus pandemic. Conversations with the operator companies indicate that a number of them are working purposefully to submit PDO/PIOs by the end of 2022 for projects which will contribute substantial emission reductions in the time to come.

Some major climate measures have either been cancelled or had their implementation postponed until after 2030, and a few have had their effect reduced compared with the 2021 estimate. But an equally good overall reduction has been achieved because emission forecasts have been amended from last year's report. Many energy efficiency measures are also included in the base-line forecasts for a large proportion of the fields. Although the overall opportunity space is at the same level as last year, cancellation or postponement of power-from-shore projects will make it very difficult to reach the climate targets for 2030.

2.1.2 Electrification with power from shore is still the measure with the biggest effect in the opportunity space

A number of measures will contribute to substantial emission reductions as early as 2023, including supplying power from shore to Edvard Grieg, Sleipner and Gina Krog as well as electricity from the Hywind Tampen offshore wind farm project. Overall, these four measures will contribute emission cuts of more than 700 000 tonnes CO_2e in 2023 – roughly six per cent of total 2021 GHG emissions from the oil and gas industry. Realising these measures represents an important step towards meeting the target. To reach the 2030 goal will demand annual average emission cuts in the same order of magnitude. An overview of measures which will yield substantial GHG emissions towards 2030 is provided

FIGURE 03 CHANGES TO THE LEVEL OF MATURITY FOR MEASURES IN THIS REPORT COMPARED WITH LAST YEAR'S UPDATE.
Abatement effect (million tonnes CO_2/y in 2030)



in figure 4. These largely represent electrification. Since maturing large electrification projects is time-consuming, the big emission reductions will be achieved gradually and closer to 2030.

Electrification with power from shore is the measure which clearly offers the biggest effect up to 2030. The total potential for emission reductions offered by power-from-shore projects with varying levels of maturity in the opportunity space is estimated at roughly 4.5 million tonnes of CO_2e in 2030. See figure 5. Electricity generated by offshore wind farms close to the installations has an estimated reduction potential of almost 0.4 million tonnes of CO_2e in 2030. In addition to Equinor's Hywind Tampen project, several operator companies are assessing various concepts for power supply directly from offshore wind turbines close to installations. See chapter 5.3 for a more detailed description. This measure contributes to emission cuts, but its effect is limited by the variable output of the turbines. A number of installations will also be dependent on gas turbines or power from shore for compressors and pumps which require a stable energy supply.

Where a number of offshore installations are concerned, consolidation will also contribute to substantial emission reductions. As illustrated in figure 5, this measure will reduce overall annual emissions by about 0.5 million tonnes of CO_2e up to 2030. Consolidation involves major changes to the infrastructure so that the resources can be produced more efficiently. Gas streams could be combined in fewer compressors and thereby reduce compressor capacity, for example, or a platform can be eliminated by routing one or more wellstreams to another facility with spare capacity. These are considerable projects which call for major investment decisions.

2.1.3 New low-emission technologies and enhancing energy efficiency could also contribute to substantial emission reductions

Many companies are actively pursuing R&D with new technologies such as carbon capture on the installations, qualifying subsurface areas for CO_2 storage, installing compact combined cycle power plants and using hydrogen or ammonia for offshore electricity generation. These solutions are expected to

FIGURE 04 OVERVIEW OF VARIOUS MEASURES WITH A SUBSTANTIAL EFFECT ON OVERALL GHG EMISSIONS.
Emissions (million tonnes CO_2/y)

Source: KonKraft

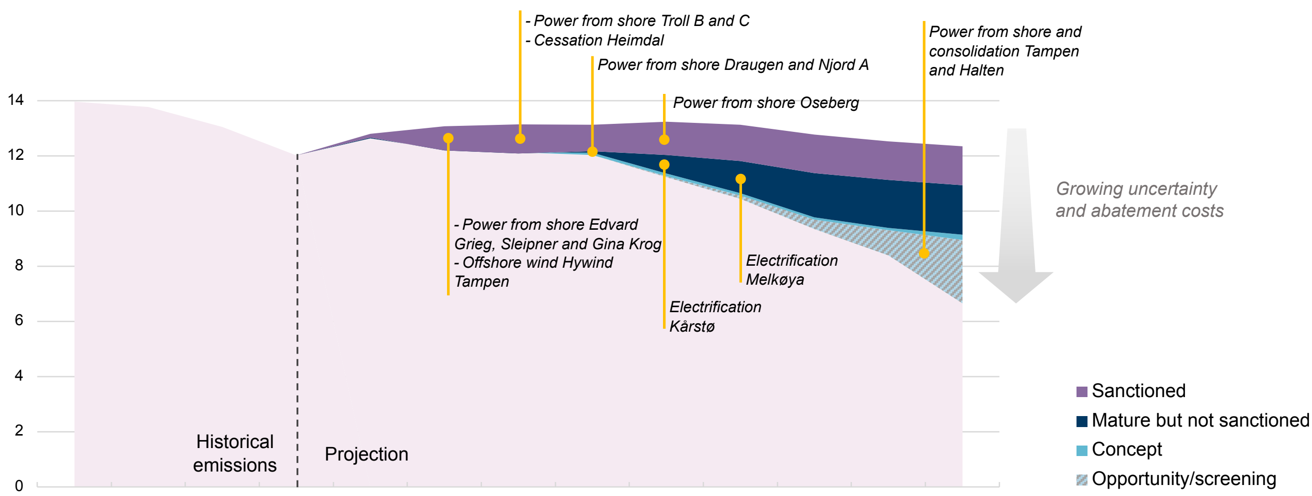


Figure: Overview of various measures with a substantial effect on overall GHG emissions, showing their maturity and their reduction potential up to 2030. NB: only measures giving the biggest emission reductions are illustrated in the figure. Many more measures will contribute to emission cuts up to 2030.

become more relevant over time, but it is uncertain how far they will affect the opportunity space and produce emission reductions by 2030.

Measures reported so far for enhancing energy efficiency and reducing flaring will cut annual emissions by 0.25 million tonnes of CO_2e in 2030. All the operator companies are working continuously to identify, assess and initiate energy efficiency measures, but reservations apply to the estimate because a number of measures have (still) not been reported – and the overall effect of emission-reducing measures could affect the climate gain from efficiency enhancements.

Many of the measures identified for energy efficiency and reduced flaring in the previous status report were implemented in 2021, and even more are planned for 2022 and beyond. They include optimisation and adaptation of processes and power-intensive equipment on such fields as Ekofisk, Brage, Åsgard and Kristin. Because of the short planning horizon, the total contribution by such measures to the opportunity space is probably underestimated, particularly on installations where electrification is not possible. As mentioned above, many small flaring and energy efficiency measures are also included in the forecast for emissions if no action is taken (base line).

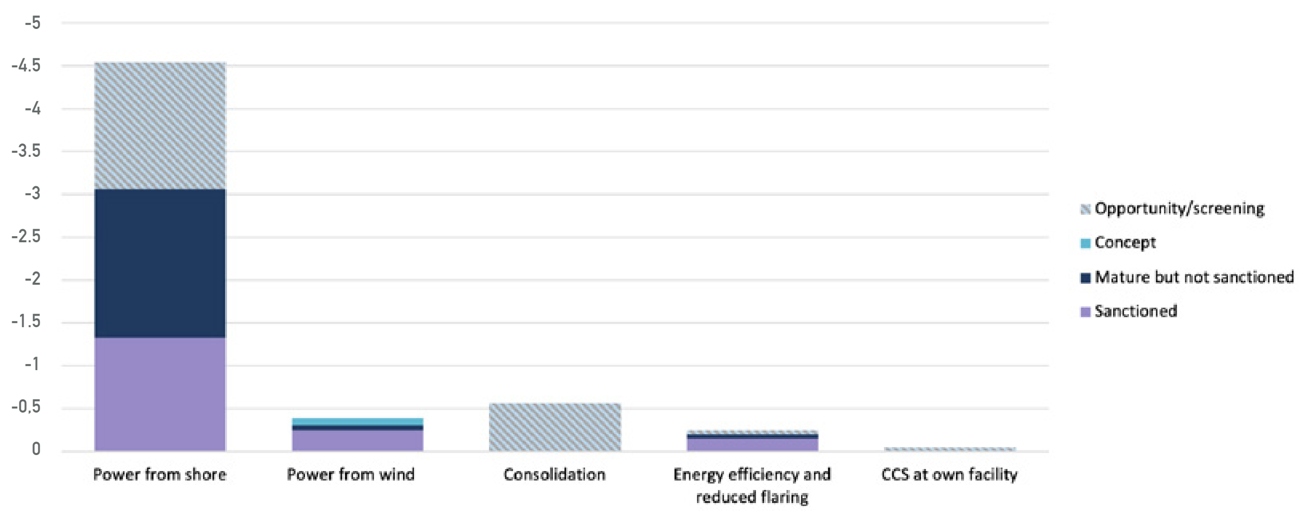
Measures to reduce flaring help to cut the loss of valuable natural gas, which can be exported instead or used locally for power and heat. Action on flaring involves various organisational and technical solutions, such as optimisation of operating procedures or implementing enclosed flare systems with gas recovery. The latter are being adopted on an ever-growing number of installations, and three companies are considering them on existing facilities in this year's status update.

2.1.4 Low methane emissions from oil and gas production on the NCS

Methane released directly from oil and gas production on the NCS is also included in KonKraft's climate goals for 2030 and 2050. These emissions are small and represent about a 10th of the methane intensity found in other petroleum provinces. Methane intensity for 2020 is estimated at 0.02 per cent. The main reason for this low figure is the attention devoted to avoiding releases for safety reasons, robust and risk-based regulations, the choice of good technical solutions on the installations and good systems for follow-up. In its Global Methane Tracker report for 2020, the International Energy Agency (IEA) notes that worldwide emissions of this gas would be reduced by

FIGURE 05 CATEGORISATION OF CLIMATE MEASURES SANCTIONED AND UNDER ASSESSMENT. EXPECTED EFFECT UP TO 2030. Abatement effect (million tonnes CO_2/y in 2030)

Source: KonKraft



more than 90 per cent if all countries limited them to Norway's level. The industry works on continuous improvement and better quantitative methods for detection, mapping and reporting methane emissions. In addition, the companies pay an increased CO_2 tax for direct releases of natural gas on the NCS, which supports work for a further reduction in methane emissions towards 2030.

2.2 Electrification and power requirements

Electrification on the NCS is an effective climate measure for reaching national and global climate goals, and increased provision of renewable power is a matter of urgency. Such electricity is important as the driver of and transition engine for future industrial growth. The power generation sector will be strengthened by a successful energy transition and further industrial initiatives in both new and established sectors.

2.2.1 NCS electrification is an efficient measure for reaching the climate goals

The updated opportunity space shows the significance of electrification using power from shore and offshore wind farms for reaching KonKraft's climate goals. Power from shore is the measure with the greatest effect in the opportunity space up to 2030, with emission cuts of 4.5 million tonnes of CO_2e in 2030 spread over measures with different levels of maturity. This solution is sensible both commercially and socioeconomically, given the high and rising carbon cost on the NCS.

Electrification also has positive effects because natural gas can be used considerably more efficiently in modern gas-fired power stations on land in Europe. At the same time, the natural gas freed up reduces the need to import liquefied natural gas (LNG) with a higher carbon footprint. Gas from the NCS can also replace the use of coal in the European power market.

Real emission cuts on a global scale are offered by running the NCS on electricity. The EU has reformed its emission allowance system by establishing a mechanism which removes surplus allowances from the market. When companies need fewer allowances, the unwanted ones are thereby deleted instead of letting others acquire them and emit more. As a result, even fewer allowances are available on the market and all industries covered by the allowance system must implement additional measures to reduce their emissions. The goal in 2050 is a carbon-neutral society, and all sectors must then have reduced their net emissions to near zero. Replacing offshore gas-fired power with renewable electricity yields large and rapid emission cuts in the Norwegian and global petroleum industry.

> Measures to reduce flaring help to cut the loss of valuable natural gas, which can be exported instead or used locally for power and heat

2.2.2 Halting electrification projects will carry a big cost in buying emission allowances

A substantial proportion of the electrification projects have an abatement cost below the total carbon price of NOK 2 000 per tonne set by the Storting for 2030. The balance between the cost of allowances in the EU emission trading system (EU ETS) and Norway's CO_2 tax has changed markedly over the past year, so that the allowance price was higher than the CO_2 tax at 1 January 2022. How EU ETS prices affect the economics of electrification projects and Norwegian oil revenues is therefore important. The price of EU allowances is determined by the ETS. Unlike the CO_2 tax, the cost of allowances which companies are obliged to purchase reduces taxable income on the NCS krone for krone. An increase in the EU allowance price will therefore reduce the tax base for Norwegian petroleum production, and 78 per cent of that cut represents lower revenues for the government.

Equinor has calculated that a halt to extending electricity use could increase the cost of buying EU ETS allowances by a total of NOK 60 billion up to 2040. This estimate is based on the company's expectations of overall future production as well as emissions and the producing life of the NCS fields it operates. Equinor has calculated emissions from individual fields and taken account of the planned timing for phasing in the electrification projects. It estimates that the licensees would have to buy allowances for about 3.5 million tonnes of CO_2 emitted annually up to 2040 if all electrification projects were halted immediately. The company announced in the third quarter of 2021 that the allowance price per tonne of CO_2 was likely to be NOK 650 in 2030 and NOK 1 000 in 2050. Other players, such as Blomberg, gave an estimated price of about NOK 1 000 per tonne in 2030. Applying that figure, production licences operated by Equinor would have to pay, on a 100 per cent basis, up to NOK 60 billion more in ETS allowances up to 2040. This calculation takes account of free allowances but not government revenues from allowance sales.

Summing up, the following can be said.

- Halting all electrification projects on the NCS today will impose a significant extra cost for buying ETS allowances.
- Purchasing ETS allowances will reduce government revenues from Norwegian petroleum production krone for krone.
- This could impose an additional cost of as much as NOK 60 billion up to 2040 for the licences operated by Equinor.
- The total amount for the whole NCS will be higher – Equinor-operated licences account for about three-quarters of emissions from the NCS.
- In addition, as yet uncalculated costs are likely to be incurred in buying ETS allowances in 2040-50.

2.2.3 Updated forecast for power from shore on the NCS

The updated forecast for power from shore on the NCS at March 2022 shows that electricity demand will almost double towards 2030 from today's figure of just over nine TWh if sanctioned and planned electrification projects are realised. Figure 6 presents an updated power forecast for the petroleum industry, including a categorisation of electrification projects by their maturity.

This forecast rests on detailed analyses of the gas network, updated analyses of power requirements by field operators for electrification projects being matured, and the expected development of gas exports in the spring of 2022. It is based on expected power consumption by facilities broken down into the following categories: operational today, sanctioned or in the planning phase, possible and under assessment, and identified measures with greater uncertainty. The gas processing plants at Nyhamna, Melkøya, Kårstø and Kollsnes are included in the forecast, but not Tjeldbergodden and Mongstad. Power consumption after 2030 is uncertain, and the forecast has been harmonised by the Forum for Power Supply in Offshore Norway.

The power forecast in figure 6 shows that demand from the projects in the first three maturation categories will be just under 23 TWh in 2030. Consumption could increase if very uncertain electrification projects are implemented. About 70 per cent of future power demand comes from oil and gas installations which run wholly or partly on electricity and which are operational, already sanctioned or in the planning phase. The companies have been assured of grid access for these projects. That could create a need to reinforce the grid infrastructure, which is a natural part of the process for executing a number of electrification projects. Where expanded power consumption at Melkøya is concerned, transmission capacity north of Ofoten is limited and an anticipated substantial rise in electricity demand in Finnmark county – particularly from the petroleum industry – is an important consideration in the discussion on new 420 kilovolt power lines between Ofoten-Balsfjord and Skaidi–Hammerfest. These new transmission facilities are needed to ensure security of supply in Finnmark county, and will provide for increased value creation in the region and for the development of more renewable energy.

Compared with last year's power forecast, a number of projects have matured and moved into the categories of sanctioned or being planned, and the timeline for realising them has been brought forward by a few years. Implementing a number of projects has also become more uncertain, and these have been moved into the category for identified measures with great uncertainty. Examples include power expansion in the Halten North area and full electrification of Troll B and Oseberg. An overview of the categorisation of electrification projects for fields and plants is provided in table 1.

2.2.4 Power demand rising in many sectors up to 2050

Electrification and establishing new industries in Norway will help to increase demand for power in coming decades. Figure 7 shows grid operator Statnett's projection for Norwegian electricity consumption up to 2050 by various sectors. According to this forecast, total power usage in Norway will increase from 140 TWh in 2020 to 190 TWh in 2050. Statnett also has a high scenario, which shows a rise to 220 TWh in 2050. Among other applications, this projection laid the basis for the grid development plan published in the autumn of 2021.[6]

6 Statnett (2021), Nettutviklingsplan 2021.

FIGURE 06 ELECTRICITY DEMAND ON THE NCS. (TWh)

Source: Norwegian Oil and Gas

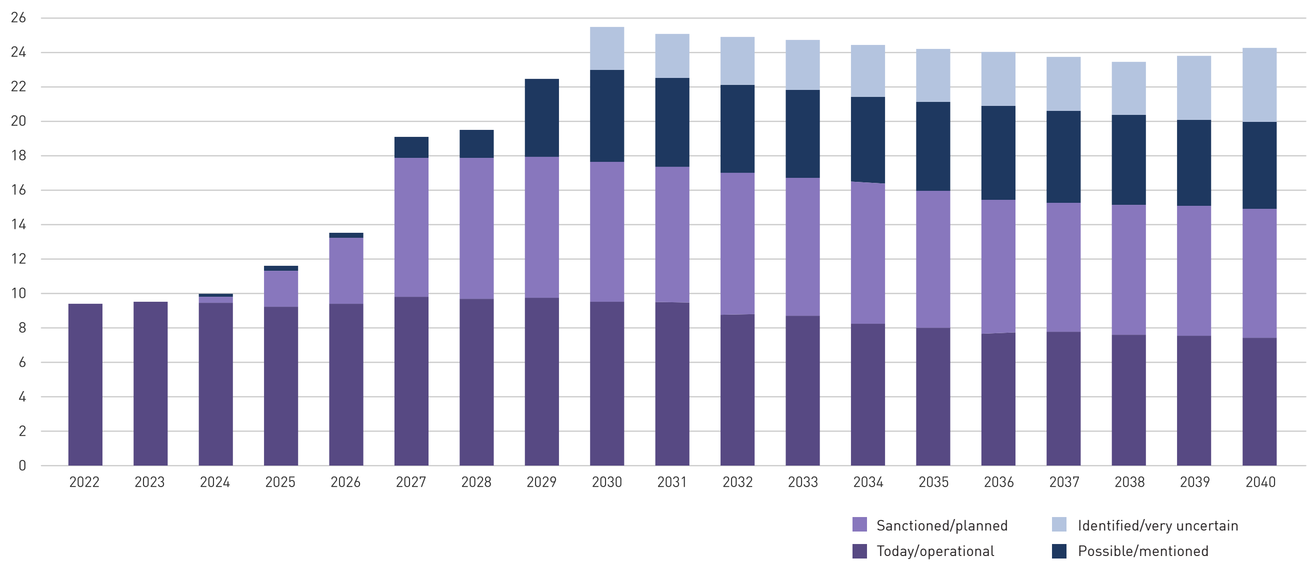


TABLE 01 ELECTRIFICATION PROJECTS ON THE NCS.

Operational today	Sanctioned or in planning phase	Possible and being studied	Identified with greater uncertainty
Kårstø gas processing plant	Kårstø base requirement	Kårstø high requirement	Full electrification of land plants
Utsira High (Johan Sverdrup phase 1 – from 2022, Johan Sverdrup phase 2, Edvard Grieg, Ivar Aasen, Gina Krog, Gudrun and Sleipner East)	Kårstø partial electrification	Partial electrification of central Norwegian North Sea fields (Balder, Ring-horne and Grane)	Increased compression Kollsnes
Valhall	Kollsnes base requirement	Kollsnes high requirement	Oseberg full electrification
Kollsnes gas processing plant	Troll West electrification first step	Nyhamna high requirement	Halten North step 2
Troll A	Krafla/Askja	Snøhvit FP2 – offshore compression	Troll West electrification step 2
Martin Linge	Noa/Fulla	Barents Blue	
Gjøa	Oseberg gas capacity up-grade, incl partial electrifi-cation	Halten North step 1 (Heidrun)	
Nyhamna gas processing plant	Nyhamna base requirement	Tampen	
Melkøya LNG	Ormen Lange phase 3		
Goliat	Melkøya full electrification		
	Melkøya full electrification		
	Snøhvit FP2 – onshore compression		
	Wisting		
	Linnorm		
	Halten South (Draugen, Njord)		

The Statnett projection shows that the growth in power consumption relates primarily to electrification in the transport sector, new data centres, hydrogen production and new industries. Where the petroleum sector is concerned, Statnett expects a doubling in electricity usage to 20 TWh in 2030. The industry's share of total power demand depends on which future scenario is utilised. Applying the forecast presented in figure 7, with 20 out of 170 TWh in 2030, the maximum share will be 12 per cent of the total electricity requirement during the period. This could be somewhat larger, given that the petroleum sector's power forecast includes electrification projects with a high level of uncertainty.

2.2.5 Renewable power supplies must rise

Electrification based on renewable power is the most important measure for meeting climate goals and realising industrial ambitions. Predictable electricity supplies at competitive prices are a precondition for many electrification measures in Norwegian industry, on land and offshore, and represent an important competitive advantage in the climate and energy transition. The NCS is already among the areas of the world with the lowest emissions from oil and gas production, and power from shore has already contributed to large emission reductions. Frequently-asked questions are whether the country has sufficient renewable energy to implement industrial commitments, and how much additional power output is required. The aggressive industrial commitment and the electrification needed to meet the climate goals will mean a significantly larger growth in consumption than is assumed in Statnett's base scenario. Policies must also take this into account.

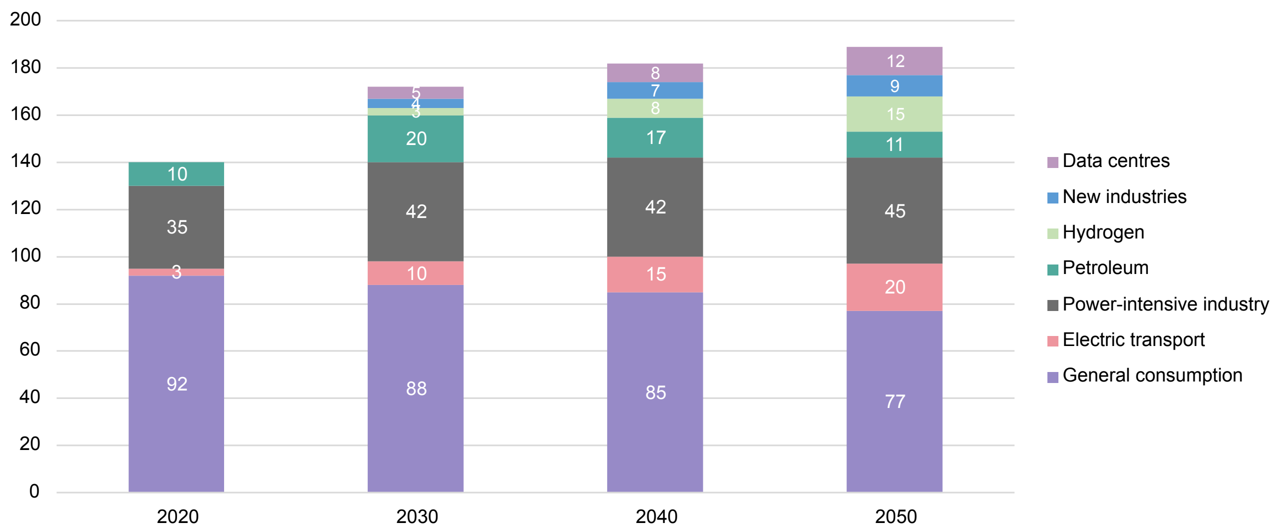
Norway has very good natural advantages for increasing the generation of renewable electricity to meet future consumption growth. In 2020, the Norwegian Water Resources and Energy Directorate (NVE) put the total technical-economic potential for increasing the country's hydropower capacity at 23 TWh.[7] Its latest long-term power market analysis estimates that hydropower output will rise by 11 TWh up to 2040. This increase breaks down into five TWh from expansions and new hydropower stations, three TWh from turbine upgrading and four TWh from larger reservoir inflow as a result of climate changes, with one TWh lost because of changes to concession terms which could reduce output from some hydropower stations.[8] Towards the end of this decade and up to 2050, the big potential offered by offshore wind will make a contribution. See chapter 5.3. To meet electricity requirements within this time frame, more generating capacity must also be provided by upgrading existing hydropower stations, increasing wind power output on land and improving energy efficiency.

7 NVE (2020), Hva er egentlig potensialet for opprusting og utvidelse av norske vannkraftverk? Fact sheet no 6/2020.

8 NVE (2021), Langsiktig kraftmarkedsanalyse 2021-2040 – Forsterket klimapolitikk påvirker kraftprisene.

FIGURE 07 PROJECTION FOR NORWEGIAN ELECTRICITY CONSUMPTION UP TO 2050 BY CONSUMER SEGMENT. (TWh)

Source: Statnett



In its long-term market analysis,[9] Statnett estimates that Norwegian electricity generation in a year with average output will increase from 150 TWh in 2020 to 205 TWh in 2050. This assumes that output expands in line with consumption growth: "We consider it ... realistic, both economically and politically, that production rises at about the same pace as consumption".[10]

The amount generated is expected to rise by 25 TWh from 2020 to 2030. A substantial part of this expansion will come from wind power developments already sanctioned as well as greater hydropower output. From 2030 to 2040, however, offshore wind will be the main source of growth. See figure 8. Statnett has written: "Opposition to wind power developments on land and the limited potential for hydro and solar generation mean that offshore wind now represents the most realistic source of increased electricity output further down the road".

9 Statnett (2021), Langsiktig markedsanalyse 2020-2050, updated spring 2021.
10 Statnett (2020), Langsiktig markedsanalyse Norden og Europa 2020-2050.

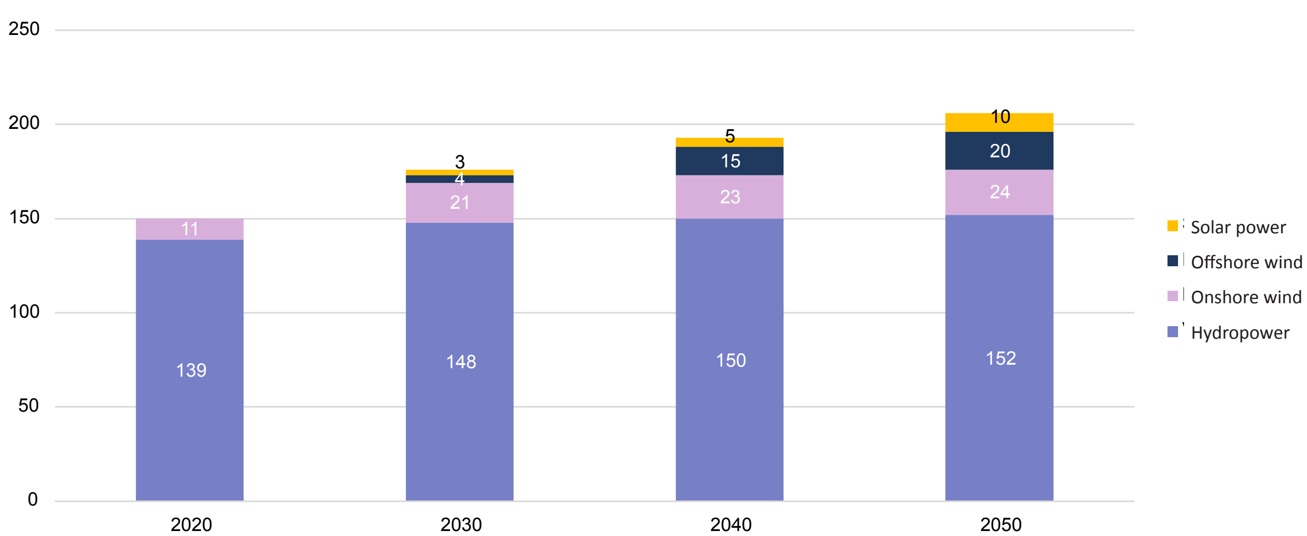
2.3 Improving energy efficiency and other low-emission technologies

Implementing energy efficiency improvements and other low-emission technologies involves important climate measures which will contribute, along with electrification, to reaching the 2030 target. Most energy-efficiency measures for specific installations or fields are less extensive. Individually, they will yield smaller emission reductions than the large-scale electrification and consolidation projects. Collectively, however, they will have a substantial effect over time. These measures can be planned and executed in a shorter time frame – two-four years from identification to actual implementation, for example.

More than 150 measures were implemented in 2021 to improve energy efficiency on the NCS, with an overall estimated reduction effect of more than 0.25 million tonnes of CO_2e per annum. Sixty per cent of these cuts come from measures for rotating machinery (power

FIGURE 08 FORECAST DEVELOPMENT IN POWER GENERATION 2020-50. (TWh)

Source: Statnett, Long-term market analysis – updated spring 2021



generation, compressors and pumps) and with flaring. Energy efficiency improvements and reduced flaring are expected to continue to play an important role in work on reducing emissions up to 2030 and beyond.

Systematic reviews and producing action plans for energy-efficient operation on installations

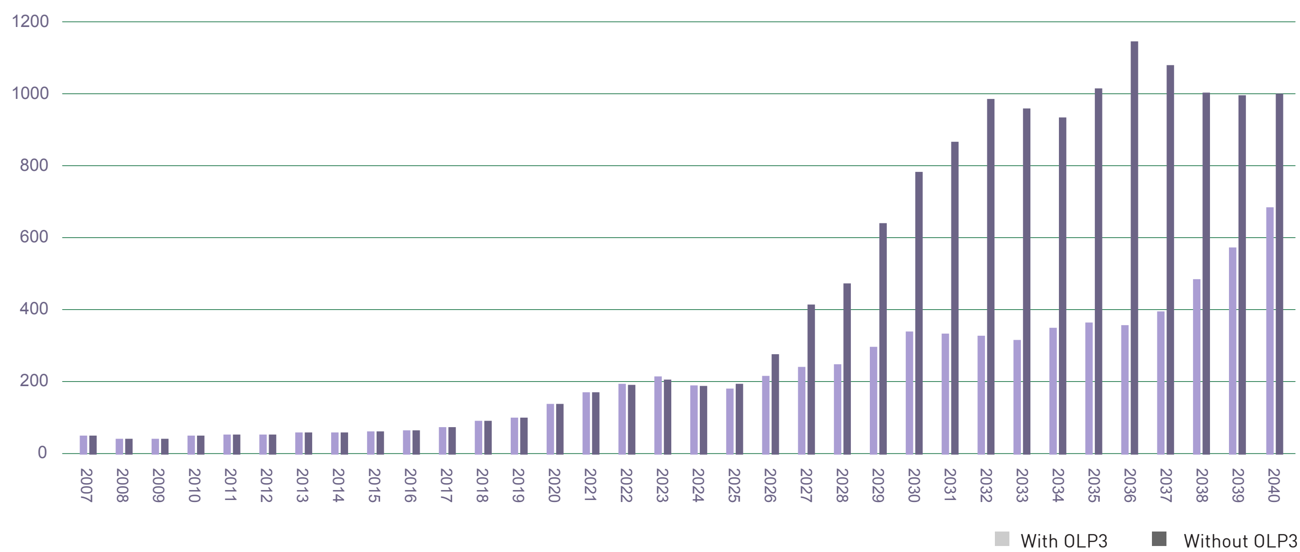
Equinor implemented operational measures in 2021 which reduced emissions by more than 200 000 tonnes of CO_2e. Work in this area has been further strengthened, and the company is making systematic efforts to identify measures and produce action plans for energy-efficient operation on each installation. It has also developed a tool which provides short- and long-term estimates of CO_2 emissions on the basis of production and injection profiles as well as the operation of equipment on the individual installation. This tool creates a platform for collaboration and communication between the various expertise centres in the company, and permits the evaluation of different scenarios for balancing increased production against reduced CO_2 emissions. In addition, Equinor has matured the understanding of which parameters are important drivers of GHG emissions and the work of reducing these.

More efficient compressor trains on Ekofisk J

The potential for enhanced energy efficiency and reduced flaring changes as production conditions on existing fields alter. That provides opportunities for customising equipment to save energy and cut emissions. ConocoPhillips, for example, has conducted a detailed study of the potential for more efficient operation of the compressor trains on Ekofisk J. The company identified opportunities for adapting existing hardware by "rebundling" the compressors, which can yield an average efficiency improvement of 12 per cent compared with today's equipment. This measure has been sanctioned, and will become effective in 2023. Combined with an efficiency upgrade for a gas turbine on the same platform, the compressor measure will cut annual CO_2e emissions by 23 000 tonnes from 2023 and, with a further licence extension, probably to 2048. Recovering flare gas is another move which could yield substantial reductions on new and existing platforms. The company installed a new flare-gas recompressor with flare-gas recovery on Ekofisk J in 2021, which is expected to help cut flaring by more than 90 per cent while eliminating 26 000 tonnes of annual CO_2e emissions in the time come. Rather than being flared, the gas will be sold to Europe.

FIGURE 09 ENERGY EFFICIENCY OF PRODUCTION FROM ORMEN LANGE WITH AND WITHOUT PHASE 3 DEVELOPMENT (OLP3).
Energy consumption per oil equivalent produced (kWh/scm)

Source: Shell



Subsea compressions and boosting give big energy savings on Ormen Lange

Subsea compression and boosting provide examples of technologies developed over a number of years which are now yielding a return in the form of big energy savings. Norske Shell announced in the autumn of 2021 that the investment decision for subsea compression had been taken on Ormen Lange. OneSubsea, an arm of Schlumberger, will supply the compression equipment. Ormen Lange is located 120 kilometres from the export facilities at Nyhamna, and this technology will help to improve natural gas recovery much more energy-efficiently by utilising power from shore to run the seabed compressor stations. This electricity will be met from existing supply capacity at Nyhamna via cables to the field. Figure 9 shows that subsea compression substantially reduces the energy required per unit of gas produced. In most of the field's remaining years on stream, energy consumption per unit produced will be reduced by more than 50 per cent compared with conventional recovery. The technology is in use on Åsgard and a few other fields worldwide, but Ormen Lange will be the first to install such a solution without support from a surface facility. OneSubsea is also to deliver three new and customised subsea booster pumps to Okea's Draugen platform, giving major energy efficiency gains.

Ormen Lange will be the first field in the world to integrate reservoir and process plant in a digital twin. Norske Shell, in cooperation with Kongsberg Digital, is creating a virtual copy of the whole Nyhamna plant – comprising 220 000 components large and small – and Ormen Lange. This offers the opportunity to optimise production and processing while reducing energy consumption and GHG emissions.

Compact combined cycle plant can increase NCS power efficiency in the medium to long term

Where power generation is concerned, current research on lighter, more compact and more efficient combined cycle plants could help increase the efficiency of conventional generation offshore. This measure is not sufficiently mature to be adopted in the short term, but Sintef and several partners in the LowEmission Centre are collaborating to help cut emissions in the medium to long term. The technology has been assessed for two installations on the NCS, but the operator company is waiting for a further maturation of the technology before possibly assessing it anew. Any benefit from this measure is limited to a relative improvement of about 10 per cent in energy utilisation. In itself, that would not be sufficient to deliver the substantial emission reductions the industry aims to reach in 2030, but could be relevant for installations without other and better options.

Electrification of the NCS has UK spin-offs

Great interest in the Norwegian power-from-shore projects is moreover being shown in the UK. According to Britain´s Oil and Gas Authority (OGA), gas-fired power accounts for approximately two-thirds of production emissions from the UK continental shelf. Expectations are that emissions from this source could be reduced by two-three million tonnes per annum through power from shore and offshore wind. Norwegian suppliers such as Aibel, with experience from delivering a large number of power-from-shore projects on the NCS, could position themselves well in this market.

A good collaboration between operators, vessel owners, industry and government will be crucial for meeting the goals.

3

REDUCED EMISSIONS FROM MARITIME OPERATIONS

The players on the NCS are working actively to reduce emissions from offshore maritime operations by improving energy efficiency, optimising operations and adopting new technologies. Many of them have set ambitious climate goals related to their own operations, and have already achieved good results. Securing accurate figures for the overall status and development of emissions from maritime operations on the NCS is difficult, but preliminary estimates show annual CO_2 emissions of roughly 2.1 million tonnes in 2021.

Since the model for estimated emissions in 2019-21 is based on automatic identification system (AIS) data for vessel movements and ship information about installed engine output and design speed, it does not pick up the effect of measures to enhance energy efficiency. To measure actual progress in coming years, today's methods must be combined with more precise information on emission-reduction methods and optimisation of operations at rig and vessel level. The KonKraft partners will prioritise the work of securing better figures in the future.

3.1 Target for emissions from maritime operations

The Norwegian government's action plan for green shipping has set a 50 per centre reduction in emissions by 2030 as the target for domestic maritime transport and fishing, which includes activities in the petroleum sector. In 2020, the RF also introduced its own climate goals for 2030 and 2050.[11]

KonKraft's climate strategy includes a commitment that the Norwegian oil and gas industry will, together with vessel and rig owners, be a driver in ensuring that vessel categories involved in offshore maritime operations contribute actively to achieving the goal specified above.

3.2 KonKraft will continue work on securing better emission data from maritime operations

The KonKraft partners have worked over the past year to concretise the goal of a 50 per cent emission reduction by 2030 compared with 2008 for maritime operations in the petroleum sector.[12] DNV was commissioned in 2021 by the RF and Offshore Norway to produce base data on emissions from maritime activities on the whole NCS in 2008. According to the resulting analysis, domestic maritime emissions from the petroleum sector came to about 2.1 million tonnes of CO_2 in that year. [13]

11 Norges Rederiforbunds klimastrategi (2020).
12 The reference year for emission reductions has been set at 2008 by the International Maritime Organisation (IMO).
13 Adjustments could be made to this estimate for 2008 as a result of methodological changes, scope and future guidelines for reporting. Some uncertainty also relates to calculating emissions from AIS information and the correlation between emission and activity data. Given this uncertainty, the estimate has room for improvement through more detailed calculations.

DNV's model for estimating emissions in the 2019-21 period is activity-based. It estimates fuel consumption and emissions for each ship based on AIS data for vessel movements and information about the vessel's installed engine output and design speed before aggregating emissions at fleet level. The AIS-based emission estimate is thereby affected by activity (distance sailed), speed profile and fleet composition (vessel age and size), but the model fails to pick up the effect of energy-efficiency measures. The emission figures presented in figure 10 therefore do not reflect the commitment to enhancing energy efficiency in 2008-21.

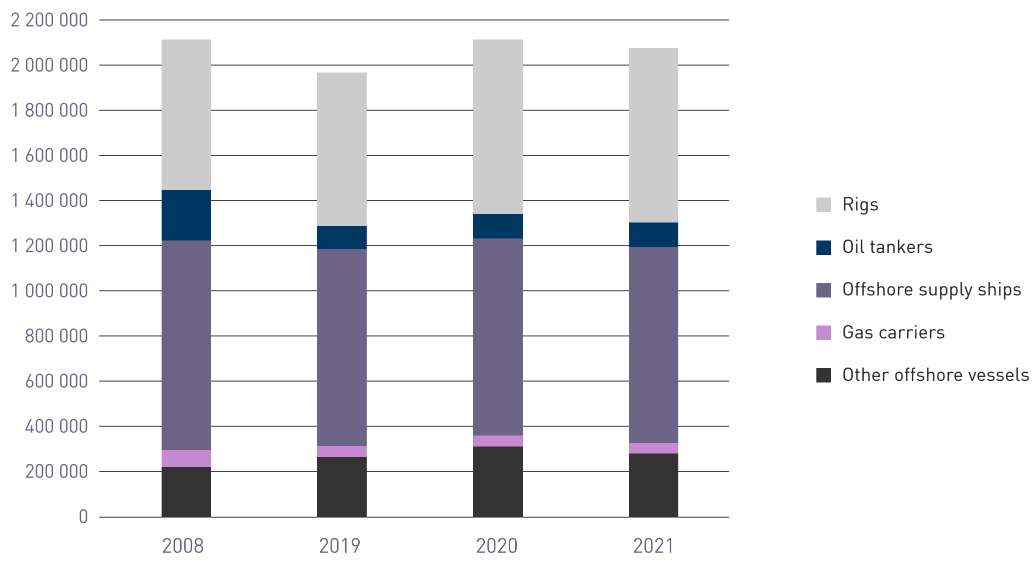
In KonKraft's view, using the AIS-based method alone is inappropriate for estimating progress with emissions towards the 2030 goal. Effective measurement of actual progress and following up the climate ambitions over the next few years will call for the method to be combined with more precise information on emission-reduction measures and optimisation of operations at rig and vessel level. KonKraft will prioritise efforts to establish an improved method which can be used in the work on the next status report.

3.3 Status of and outlook for emission reductions

Allowing for the reservations expressed in the previous section on the uncertainty in the base data, figure 10 presents estimated domestic CO_2 emissions from maritime activities in the Norwegian petroleum industry for the 2008 reference year and the 2019-21 period. Emissions vary year by year, but were at roughly the same level in 2021 as in the 2008 base year – in other words, about 2.1 million tonnes of CO_2. Offshore supply ships and rigs account generally for the bulk of the emissions.

FIGURE 10 DOMESTIC CO2 EMISSION IN 2008 (ESTIMATED) AND 2019-21 (AIS-BASED). (CO_2 emissions in tonnes)

Source: DNV



3.4 Emission-reduction measures

To reach the goal of a 50 per cent emission reduction by 2030, measures and modifications must be implemented in the existing fleet because many vessels have a long remaining commercial life. A number of operator companies give emphasis to emissions from the maritime sector in their climate effort and work to include requirements for low-emission technology and operating incentives for emission reductions in long-term charters for ships and rigs.

3.4.1 Emission-reduction measures on ships

Lundin has presented a strategy for reducing GHG emissions from the existing supply-vessel fleet. Figure 11 presents the company's assessment of how cuts can be made on a diesel-powered vessel through such measures as battery hybridisation, hull cleaning, operational steps, heat recovery and phasing out fuels in favour of more sustainable options. The biggest contribution to reductions in the figure comes from the use of biogas, which is regarded in climate accounting as a zero-emission fuel. Liquefied biogas (LBG) is fully compatible with LNG and can therefore be utilised in existing LNG-powered vessels without further modifications. Norway currently has only a few LBG suppliers and the volumes produced at present would meet fuel consumption by only four-five supply ships. However, a number of plans exist to start biogas production in Norway over coming years, and local supplies of this fuel are important for achieving the best possible climate effect.

At the end of 2021, Equinor had cut absolute emissions from its offshore fleet by 46 per cent compared with 2005. These substantial reductions derive primarily from energy-efficiency measures and optimising operations. Furthermore, Equinor has a clear plan for accelerating emission reductions up to 2030, which includes phasing-in zero-emission technologies from as early as 2024. See figure 12.

Many vessels on the NCS have been fitted in recent years with battery packs, with electricity supply points provided at a number of quays. Aker BP has established, for example, that its platform supply ships (PSVs) spend 27 per cent of their time berthed. Similarly, Equinor's

FIGURE 11 LUNDIN'S PATH TO ZERO EMISSIONS FOR AN EXISTING SUPPLY-SHIP FLEET.

Source: Lundin

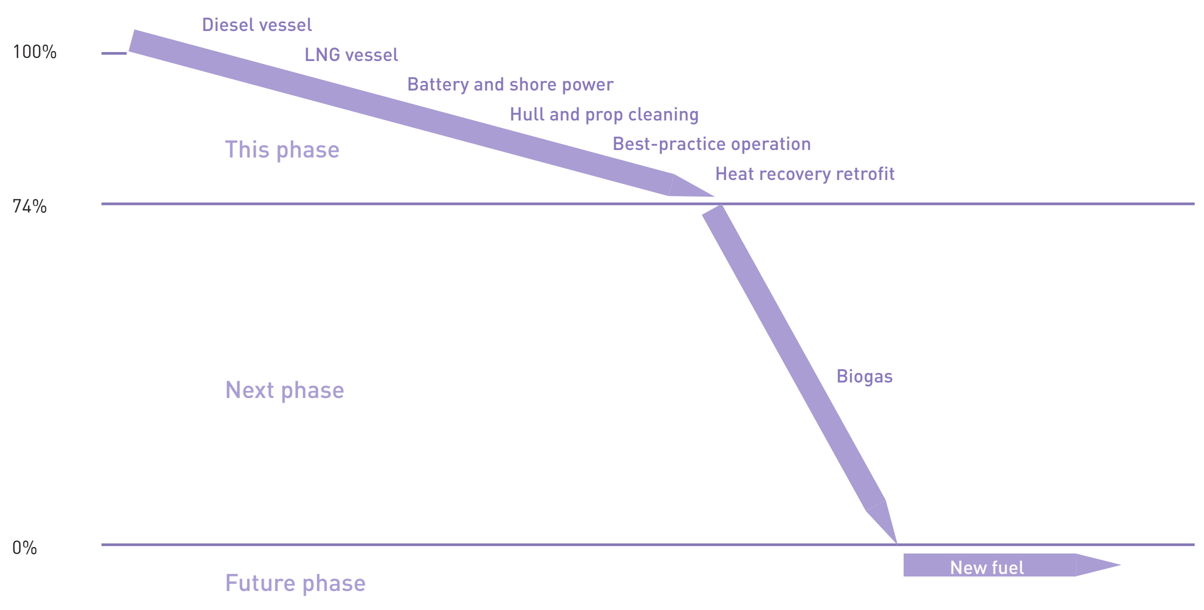


Photo: Øyvind Knoph Askeland, Offshore Norway.

fleet of offshore support vessels (OSVs) were berthed 26 per cent of their time in 2021. All Equinor's PSVs on medium- and long-term charters are now equipped to run on electricity from land when berthed, but a big potential remains to be utilised in this area. Were land-generated electricity fully exploited, CO_2 emissions while berthed could be cut by roughly the amount emitted annually from two PSVs, or 12 500 tonnes. Vessel crews are highly motivated to use power from shore, which is also a good health, safety and environmental (HSE) measure since it reduces local noise levels. Lundin also reports positive HSE effects from installing hybrid packages on the vessels from its providers. A transition to battery operation will avoid air pollution from exhaust fumes when the vessel is not under way, as well as reducing the need to wash the hull and white surfaces. Good functionality and continued development of electricity supply points at offshore bases should be given priority.

Regular propeller polishing and hull cleaning reduce vessel resistance in the water and thereby cut fuel consumption. Aker BP has estimated that this measure reduces CO_2 emissions from its vessels by a couple of per cent. Operational measures such as route planning and pool sailing are implemented by a number of companies, and fuel consumption can be heavily influenced by wind and current conditions. Many players use Yxney Maritime's Maress tool to monitor fuel usage and to optimise energy consumption and emissions.

Hydrogen and ammonia as low-emission fuels for new and existing ships

ShipFC[14] is a pilot for testing green ammonia on the *Viking Energy* supply ship, owned by Eidesvik and chartered to Equinor. This project is being conducted by a 14-member consortium, with pilot operation using this fuel solution due to start in January 2024. The ship currently runs on LNG and will be converted with a two MW fuel cell in order to operate on a mix containing 70 per cent green ammonia from Yara for 3 000 hours per annum. Support is being provided by the Clean Hydrogen Partnership, Horizon 2020 and Hydrogen Europe.

14 Maritime Cleantech (undated), ShipFC - Green Ammonia Energy System.

FIGURE 12 REDUCTIONS IN EQUINOR'S SUPPLY FLEET AT 31 DECEMBER 2021. AND ONWARDS TO 2030 AND 2050. (Million tonnes CO_2)

Source: Equinor

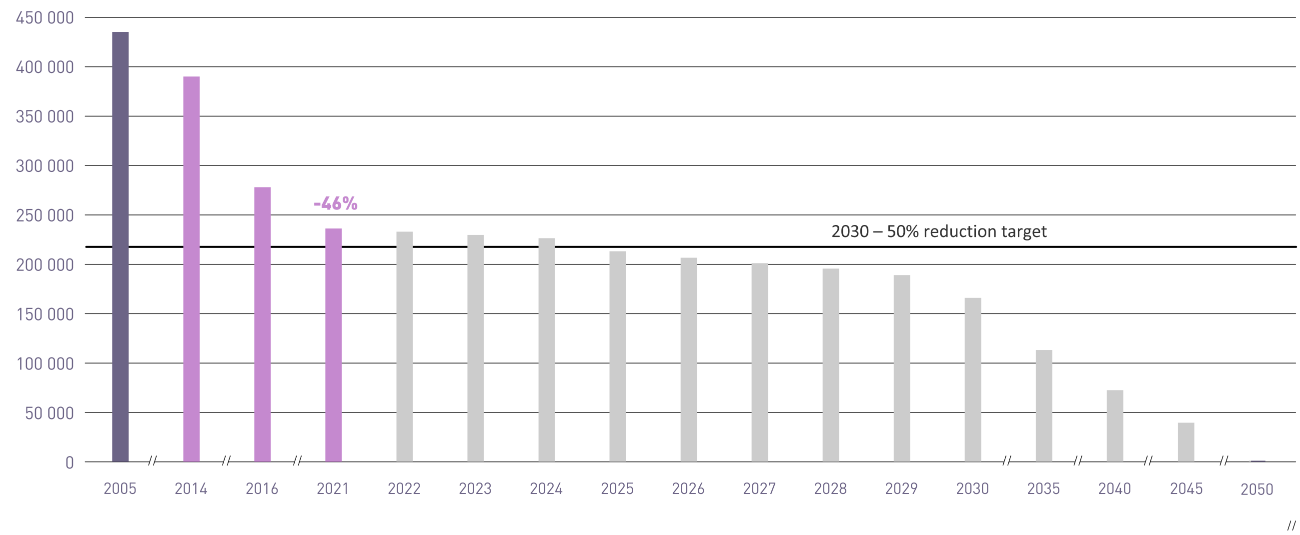


Photo: Island Offshore.

Aker BP and Eidesvik are to cooperate in the Retrofit project on developing new low-emission solutions tailored for retrofitting in existing vessels.[15] With ambitions to develop solutions which cut emissions from existing vessels by 70 per cent, the companies are giving particular emphasis to adaptations which enable operation with ammonia. Assessing modifications to Aker BP's NS *Orla* and NS *Frayja*, both managed by Eidesvik, and other ships will be relevant. The companies have also collaborated earlier on installing battery packs in the supply ships under long-term charter to Aker BP.

Wärtsilä, a leading developer of internal combustion engines running on hydrogen and ammonia, is contributing to both the above-mentioned projects. It aims to have an engine concept ready for burning pure ammonia fuel in 2023 as well as an engine and plant concept for pure hydrogen operation by 2025.[16] The company has so far succeeded in running a test engine in a marine load scenario on a fuel mix comprising 70 per cent ammonia. Looking ahead, Wärtsilä will test ammonia in a four-stroke internal combustion engine at the Sustainable Energy Norwegian Catapult Centre in Stord together with Repsol Norge, Equinor and Knutsen OAS. If the initial tests with the engine go as planned, it will be installed in a Knutsen tanker or on a Repsol platform.[17] This joint project runs to 2023 and is receiving NOK 20 million in support from the Demo 2000 programme.

Island Crusader[18] is the first vessel on the NCS to be fuelled by biogas, and the world's first carbon-neutral supply ship. It has run so far on LNG but, as a pilot project, Lundin Energy Norway has now tested filling two of its tanks with biogas. This fuel is CO_2-neutral and derived from the farming and fishing industries. Over a two-month period, LNG consumption was reduced by 50 per cent and Island Offshore Management takes a positive view of its experience with biogas.

15 Eidesvik (undated), Eidesvik and Aker BP join forces to develop low-emission vessels.
16 Wärtsilä press release, 14 July 2021, Vellykket test av ammoniakk og hydrogen i forbrenningsmotor.
17 Research Council of Norway, project bank, Grønn Ammoniakk som drivstoff i Forbrenningsmotor.
18 Maritimpolitikk.no (2022) – Verdens første karbonnøytrale forsyningsskip.

Efficient and emission-reducing tanker cleaning

In addition to measures for reducing emissions while vessels are in operation, Schlumberger has developed an automated technology which reduces emissions and waste when cleaning tankers. Reusing water cuts the amount needed in the cleaning process, and thereby the amount of waste, by 70 per cent. Further emissions can be achieved by electrifying the cleaning vehicles, but this depends on sufficient capacity being available in the port area.

3.4.2 Emission-reduction measures on rigs

A number of the operator companies are also working to reduce emissions from rigs. ConocoPhillips has ambitions of reducing GHG emissions from well operations by 35-40 per cent in 2025. It has studied and will implement a number of emission-reduction measures on jack-up rigs. Viewed overall, a set of energy-optimising steps could reduce GHG emissions by 10 per cent. That includes automating hydraulic pumps, running generators optimally, regulating heat with thermostats and reusing coolant and raw water. Furthermore, water-based drilling fluids and automated drilling could help to cut CO_2 emissions by five to 15 per cent per well.

Aker BP implemented a number of emission-reduction measures on several of its rigs in 2021. That included installing systems to optimise energy emissions on the *Maersk Integrator* jack-up, along with battery packs for peak-shaving and Blunox selective catalytic reduction (SCR) to reduce NO_x emissions. Viewed overall, these steps have cut fuel consumption by 19.5 per cent to 14.1 tonnes per day while reducing CO_2 and NO_x emissions by 25 and 97 per cent respectively. They contributed specifically to reducing CO_2 emissions from drilling campaigns by 849 tonnes on Tambar and Ula and 977 tonnes on Ivar Aasen.

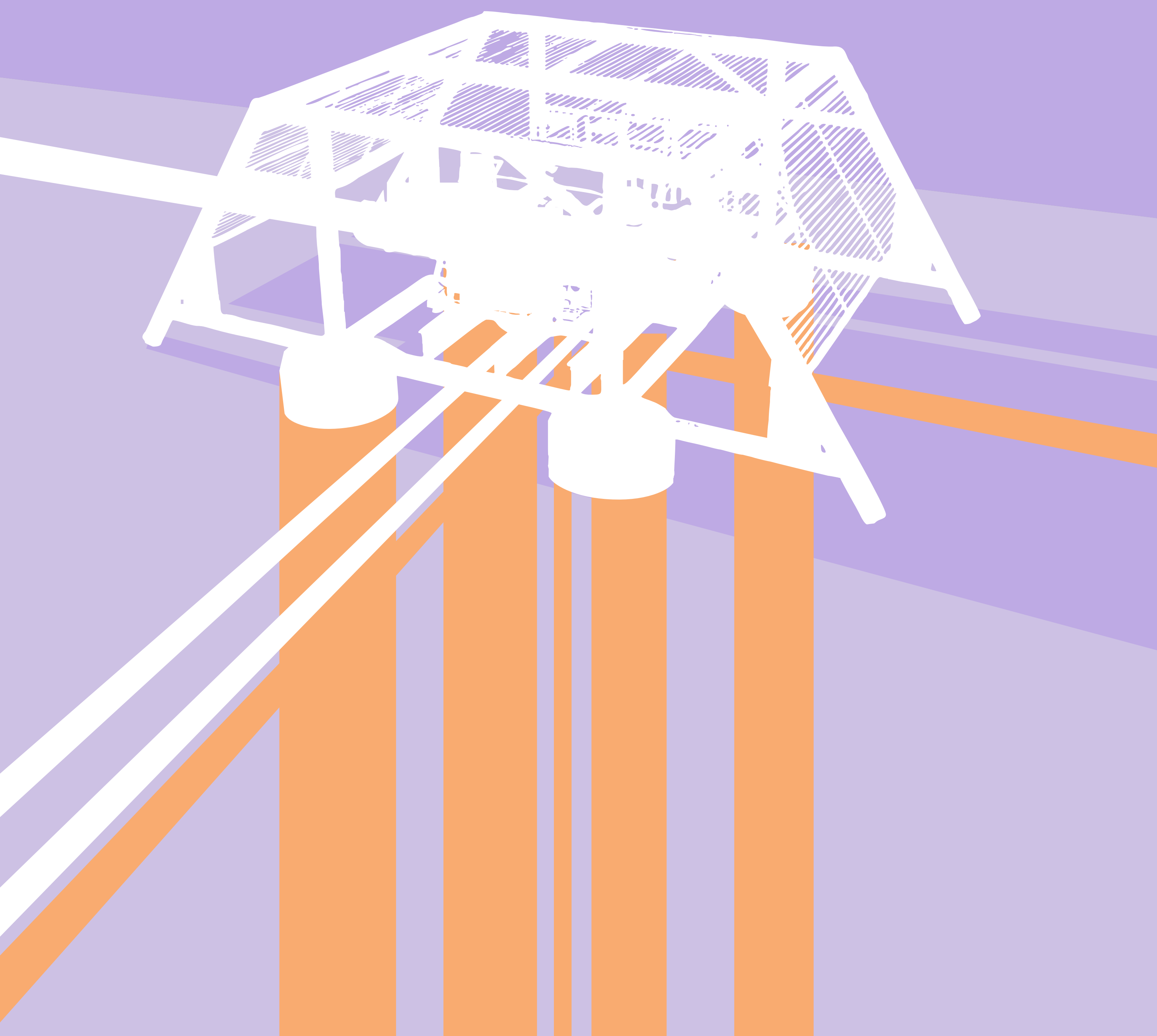
Equinor is working continuously on energy management and implementing available technical measures on rigs it has chartered, and holds regular meetings with the vessel owners to ensure a common direction and shared goals. The bigger technical steps include heat recovery, installing battery packs and flywheels to reduce output peaks, and upgrading and optimising energy management – in part with the aid of frequency and current control systems. SCR is installed to cut NO_x emissions. These are complex measures, and experience so far is that it takes time to achieve the full design effect.

To reach the climate targets, Equinor sees that action must extend beyond rig optimisation. The company is therefore assessing such aspects as the opportunity to mix in low-emission energy bearers by modifying existing engines. These studies are being pursued in close collaboration with its in-house research centre and external players. Fuel solutions typically include:

- ammonia, both as a diesel replacement (dual fuel) and in fuel cells
- methanol (dual fuel)
- advanced biodiesel (hydrotreated vegetable oil – HVO)
- fuel cells
- electrification

Experience so far has been encouraging, and it could be realistic to combine low-emission solutions and energy optimisation. A good collaboration between operators, vessel owners, industry and government will be crucial for achieving this.

The 2020 strategy makes special mention of value chains for offshore wind, hydrogen and CCS, and this status report also draws attention to seabed minerals as a possible new value chain in the longer term



4

NEW VALUE CHAINS ON THE NCS

Expertise and experience from operators, suppliers and the shipping industry in Norway will be utilised in gradually establishing new energy value chains and thereby securing continued value creation and jobs related to activities on the NCS. Substantial work is currently under way in new projects large and small for offshore wind power, hydrogen and CCS, and the industry is well on its way to meeting the climate strategy's original goals.

4.1 The climate strategy's original goals

KonKraft's climate strategy emphasises the importance of developing a forward-looking energy industry on the NCS through a commitment to, and new value chains which facilitate, a zero-emission society in Norway and Europe. Expertise and experience from operators, suppliers and the shipping industry in Norway will be utilised in gradually establishing these value chains and thereby securing continued value creation and jobs from activities on the NCS. The 2020 strategy makes special mention of value chains for offshore wind, hydrogen and CCS, and this status report also draws attention to seabed minerals as a possible new value chain in the longer term.

In the 2020 strategy, the Norwegian oil and gas industry notes that it will work to realise the following ambitions in order to support the development of new energy value chains related to CCS, hydrogen and offshore wind.

- 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's cement mill in Brevik and Fortum's energy recovery plant 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.
- The oil and gas industry will work for the further development of Norway's strong position in renewable energy from offshore wind.

4.2 A common Norwegian plan for industrialising new value chains

Since the previous status report, Equinor has launched a far-reaching plan for industrialising new value chains on the NCS called the Norway Energy Hub (NEH).[19] This plan is an invitation to join a national collaboration on, and concretisation of what will be required to create, new green value chains and to continue developing Norway's position as an energy nation on the basis of its energy resources, expertise and capital. Equinor wants to play a leading role in this development and to facilitate collaboration between Norwegian companies, the government and other organisations to take the crucial steps required to restructure Norway and create jobs, value and prosperity. The plan involves a major commitment to new value chains on the NCS for CCS, offshore wind and hydrogen up to 2030-35. Its ambitions can be summarised as follows.

- **CCS** – a commercial service by 2030. Establish a system of regular licence awards for carbon storage and make provision for 10-15 new storage licences on the NCS. A step-by-step increase in capacity on the NCS up to 40 million tonnes per annum by 2035 in order to provide carbon storage services for Norwegian and European industrial companies.

- **Offshore wind** – a possible major new industry in Norway. Developing a total of 10 GW of offshore wind (6.5 GW fixed and 3.5 GW floating) to come on line in 2030-35. Establishing offshore wind projects will provide four times the electricity capacity required for electrification of the NCS during the same period. It will also supply Norway with electricity and can contribute to profitable power exports to continental Europe. This could create several thousand new jobs in the Norwegian supplier industry up to 2030.

- **Hydrogen** – scaling up production and building markets in parallel. A capacity of two GW for hydrogen production from natural gas, with a gradual increase to 10 GW in 2040, supplemented with green hydrogen from exploiting existing infrastructure. This is expected to require the investment of an estimated NOK 50 billion.

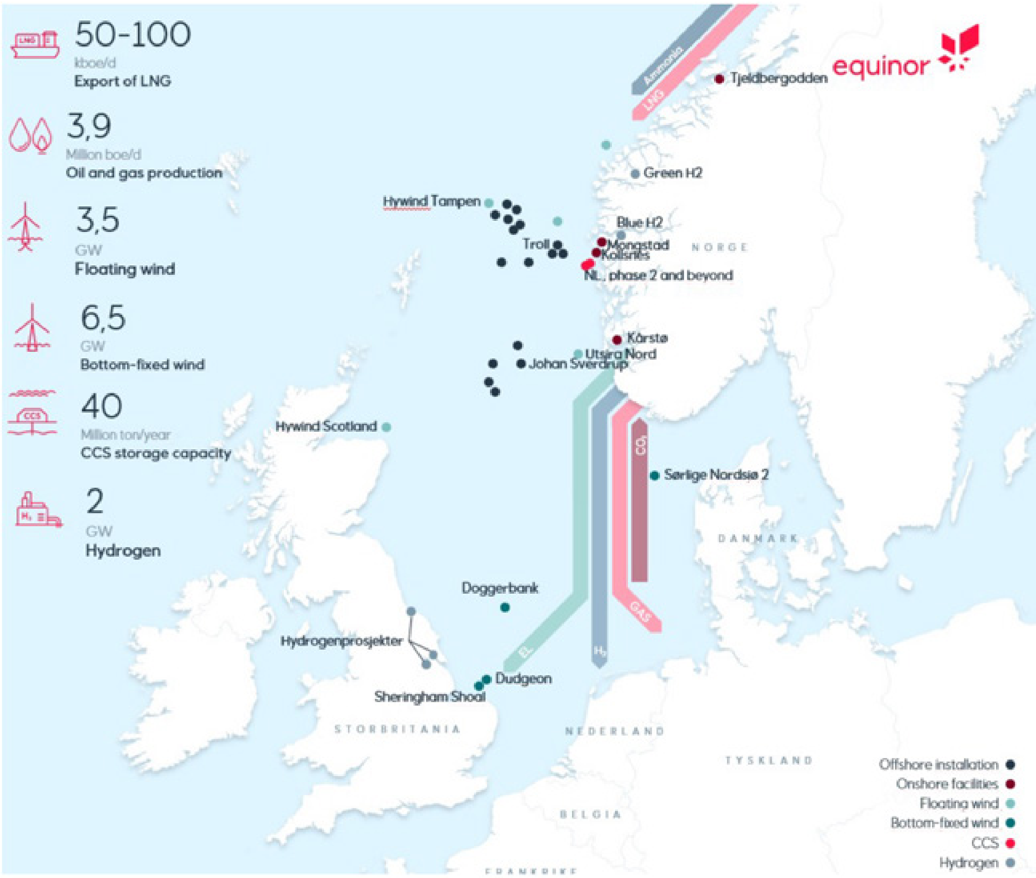
Realising the ambitions in the plan will call for an estimated NOK 350 billion in private investment in 2025-35. In addition, NOK 50-60 billion in risk reduction measures will be needed from the government. Revenues from the CO_2 tax on the oil and gas industry will amount to roughly NOK 100 billion over the period to 2035. When devising risk-reduction mechanisms, it will be important to look after the development of competitive value chains and markets. The NEH plan notes that support programmes should be flexible, so that they can be adapted to the maturity of the various value chains. In addition to risk reduction for developments, the plan emphasises the importance of a government contribution to ensuring market access in the EU and adequate markets for new value chains such as CCS, offshore wind and hydrogen.

19 Equinor (2022) – Norway Energy Hub.

Realising the ambitions in the plan will call for an estimated NOK 350 billion in private investment in 2025-35

FIGURE 13 AN INDUSTRIAL PLAN FOR NORWAY AS AN ENERGY NATION. NORWAY ENERGY HUB.

Source: Equinor



4.3 Offshore wind power

Global offshore wind capacity at 31 December 2020 totalled 35.3 GW, with floating turbines accounting for 0.07 GW of this.[20] In addition, the Global Wind Energy Council estimated new capacity of 12.7 GW for 2021. Roughly 80 per cent of the world's offshore wind resources are found in waters more than 60 metres deep, which will therefore be more suitable for floating concepts. Wind power resources in the North and Norwegian Seas are particularly good, and Norway has a big potential for developing floating wind farms.[21] Such projects are less mature than fixed developments, and are not expected to be competitive with the latter until nearer 2030.

Based on known projects in Europe, Norwegian Energy Partners (Norwep) expects installed capacity from offshore wind to approach 120 GW in 2030. The EU's offshore renewable strategy has set a target of 60 GW in 2030 and 300 GW by 2050, while the UK's goal is 100 GW up to 2050.[22] In May 2022, four North Sea countries – Denmark, Germany, the Netherlands and Belgium – announced a joint objective of 150 GW by 2050.[23]

In Norway, the Southern North Sea II and Utsira North areas were opened for offshore wind projects in 2020 with a specified maximum installed output of three and 1.5 GW respectively. The government announced a Norwegian offshore wind target in May 2022 which involves awarding NCS areas for 30 GW of output by 2040. These ambitions for area awards are welcomed by the KonKraft partners, and it is important that they are followed up with operating parameters and support programmes which ensure the goals are met.

20 Global Wind Energy Council (2021), Global Offshore Wind Report 2021.
21 IEA (2019), Offshore Wind Outlook 2019. World Energy Outlook Special Report.
22 COM/2020/741 final, EU, Offshore renewable energy strategy.
23 Euractive (2022) – Germany, Denmark, Netherlands and Belgium sign €135 billion offshore wind pact.

As early as January 2022, KonKraft, Energy Norway and the Electrician and IT Workers Union submitted a document to the government entitled *Increasing need for offshore wind – urgent need to get started*,[24] which contained specific proposals on what is required to ensure a large-scale commitment in this area. The players made it clear that a purposeful Norwegian commitment to offshore wind could:

- build a completely new supplier industry with several thousand industrial jobs and provide the basis for activity over several decades to come
- increase Norwegian energy supply, provide greater security of supply and maintain Norway's position as a net power exporter
- help to reach Norwegian and European climate goals and ensure a strong role for Norway in developing the North Sea grid.

In order to realise a major commitment to offshore wind in Norway, KonKraft is calling on the government to take a number of steps relating to licensing processes, market and grid design, and financial parameters and support schemes for R&D, industrialisation and development. These proposals are covered in more detail in chapter 5.2.

National and international ambitions and commitments to offshore wind offer substantial opportunities for developing a Norwegian supplier industry in this area. Suppliers in Norway with long experience from the offshore petroleum and maritime industries have a competitive advantage, particularly where the floating segment is concerned. In a report on developing Norwegian supplier models for offshore wind, presented in March 2021, the NI and key players in the sector identified a "desired scenario" where exports to such projects amounted to NOK 50 billion in 2030.[25] This ambition represents market shares of 15-20 per cent in the floating wind farm segment and 10 per cent for fixed offshore farms.

To succeed in developing a Norwegian supplier industry for offshore wind, it will be particularly important to make provision for a domestic market with operating parameters which ensure the industrial-scale development of floating wind farms on the NCS. That will strengthen the opportunities for Norwegian players to promote their technological solutions and to use the NCS as a display window. Being able to test, qualify and demonstrate new technology in these waters will be a very important foundation for international marketing and exports. Foreign sales of petroleum-related technology based on experience and expertise from the NCS provide a good example of this. Where the supplier industry and maritime players are concerned, being able to act swiftly and exploit Norway's advantages will therefore be very significant.

It is important to note that the industry is already heavily involved in many large foreign projects, but a robust national framework is required which provides a good commercial basis for extensive development of offshore wind on the NCS. Engaging in and linking with the development of a North Sea infrastructure in this sector is crucial for safeguarding Norwegian interests. Grid development in these waters must support a commitment to offshore wind in Norway through an efficient and integrated power market with the countries around the North Sea. In its supplementary White Paper, the government assumes that Statnett will take the role of system manager and be responsible for developing the offshore grid.[26]

Developing good operating parameters which facilitate the growth of a Norwegian offshore wind industry and support the players moving up and out in the market is an absolutely key requirement. Equinor is a leading offshore wind player with its Hywind Tampen project, which will rank as world's largest floating wind farm when it becomes operational. Other operator companies, such as Shell, are entering into collaborations with Norwegian energy players such as Lyse and Eviny to bid for offshore wind licences or invest in relevant technology. In the supplier industry, players are applying their offshore expertise to develop new concepts and technologies for this growing market.

24 KonKraft, Energy Norway and the Electrician and IT Workers Union (2022), Økende behov for havvind – det haster med å komme i gang.
25 Federation of Norwegian Industries (2021), Leveransemodeller for havvind.
26 Report no 11 (2021-2022) to the Storting. Energi til arbeid – langsiktig verdiskaping fra norske energiressurser (preliminary edition).

Hywind Tampen. Photo/illustration, Equinor

Hywind Tampen – world's largest floating wind project

Equinor's Hywind Tampen project will rank as the world's largest floating wind farm when it begins supplying electricity to the offshore petroleum sector in 2022. Comprising 11 turbines with a total capacity of 88 MW, the facility will provide power to Snorre and Gullfaks in the Norwegian North Sea. Connecting these fields to local renewable electricity generation will reduce annual GHG emissions by 35 per cent or 200 000 tonnes of CO_2.

Establishing Hywind Tampen represents an important step towards industrialising solutions and reducing the cost of future offshore wind projects, especially floating farms. Equinor is also taking part in the construction of offshore wind farms internationally, and thereby acquiring experience which can contribute to a competitive development of offshore wind on the NCS. This renewable source could play an important role in electrification of oil and gas installations over the coming decade, assuming the necessary operating parameters are established.

New mobile offshore wind concepts

Odfjell Oceanwind is planning to lease floating wind turbines for supplying renewable power offshore in collaboration with Siemens. The concept is mobile and has been tailored to challenging weather conditions by drawing on Odfjell's offshore experience from oil drilling and service. Several turbines can be integrated into a single system, including transmission and storage facilities. The solution is also tailored to supplying electricity for oil and gas platforms. Mobile floating turbines could permit partial electrification on existing installations where power from shore is difficult to implement for technical and/or financial reasons. This concept could be particularly attractive for installations with a limited producing life, because it ensures relatively rapid connection to a low-emission power supply which helps to achieve the climate ambitions while avoiding large and expensive development of new infrastructure at a late stage in a field's producing life. Odfjell Oceanwind's ambition is to start series production of floating wind turbines in Norway as early as three-four years from now. The company is also working on a hybrid solution where offshore wind turbines can be connected to platforms which are already fully electrified.

Ekofisk Wind – electrification with fixed turbines

ConocoPhillips Scandinavia is pursuing several methods for reducing GHG emissions on fields it operates, including assessment of partial electrification of Ekofisk with fixed wind turbines. Two turbines are under evaluation, each with a capacity of up to 10-14 MW and located five to 10 kilometres west of the Ekofisk centre.

The preliminary concept calls for turbines on steel support structures in 70 metres of water supplying electricity from 2026. This renewable power provision will reduce annual emissions from Ekofisk by about 60 000 tonnes of CO_2 and roughly 49 tonnes of NO_X. A PDO/PIO is due in late 2022 if the licensees make the final investment decision.

Adaptable suppliers for the offshore wind sector

Expertise and technology from offshore industry suppliers are transferrable to offshore wind developments, with a particular advantage for floating turbines. Floating structures, subsea solutions, marine operations, and digital monitoring and control systems are among the petroleum industry solutions with transfer potential. Figure 14 presents Aker Solution's possible deliveries to the offshore wind market relating to engineering, fabrication and operation. The company supplies fixed and floating support structures for offshore wind farm projects, as well as offshore converter stations. It has entered into consortium agreements on platform design and construction for the Sunrise project off New York as well as the East Anglia Three and Norfolk Offshore Wind Zone schemes in the UK. Developing high-voltage direct current (HVDC) converter stations will be more important in the future as wind farms are developed far from land.

Aibel is to deliver three HVDC converter platforms to the Dogger Bank A, B and C projects in what ranks as the world's largest offshore wind farm area. With consortium partner Keppel Fels and subcontractor Hitachi Energy, HVDC converters – both platform-mounted and onshore – are also being delivered to the DolWin cluster in the German North Sea sector. The latest generation of HVDC technology will be installed at Aibel's Haugesund yard.

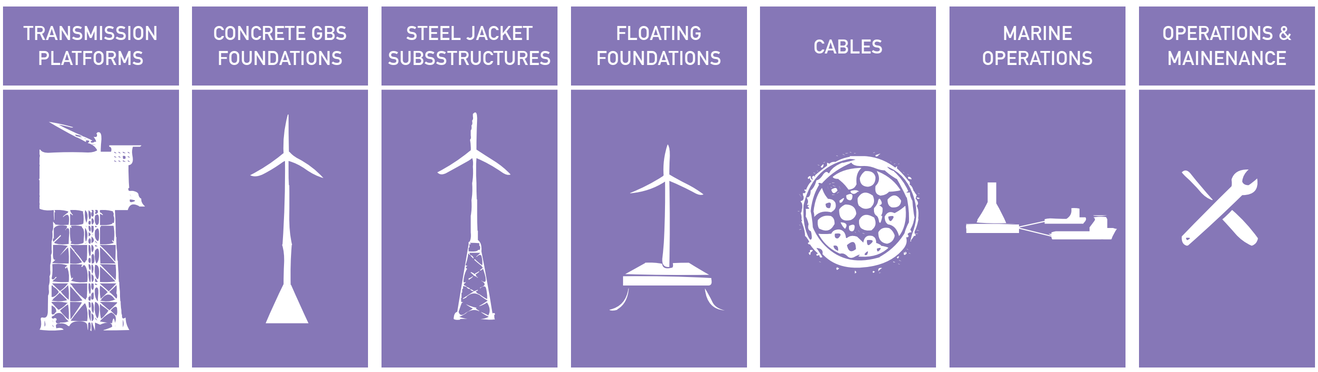
Delivery models for offshore wind power

NI secured funds in 2020 from the Ministry of Petroleum and Energy (MPE) for a project on delivery models for offshore wind.[27] Involving the supplier sector and several industry clusters, this made an important contribution to identifying opportunities for Norwegian suppliers. The goal was to develop supplier models and work to increase their ability to deliver to large-scale offshore wind projects on the NCS. Its starting point is the model for deliveries to Norway's petroleum sector, which has contributed in recent years to a high Norwegian share of orders and successful project executions. The project report with recommendations was published in June 2021.

27 Leveransemodeller for havvind.

FIGURE 14 TYPICAL DELIVERIES TO OFFSHORE WIND PROJECTS.

Source: Aker Solutions



4.4 Hydrogen

Hydrogen is viewed as a key energy bearer for the energy transition, particularly as a natural gas replacement for industry, space heating and the transport sector, and as flexible balancing power on a scale which meets the requirements of the electricity generation industry. Blue hydrogen needs to be produced on an industrial scale for rapid scaling-up and establishing a market. Considerable market opportunities are offered to the Norwegian petroleum industry, including natural gas producers with low carbon footprints and developers of value chains for carbon capture and offshore storage.

On behalf of Offshore Norway, Endrava mapped existing hydrogen production in Europe during 2020 and identified possible future users of this gas at plant level. Looking at facilities close to existing natural gas pipelines, annual energy and process demand for hydrogen from large iron, steel and cement plants as well as gas-fired power stations amounts to 11-18 million tonnes. Assuming a substantial phasing-in of hydrogen as an emission-reducing measure in these sectors, future demand could be substantially higher than current consumption.

As a result of the Russian attack on Ukraine, the EU has presented a REPowerEU proposal[28] for reducing dependence on natural gas from Russia. This includes raising the target for renewable hydrogen use by 15 million tonnes in 2030, of which 10 million will be imported and five million provided by increased European production. That goal comes on top of the 5.6-million-tonne rise proposed in the EU's Fit for 55 climate package,[29] and creates a basis for Norwegian participation in developing and delivering solutions for both blue and green hydrogen needed by Europe in coming years.

A separate hydrogen strategy was also launched in 2020 by the EU, which wants this gas to move from less than two per cent of the energy mix today to 14 per cent by 2050.[30] The strategy recognises the need for low-carbon hydrogen, particularly in building up a market for the gas. In December 2021, the European Commission presented proposals for revised gas market regulations which include guidelines on phasing-in and certifying hydrogen.[31] In order for blue hydrogen to be included in the low-carbon category, it must provide at least 70 per cent lower emissions than a fossil alternative. The methodology for calculating and documenting emission reductions in relation to fossil options is due to be presented by the end of 2021.

Norway joined the EU's strategic forum for important projects of common European interest (IPCEI) for hydrogen in December 2020. The KonKraft partners take a very positive view of this, and believe the collaboration can help to speed up developments related to hydrogen while making provision for Norway to remain a stable energy supplier to continental Europe. A year after joining the hydrogen commitment, Norway has nominated several candidates as IPCEIs, including the Barents Blue project led by Horisont Energi, Vår Energi and Equinor.

The maritime sector has identified the price differential between fossil fuels and the climate-friendly alternatives as a challenge for the green transition. One solution could be the use of contracts for difference, where the government enters into a temporary agreement to provide support which closes the gap between the two options. A collaboration project now under way between the RF and Zero is looking in more detail at the specific structure of such an arrangement.

28 European Commission (2022), COM(2022) 108 final. REPowerEU: Joint European action for more affordable, secure and sustainable energy.
29 Regjeringen (2021) – EUs Klimapakke «Klar for 55»
30 European Commission (2020), EU Hydrogen Strategy.
31 European Commission (2021), COM (2021) 803 final

Barents Blue. Photo: Horisont Energy

Barents Blue – Europe's first large-scale plant for blue ammonia

In partnership with Equinor and Vår Energi, Horisont Energi is to build Europe's first large-scale plant for ammonia with carbon capture outside Hammerfest in northern Norway. Plans call for low-emission ammonia production to start in 2027 and be scaled up to an annual production of more than one million tonnes. The plant's daily capacities for blue hydrogen and blue ammonia will be 600 tonnes and 3 000 tonnes respectively.

This facility will be supplied with natural gas from the Hammerfest LNG plant at Melkøya, and the aim is to produce blue ammonia with more than 99 per cent of the CO_2 captured.[32] The latter will transported and stored by a separate Polaris project with the same partners. See the chapter on CCS for further details. Plans call for a final investment decision towards the end of 2023. Barents Blue was one of three projects which received substantial financial support in December 2021 from Enova for a commitment to future low-emission industry. It is receiving NOK 482 million from the state-owned company and as part of Norway's nomination to IPCEI Hydrogen. The award is awaiting preliminary approval from the Efta Surveillance Authority (ESA).

Deep Purple – offshore hydrogen production from renewable sources

The Deep Purple project, led by TechnipFMC in collaboration with Vattenfall, Repsol, NEL, ABB, Sintef, DNV GL and others, aims to develop offshore technology and solutions for producing large-scale green hydrogen from offshore wind. Production will be piped ashore or stored locally to provide stable renewable power for consumers not connected to the grid. The concept uses hydrogen as an energy store and can thereby ensure a stable electricity supply with offshore wind. It has the potential for a broad range of applications, including power for island communities, hydrogen supplies to the maritime industry, and local provision of electricity, oxygen and hydrogen in the aquaculture sector.

Aukra Hydrogen Hub – production linked to Nyhamna

Aker Clean Hydrogen launched plans in April 2021 for large-scale production of blue hydrogen and ammonia linked to the Nyhamna gas processing plant in Aukra local authority. With a planned production capacity of 0.4-2.5 GW, this facility will be gradually converted to produce green hydrogen in the longer term. Norske Shell announced in July that it and CapeOmega are

32 Horisont Energi (June 2021). Project Barents Blue. Project flyer.

Aker Clean Hydrogen. Photo: Aker

partners in the project. As operator for Ormen Lange and technical service provider for Nyhamna, Shell has good qualifications to help realise the plans. The project passed decision gate (DG) zero in February 2022, and can point to a potential for technical and financial viability and a competitive levelised cost of hydrogen (LCOH). The players are also looking at opportunities for exporting hydrogen through the existing gas transport system to the UK and potential new dedicated pipelines to the EU. The first of these options is being viewed in relation to plans published by the UK Energy Networks Association for Britain's existing gas pipelines to be able to deliver 20 per cent hydrogen to households and companies from 2023.

Scaling-up and adapting pipeline infrastructure for hydrogen

In its role as the architect for developing Norway's offshore gas transport network, Gassco has initiated processes for the gas infrastructure of the future. These function as a strategic decision tool for future operation and development. Through constructive dialogue between the industry and government, Gassco will help to make provision for good, timely and knowledge-based decisions. This process includes assessing how Norway's gas infrastructure can be tailored to future requirements and opportunities for alternative use of any spare capacity.

Work done so far shows that the Norwegian gas transport system is flexible, has been developed stage-by-stage and can be reduced in the same way. No technical obstacles have been identified for using existing gas pipelines to transport such commodities as blue hydrogen or CO_2 back from Europe should this become relevant. Assessments of available capacity in the transport system indicate that alternative uses will first become relevant after 2030. Transporting natural gas and hydrogen together in the same pipeline has also been assessed as technically feasible.

Several of the companies on the NCS are looking at longer-term opportunities to export some gas from their Norwegian portfolio in the form of blue hydrogen. Interest in this commodity is growing in a number of European countries. Opportunities for large-scale transport of blue hydrogen, including by pipeline, form part of the energy dialogue with the German government. Gassco's architect role covers all relevant export solutions for gas. Over time, the company has studied the opportunities for and consequences of increasing gas export capacity from the Barents Sea. This is currently limited by process constraints at Hammerfest LNG. Alternatives studied have included both a connection to the European pipeline system and increased LNG export capacity. Sending gas abroad as blue ammonia through the Barents Blue project has recently been introduced as a third option.

An increase in export capacity will provide opportunities for accelerating gas production from Barents Sea fields, permitting the development of small discoveries in coming years and making it more attractive to explore because prospects for profitable development and production could improve. As the gas transport system's architect, Gassco will assess such a solution in relation to the other options.

4.5 CCS

CCS is a key technology for reducing emissions from the production of energy carriers and industrial processes based on fossil fuels. Success in developing CCS is essential for meeting the ambition of net zero emissions in 2050. Published in April 2022, part three of the sixth assessment report (AR6) from the IPCC on emission reductions, take-up and instruments notes that the present pace of dissemination for CCS technology is substantially lower than has been identified as necessary by its scenarios on limiting global warming to 1.5°C or 2°C.[33] Increased political attention, support and commitments from government and industry, and a continued commitment to technology development, are important for realising the concentration on CCS needed to reach the climate goals.

The Norwegian government has long been a prime mover globally in developing CCS solutions, and has supported technology development and international collaboration in a number of arenas. Norway's oil and gas industry is a front-runner, and Equinor has been storing CO_2 on the Sleipner field ever since 1996. The Norwegian Petroleum Directorate (NPD) published a carbon storage atlas in 2019 which estimates that it would be possible to store at least 80 billion tonnes of CO_2 on the NCS. The first licence for carbon injection and storage was awarded in the autumn of 2018, with Northern Lights – part of the Longship project – as the only applicant and the recipient. Further licence awards for carbon storage were announced in the autumn of 2021, and five companies applied for the two on offer in the North and Barents Seas. These were allocated to Equinor and a group comprising Horisont Energi, Vår Energi and Equinor respectively. The Longship project and the government's commitment help to reduce the risk of CCS projects, and more of these are expected in the time to come. Several operator companies are already involved in large initiatives for CCS, such as Northern Lights and Polaris, and also participate with the supplier industry in the Carbon Links (LINCCS) industry project on developing cost-effective value chains.

Longship – basis for establishing a national CCS value chain on an industrial scale

Longship is Norway's largest climate project and aims to offer a complete value chain for CCS with opportunities for large-scale storage of CO_2 from continental Europe. It involves carbon capture from Norcem's cement mill in Brevik and the Fortum Oslo Varme waste management facility, CO_2 transport by ship to a terminal in Øygarden outside Bergen, and onward pipeline transport and carbon injection in geological formations on the NCS. Longship is being realised as a consequence of the major collective commitment to CCS by government and industry.

The government is supporting Longship by providing NOK 16.8 billion to realise a capture plant at the Norcem mill and a value chain for carbon transport and storage, including operating costs for 10 years. In addition, the government will support carbon capture at the Fortum Oslo Varme facility with NOK 3 billion providing sufficient external finance is secured. The company applied for a EUR 180 million grant from the EU innovation fund but was turned down in November 2021. Nevertheless, it was announced in March 2022 that financing of the capture plant had been secured with Hafslund Eco, Infranode and HitecVision as new shareholders in Fortum Oslo Varme. KonKraft's ambition in the climate strategy of working to establish two carbon capture plants in Norway thereby appears to be closer to fulfilment.

33 Working Group III Contribution to the IPCC sixth assessment report (AR6). Summary for Policymakers.

These two capture facilities will reduce annual GHG emissions by an estimated 800 000 tonnes of CO_2. Plans call for the Norcem plant to be operational in 2024, with Fortum Oslo Varme following two years later. Northern Lights partners Equinor, Shell and Total will deliver transport and storage solutions to the project, and their PDO/PIOs were approved in March 2021. An annual carbon transport and storage capacity of 1.5 million tonnes is due to be offered by Northern Lights during 2024. Its ambition is to increase this to five million tonnes and to make provision for carbon storage elsewhere in Europe.

Realising two capture plants is important for the industry and will provide a better foundation for success in establishing a competitive value chain for CCS. They will create a number of new jobs and strengthen Norwegian expertise and ability to deliver such installations. In addition, the plants in Norway relate to two industries which are difficult to decarbonise without CCS, and the global potential for extending the technology in both waste processing and cement production is considerable. Several recent examples indicate that such dissemination is really starting to happen. One is the announcement by the EU innovation fund in November 2021 that it had pre-selected four carbon capture projects for support. All could become customers for Northern Lights. They are located in Finland (blue hydrogen), Sweden (bio-CO_2), Belgium (blue hydrogen) and France (cement). Another example is the collaboration agreement reached in May 2022 between Northern Lights and Cory, which will work together on seeking to realise CCS of up to 1.5 million annual tonnes from the latter's waste incineration plant in London by 2030.

Capacity in Northern Lights will permit storage of CO_2 captured in Europe. The company announced recently that it will receive EUR 4 million from the European Commission to support front-end engineering and design (Feed) studies for expanding its annual transport and storage capacity to more than five million tonnes of CO_2.[34] In addition, it has signed a non-exclusive memorandum of understanding with Aker Carbon Capture to collaborate on a complete CCS value chain solution. The latter company has also entered into a similar agreement with Stella Maris CCS based on carbon transport and storage using ships. Such a solution would also give Norwegian shipping and shipbuilding companies an important new segment in coming years. Several plans for Norwegian value chain projects have been brought forward and made possible by the Longship commitment.

LINCCS – industrial collaboration to commercialise carbon capture, transport and storage up to 2030

LINCCS was established in 2021 to expedite cost reductions in the CCS value chain and to help commercialise the necessary technology. The project is led by Aker Solutions as an industry collaboration between key petroleum and maritime industry players, with participation from Sintef. Its aim is to develop technology and solutions by 2030 which help to reduce carbon storage costs by 70 per cent and permit the storage of more than 100 million tonnes of CO_2 per annum.

The project will also contribute by 2030 to creating 1 000 new jobs and generating more than NOK 8 billion in annual turnover. To fulfil these ambitions, LINCCS will develop and commercialise the following innovations which combine carbon capture with storage:

- unmanned/low-manned solutions to cut carbon capture costs
- a ship's engine with integrated carbon capture
- a digital tool for the transport and logistics side of CCS
- a digital tool to provide decision support on reusing existing oil and gas infrastructure for carbon storage

34 Northern Lights (27 January 2021), Northern Lights awarded EU funding for expansion studies.

- a system for cost-effective carbon injection and storage in wells.

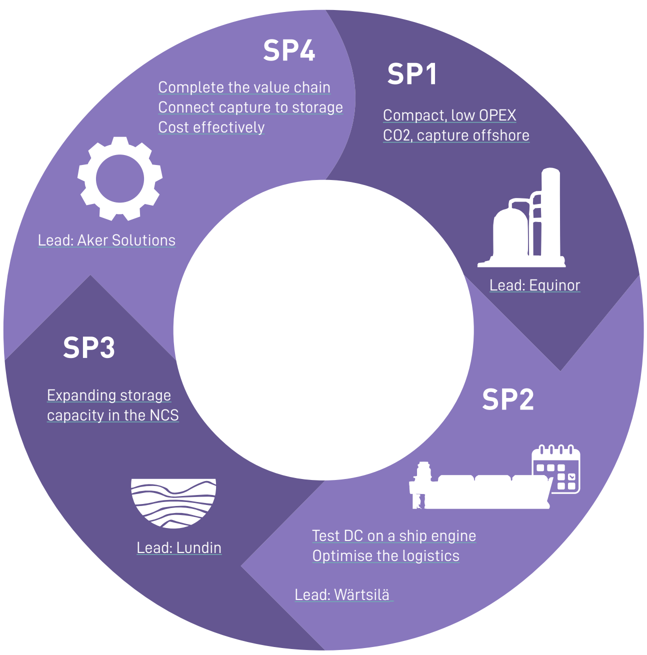
The project comprises five sub-projects where activities will yield concrete results for further work. It has a preliminary timetable of three years, which can be extended if the partners wish. Figure 15 presents an overview of the four technical sub-projects with the company responsible for each: Aker Solutions, Equinor, Wärtsilä and Lundin. In addition comes an administrative sub-project led by Aker Solutions for following up all the activities, information sharing and taxonomy adaptation. The project has 15 participants making in-kind and cash contributions, as well as funding from support programmes. Its total budget is NOK 178 million, including NOK 111 million in support from Green Platform.

Polaris – first large-scale transport and storage project after Longship

Horisont Energi, Vår Energi and Equinor are collaborating in the Polaris project to develop a transport and storage solution for CO_2 in the Barents Sea. The partners applied jointly in December 2021 for a carbon storage licence in these waters from the NPD's second licensing round. On 5 April, the MPE announced that the three companies would be offered an area of the Barents Sea for storing CO_2 with Equinor as operator. Polaris is an integrated part of the Barents Blue project, where the same partners are collaborating on developing a blue ammonia plant outside Hammerfest. CO_2 from this facility would be piped offshore and injected as a supercritical liquid in the storage formation, which the NPD estimates to have a capacity of more than 100 million tonnes of CO_2. Plans envisage Polaris becoming operational in 2027 at the same time as the ammonia plant, which will then have an output of about two million tonnes of CO_2 per ammonia train. In addition to CO_2 from Barents Blue, Polaris aims to handle third-party storage. If these ambitions are realised, this will be the first large-scale Norwegian transport and storage project after Longship.

FIGURE 15 LINCCS PROJECT AMBITIONS FOR 2030 AND WORK PACKAGES.

Source: LINCCS/Aker Solutions



Stella Maris – reversing the logistics chain for oil and gas

Altera Infrastructure and Höegh LNG are partners in the Stella Maris CCS project, which aims to offer a complete transport and storage service for CCS. Expertise will also be contributed about reservoirs and applying for CO_2 licences on the NCS. The Stella Maris CCS concept reverses the logistics chain for petroleum and is not pipeline-dependent. Its main idea involves collecting CO_2 from various emission sources in a large floating receiving plant which can be located flexibly. These CO_2 flows can be collected via pipeline, road, rail or small ships for transport by large shuttle tankers to floating injection units in the North Sea, which will be able to inject 10 million tonnes of CO_2 per annum.

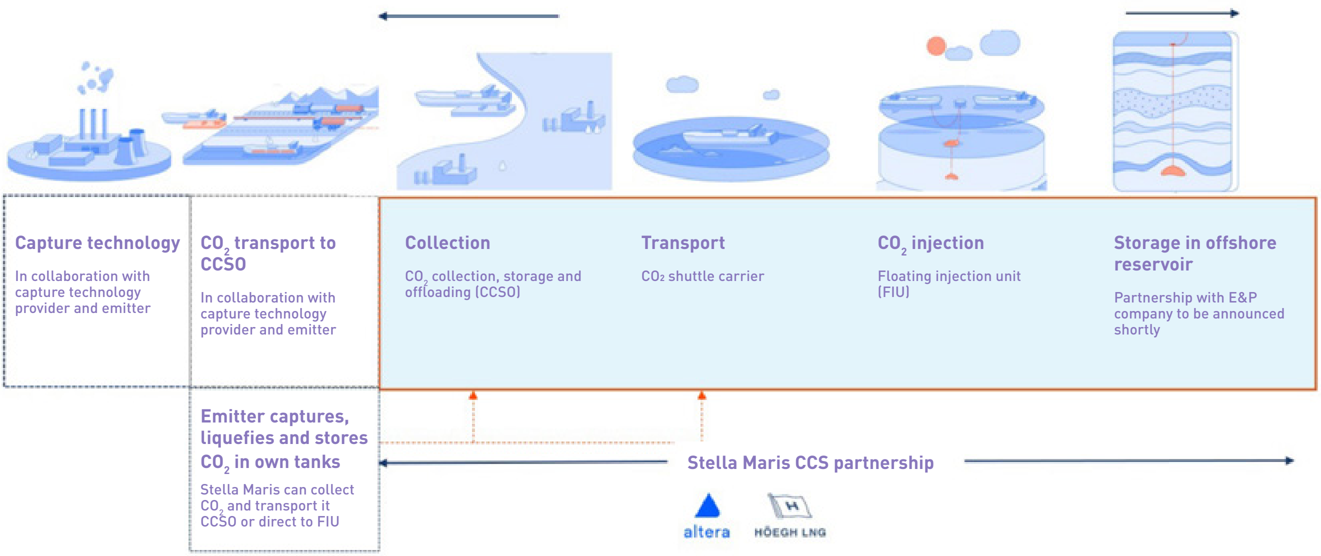
Carbon capture and intermediate ship storage

Gas shipping specialist Solvang ASA has signed a letter of intent with Wärtsilä covering large-scale carbon capture and intermediate storage on one of its newest ships. The system is located in the funnels, where the CO_2 is extracted from the exhaust fumes before being captured and stored as liquefied CO_2 in two tanks on deck. When the ship has berthed, the gas can be delivered to players for use in such applications as synthetic fuel or in the food industry.

The amount of CO_2 captured will depend on such factors as heat, energy and tank capacity. In the pilot project, the system will be dimensioned to capture up to 70 per cent of the emissions. The solution to be used by Solvang is currently under development and testing in ship-like conditions at Wärtsilä's factory in Moss. It is due to be installed in the ethylene carrier *Clipper Eos* in 2023.

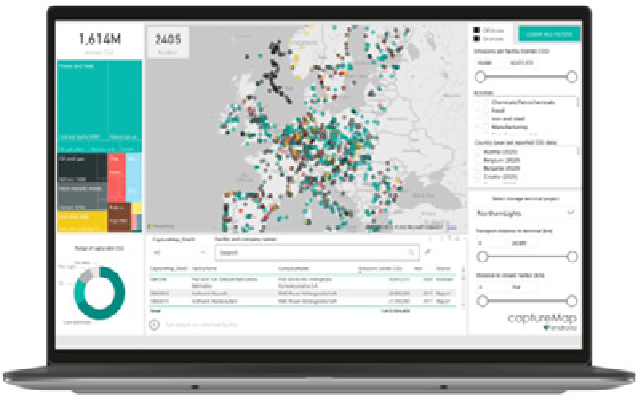
FIGURE 16 STELLA MARIS CCS OFFERS SOLUTIONS FOR COLLECTION, TRANSPORT AND STORAGE IN THE CCS VALUE CHAIN.

Source: Altera Infrastructure/Höegh LNG



CaptureMap – identifying major emission sources and potential clients for CCS

Necessary for achieving adequate emission cuts, demand for CCS is growing in Europe and the rest of the world. That opens substantial market opportunities for companies delivering technologies and services to the CO_2 value chain. To best get to grips with this market, players in carbon capture, transport and storage need information on CO_2 sources which can be captured and shipped for storage.



Endrava has developed CaptureMap to give players improved market understanding. This tool provides an integrated overview of large European facilities in the power and heat, manufacturing and waste incineration sectors, with detailed information on their activities and emissions. Originally developed with support from Offshore Norway, it is now being used by many enterprises in Norway and internationally in the CCS sector. A number of the companies mentioned in this chapter make active use of CaptureMap to identify possible customers for technology or services. Endrava is now developing an expanded version with more regions to provide a global picture.

4.6 Seabed minerals – possible new value chain under starter's orders

Recovering seabed minerals has been identified as a new industrial opportunity on the NCS with a potential for knowledge and technology transfer from the petroleum industry in relation to exploration and production.[35] OG21, the body providing strategic advice to the government on technology and research commitments in the petroleum sector, also refers to subsea minerals as one of four new industry opportunities in its latest strategy, published in November 2021.[36]

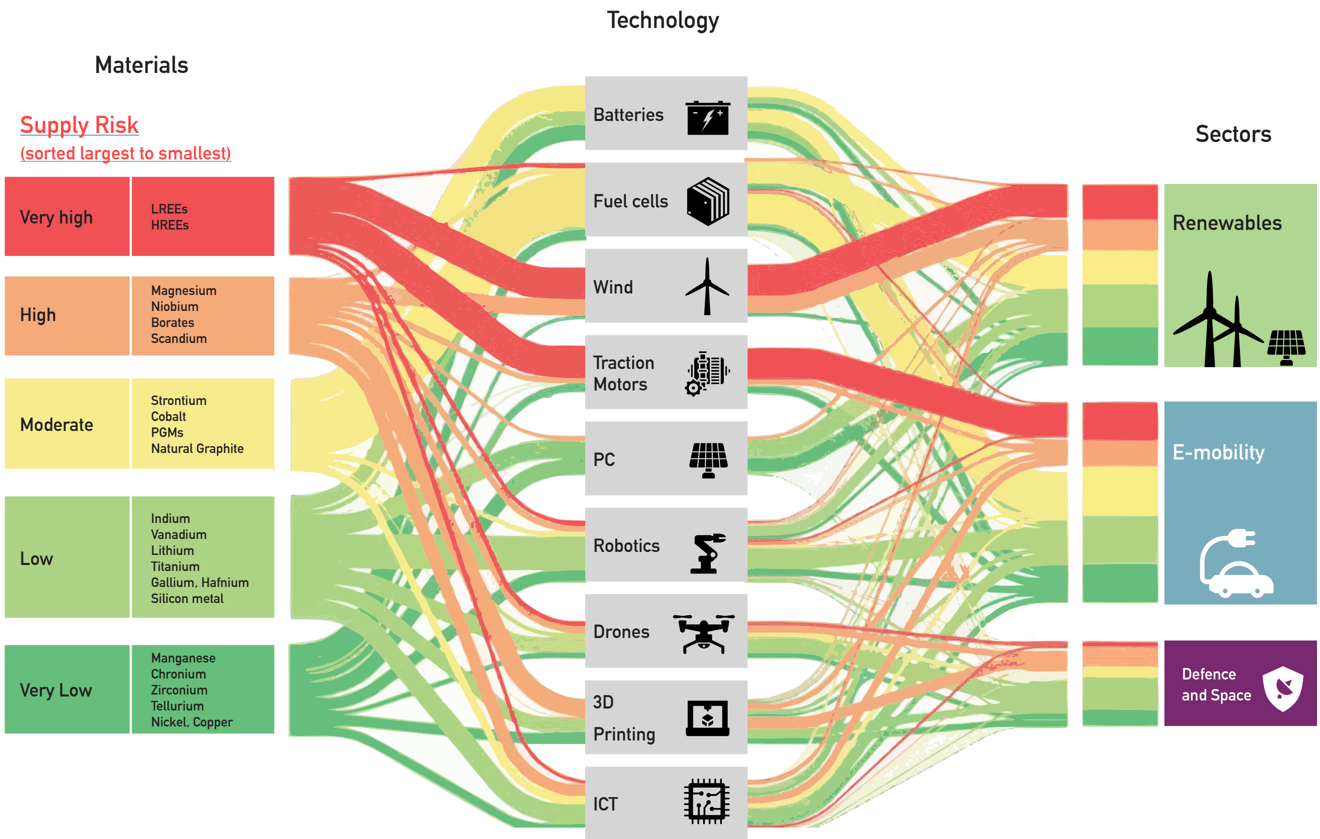
The process of opening the NCS for mineral recovery was initiated by the previous non-socialist government under Conservative Erna Solberg, and the Seabed Minerals Act came into force in July 2019. Today's centre-left coalition intends to extend mapping of mineral resources, including on the NCS, with particular emphasis on minerals which could also play an important role for success with the green shift. The final programme for an impact assessment of offshore mineral operations was established by the MPE in September 2021. An opening process for such activities on the NCS was initiated the following month. Plans call for the Storting to receive a White Paper on this subject in the spring of 2023, with the award of licences provisionally envisioned in 2023-24.[37]

In order to ensure reliable and sustainable supply chains for raw materials needed by European industries and for products required in a modern society, the EU has identified and published a triennial list of critical raw materials since 2011. The fourth version was published in 2020, and some of the substances included are cobalt, graphite, rare earths, platinum-group metals, scandium, silicon, bauxite and lithium.[38] Mapping of possible minerals on the NCS by the NPD in 2018-20 has identified such resources in massive sulphide deposits and manganese crusts.[39] These surveys were conducted in areas with volcanic ridges around Jan

35 Report no 36 (2020-2021) to the Storting. Energi til arbeid – langsiktig verdiskaping fra norske energiressurser. MPE.
36 OG21 (2021), OG21 Strategy – A New Chapter.
37 Adomaitis, Nerijus (12 January 2021, "Norway eyes sea change in deep dive for metals instead of oil". Reuters.
38 European Commission (2020), COM (2020) 474 final. Critical Raw Materials Resilience: Charting a Path Towards Greater Security and Sustainability.
39 NPD (2020), Resource report exploration 2020.

FIGURE 17 MATERIAL REQUIREMENTS AND SUPPLY RISK FOR TECHNOLOGIES IN ENERGY TRANSITION AND DEFENCE.

Source: European Commission (2020)



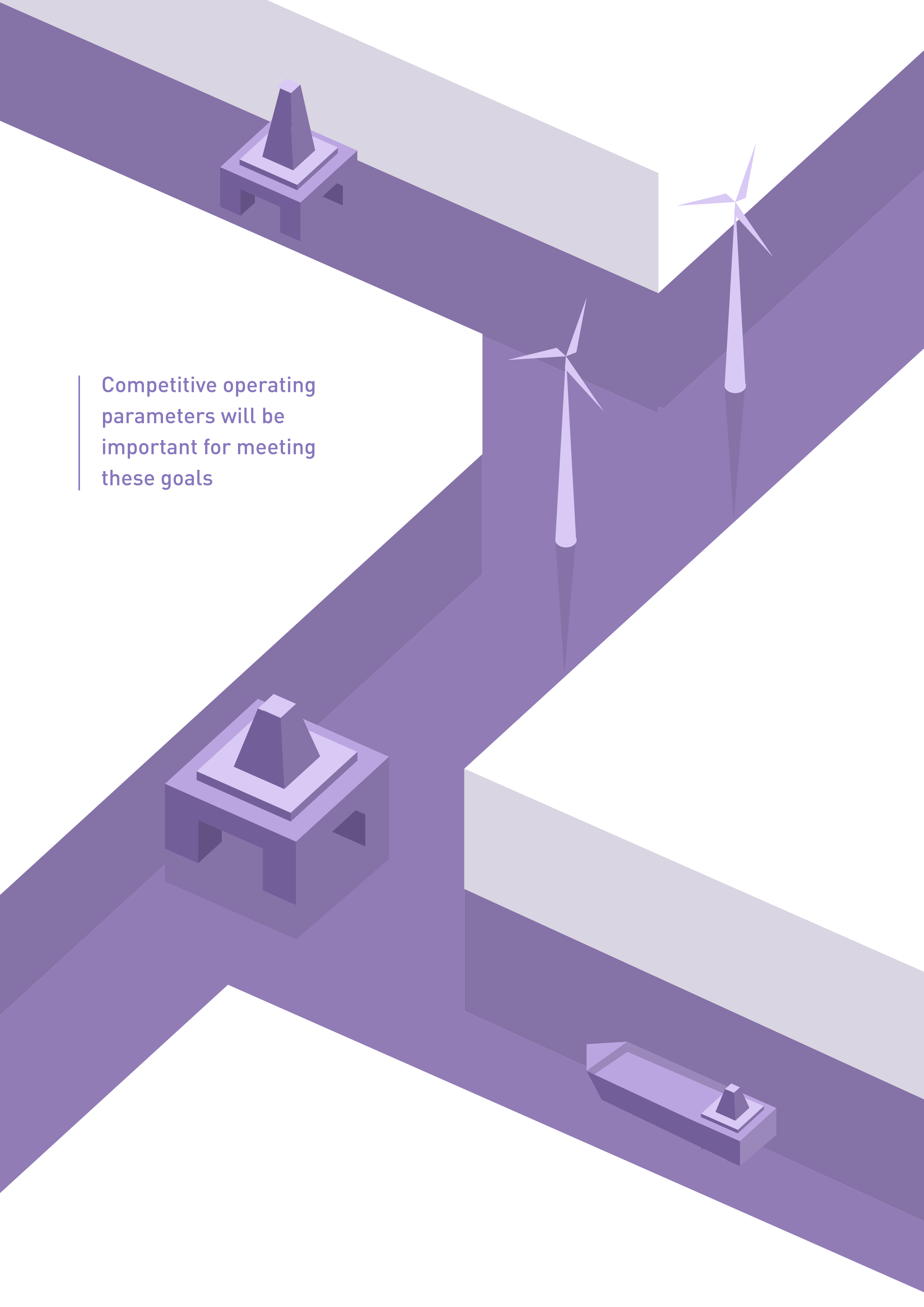
Mayen and northwards towards Svalbard. Samples from the 2018-20 expeditions reveal that the sulphides primarily contain zinc, copper, cobalt, gold and silver. In addition to a higher content of manganese and iron, the manganese crusts off Norway appear to include unusually high levels of scandium and lithium as well as a fairly high proportion of rare earths.

The green shift requires huge quantities of minerals and materials for low-emission technologies and digital solutions. In a study of critical raw materials published in 2020, the European Commission assessed resource supplies for and competition over strategic raw materials in value chains related to nine key technologies needed by a low-emission society.[40]

The selected technologies include batteries, fuel cells, wind farms, electromobility, drones and digital solutions, and several of these compete for the same raw materials. Where batteries are concerned, for example, lithium, cobalt and graphite are classified today as critical raw materials. The supply risk for lithium is assessed as low but the study notes a big need for investment beyond 2025 to avoid a shortage. In a 2050 perspective, demand for raw materials from renewable energy technologies and electromobility is expected to be several times higher than current EU consumption for all areas of application.

40 European Commission (2020), Critical materials for strategic technologies and sectors in the EU – a foresight study.

Competitive operating parameters will be important for meeting these goals



5

OPERATING PARAMETERS AND SUPPORT PROGRAMMES

Competitive operating parameters which facilitate effective implementation of industrial and climate policies will be important for meeting these goals. Support programmes must encourage technology development, innovation and upscaling.

KonKraft would give particular emphasis not only to the creation of a CO_2 fund to realise emission reductions on the NCS and contribute to building up new value chains, but also to the operating parameters required for a major commitment to offshore wind in Norway.

Achieving the goals of the KonKraft climate strategy calls for a major transformation of the oil and gas industry in Norway. That requires competitive operating parameters which allow a long-term perspective to be taken for investment in Norway, and support programmes which encourage effective climate measures. This is very important in creating a secure framework for making long-term climate and technology investments related to oil and gas production, CCS, hydrogen, offshore wind and seabed minerals.

Electrification is clearly the most important emission-reducing measure for reaching KonKraft's climate goals. In order to make provision for efficient extension of electricity use on the NCS, while ensuring competitive prices for the industry and other consumers, it is crucial that the Norwegian government quickly ensures adequate development of renewable power generation in Norway. The industry would highlight the following contributions as important for meeting these goals.

- Long-term and predictable political support for electrification with power from shore as a means to cut Norwegian emissions is important for reducing uncertainty over planning and executing long-term and complex projects of this kind.

- The licensing and application processes should be reviewed, and government administrative capacity must be strengthened in order to reduce lead times and speed up the execution of grid, renewable and power-from-shore projects.

- An integrated national electrification strategy must be developed, with an associated grid development plan which sets clear priorities.

5.1 Support programmes must be strengthened to reach climate goals for 2030 and 2050

KonKraft is working to achieve a goal of cutting emissions by 50 per cent in 2030 compared with the 2005 level. It would call attention to the following support programmes which will help ensure that the target is met.

1. CO_2 fund for realising more ambitious climate goals.

Government support programmes are important when the industry is to meet ambitious climate goals in 2030 and 2050. Raising the climate target on the NCS from 40 to 50 per cent will be significantly more demanding. Certain measures will probably carry a higher price tag than the overall carbon cost of NOK 2 000 per tonne (CO_2 tax and EU ETS allowance price).

The budget compromise between the Socialist Left and the government included the following: "The Storting requests that the government studies a climate agreement with the petroleum sector to reduce GHG emissions from Norwegian oil and gas production, including suitable support programmes for speeding up change on the NCS. This agreement will ensure that CO_2 emissions from offshore oil production do not exceed a specified emission ceiling".

KonKraft wants to collaborate with the government on preparing a climate agreement, and therefore proposes that the increase in the CO_2 tax for the industry be earmarked for a CO_2 fund. This will be used for measures which contribute to faster and further emission reductions in the oil and gas sector, while speeding up the development of new value chains such as CCS, hydrogen and offshore wind.

2. Enova's mandate should be strengthened.

Enova should also be able to help realise measures yielding large emission reductions through various support programmes for emissions subject to the EU ETS. Enova support for implementing measures based on existing technology for such emissions will reduce risk and contribute to cost reductions for strategically sensible technology with a dissemination potential. It would be an important supplement to existing support programmes for rolling out technology which has been fully qualified but where the costs are too high at present for individual companies. In order to secure adequate cost reductions when bringing new technologies and solutions to market, measurement criteria and support schemes must be organised so that Enova can provide support beyond the initial demonstration of the first plant. All available low- and zero-emission technologies in the EU ETS sector which can contribute to emission-reduction measures in the industry should be able to receive implementation support. These changes will ensure broader utilisation of technology which is fully qualified but too costly for individual companies to adopt. It must also be possible for Enova to support users of low- and zero-emission technologies such as hydrogen in order to help the build-up of markets.

3. Support programmes which help develop new and competitive value chains for energy.

R&D schemes are needed to help reduce costs and support the demonstration of new concepts which make it quicker to scale up and to take solutions to market. KonKraft wants to see a strengthening of R&D funds through the Research Council's programmes for low- and zero-emission technology and alternative fuels.

4. Ensure the continuation of the Business Fund for Nitrogen Oxides beyond 2027.

Through its grants to emission-reducing technologies and conversions, the NO_x fund has contributed to substantial reductions in such emissions since it was established in 2008. NO_x measures in the offshore petroleum industry often have a positive effect since CO_2 releases are also cut. The present environmental agreement with the government has been extended to 2027. To ensure continued reductions in NO_x emissions, in line with Norway's international obligations, the industry recommends that this agreement be extended to 2030.

5.2 Operating parameters and support programmes must back the build-up of new value chains on the NCS

The oil and gas industry will work to take a key role in building up a number of new value chains, such as offshore wind, CCS, hydrogen and subsea minerals, which will contribute to new value creation and jobs. During the build-up phase, the government must provide backing through operating parameters and support programmes which encourage industrialisation and scaling up. KonKraft would call particular attention to the following steps as important for realising its goals.

1. A large-scale commitment to offshore wind power in Norway.

A rapid and ambitious commitment to fixed and floating wind farms on the NCS will not only secure sufficient quantities of new renewable energy for industry and consumers in Norway over coming decades, but also lay the basis for a new Norwegian industrial adventure. The government's ambitions of awarding areas to generate 30 GW of offshore wind by 2040 are welcome, and it is important that these goals are followed up with operating parameters and support programmes which ensure they are met. KonKraft urges the government to take the following steps to make such a commitment possible.

- Make provision for the development of two-three GW of offshore wind per annum in the 2030s and 2040s, and start opening new areas for such projects from the present Storting period.
- Establish frameworks and structures to ensure adequate support for establishing floating wind farms on Utsira North – by utilising contracts for difference where electricity prices are concerned, for example. This work must be pursued in parallel with offering sites, and support must be assessed in relation to the goals set by the government for floating wind power.
- Floating wind farms on Utsira North must be developed quickly and connected to the main Norwegian grid and/or used for electrification offshore.
- Provide for a bidding contest over Utsira North and Southern North Sea II based on qualitative criteria, which must include plans for national spin-offs and supplier development.
- Strengthen the research and innovation commitment related to industrialisation and scaling up of offshore wind.
- Emphasise a high Norwegian HSE standard and base locations in Norway, so that value creation occurs regionally and nationally.
- Ensure that grid development on the NCS helps to strengthen value creation and supports a Norwegian commitment to offshore wind with an effective and integrated power market in the countries around the North Sea. Licensing and application processes must be adapted to shorter lead times for offshore wind farm projects on the NCS.
- Identify opportunities for Norwegian involvement in the North Sea wind power collaboration and ensure that Norway participates in relevant fora which can yield spin-offs for Norwegian industry and supplier development.
- Norwegian government bodies, including the MPE, the NVE and Statnett, must play an active role in relation to the EU's work on developing a framework for hybrid projects and a possible meshed offshore grid in the North Sea. It is particularly important that Norway ensures active involvement in the regional collaboration bodies which will plan a coordinated development of infrastructure in the North Sea. A clarification in relation to the Trans-European Energy Networks (TEN-E) regulation is important in this context. Working to ensure that offshore wind farm developers can receive part of the bottleneck revenues will also important for strengthening profitability in the projects.

2. Scaling up the Norwegian hydrogen sector.

Building up a strong hydrogen industry in Norway will create long-term and profitable jobs while also facilitating the use of this gas as an alternative to fossil fuels in a number of sectors – including the maritime industry. The Norwegian government must make provision for such a development by facilitating the establishment of markets for hydrogen production, distribution and consumption. It should therefore set specific goals for various parts of the value chain in the short, medium and long terms.

The following are important for meeting the goals.

- Shaping support programmes which encourage development and innovation in all parts of the hydrogen value chain. These programmes must contribute the necessary risk-reduction through contracts for difference required to ensure profitable development of ammonia and hydrogen production.
- Make provision for a gradual and simultaneous development of market and production capacity. Cost-effective solutions must be secured for both production facilities and for infrastructure which ensures market access.
- Use of hydrogen in Norway must be viewed in relation to pipeline exports to continental Europe and the UK.
- Detailed work must be done to establish routines and regulations for safe handling of hydrogen throughout the value chain.
- Good collaboration solutions and arenas are established between government and industry.

3. Commercialising CCS.

To ensure that CCS becomes a commercial industry, specific goals must set for how much CO_2 is to be stored on the NCS. It will also be necessary to develop many stores in parallel and award even more storage licences than have so far been handed out. The Norwegian government should also contribute to simplifying the regulations for transporting and storing CO_2, since these are currently very extensive and complex.

Support programmes should be adapted so that they contribute to risk reduction and make provision for maturing solutions which ensure the necessary scale, learning and cost reductions for both hydrogen and CCS.

4. Effective operating parameters for recovering seabed minerals.

Norway's access to minerals and rare earths is a geopolitical reality, and could speed up a green shift if efficient administrative processes are established to permit this. The impact assessment programme for mineral operations has been specified by the MPE, an opening process has been initiated for such activities on the NCS, a White Paper on this subject is due to be submitted to the Storting in the spring of 2023, and the award of exploration licences is currently envisioned in 2023-24.[41]

Keeping to the timeline outlined for the opening process is important. Furthermore, the players believe that the government should take the following steps.

- Increase the latitude available to the relevant government bodies through the regular budgetary process in order to support further resource mapping, data acquisition, industrial and environmental knowledge-building, and early-phase research and development.
- Free up data from various expeditions on the NCS. Access to information is a precondition for good resource mapping, and the industry should be given the opportunity to participate actively in building up knowledge about the relevant areas.
- Quickly clarify the financial, area-related and work-related operating parameters and give the industry sufficient opportunity to contribute to relevant processes. Furthermore, initiating the licensing process as soon as a decision to open has been taken is desirable. The players support a step-by-step process, where the necessary impact assessments are conducted at relevant milestones.

41 Adomaitis, Nerijus (12 January 2021). Norway eyes sea change in deep dive for metals instead of oil, Reuters.

> Norway's access to minerals and rare earths is a geopolitical reality, and could speed up a green shift if efficient administrative processes are established to permit this


Ocean Space Centre. Photo/illustration: Snøhetta

5.3 Key research and innovation programmes for realising a low-emission society

The Norwegian oil and gas industry is working to increase research on and development of solutions which help to reduce GHG emissions from its own activities. Expertise and innovativeness in the sector have a big transfer potential to other industries, and are highly relevant for realising a low-emission society. The companies are participating actively in developing and testing new solutions in collaboration with academics and research players. Many participants in the industry have also set their own R&D targets directed at low-emission and renewable solutions, and a number have increased their budgets in this area.

Key R&D programmes for the oil and gas industry include Petromaks 2, Demo 2000 and Climit for CO_2 management. The Petrocentres, the LowEmission Centre and several of the research centres for environment-friendly energy (FMEs) represent important commitments with industry participation. A new FME covering hydrogen and hydrogen-based energy carriers was established in March 2022. The Research Council of Norway is allocating up to NOK 310 million to create two research centres at Sintef and the Norwegian Research Centre (Norce). Energix and Enova's support programmes are particularly important where new energy value chains are concerned.

The Ocean Space Centre in Trondheim[42] will play a central role in developing tomorrow's solutions for the NCS, including technology for offshore wind, and thereby help to strengthen the long-term competitiveness of the latter sector and other commitments offshore Norway. Establishing the centre as scheduled is therefore important.

42 Norwegian University of Science and Technology (NTNU) – Ocean Space Centre.

New and updated initiatives since the previous status report strengthen the R&D commitment to low- and zero-emission technology

- **New Petrocentres.**
  Two new petroleum research facilities (Petrocentres) were announced in December 2021 and are due to become operational in 2022. The National Centre for Sustainable Utilisation of Energy Resources on the NCS (NCS2030) is affiliated with the University of Stavanger, and Norce, the Institute for Energy Technology (IFE) and the University of Bergen (UiB) are partners. It will seek solutions for maximising value creation from petroleum production while realising the zero-emission goal. Projects will increase knowledge about the NCS and its subsurface for recovering new resources, converting to renewable energy, and storing CO_2. The Centre for Sustainable Subsurface Resources is led by Norce with the UiB as its main partner, and will contribute to greater reservoir understanding – including how these formations can be utilised in the green shift as well as digitalisation of their management.

- **Updated plan for Climit.**
  Climit, the national programme for research, development and demonstration of technology for CO_2 management, updated its plan in December 2021. This programme will help to realise three main goals – decarbonisation of industry and energy resources, large-scale carbon storage on the NCS, and innovative technology development and solutions for CO_2 management.[43] Among the most important updates in the plan are greater prioritisation of hydrogen production combined with CO_2 management, and an emphasis on supporting the realisation of gains from Longship.

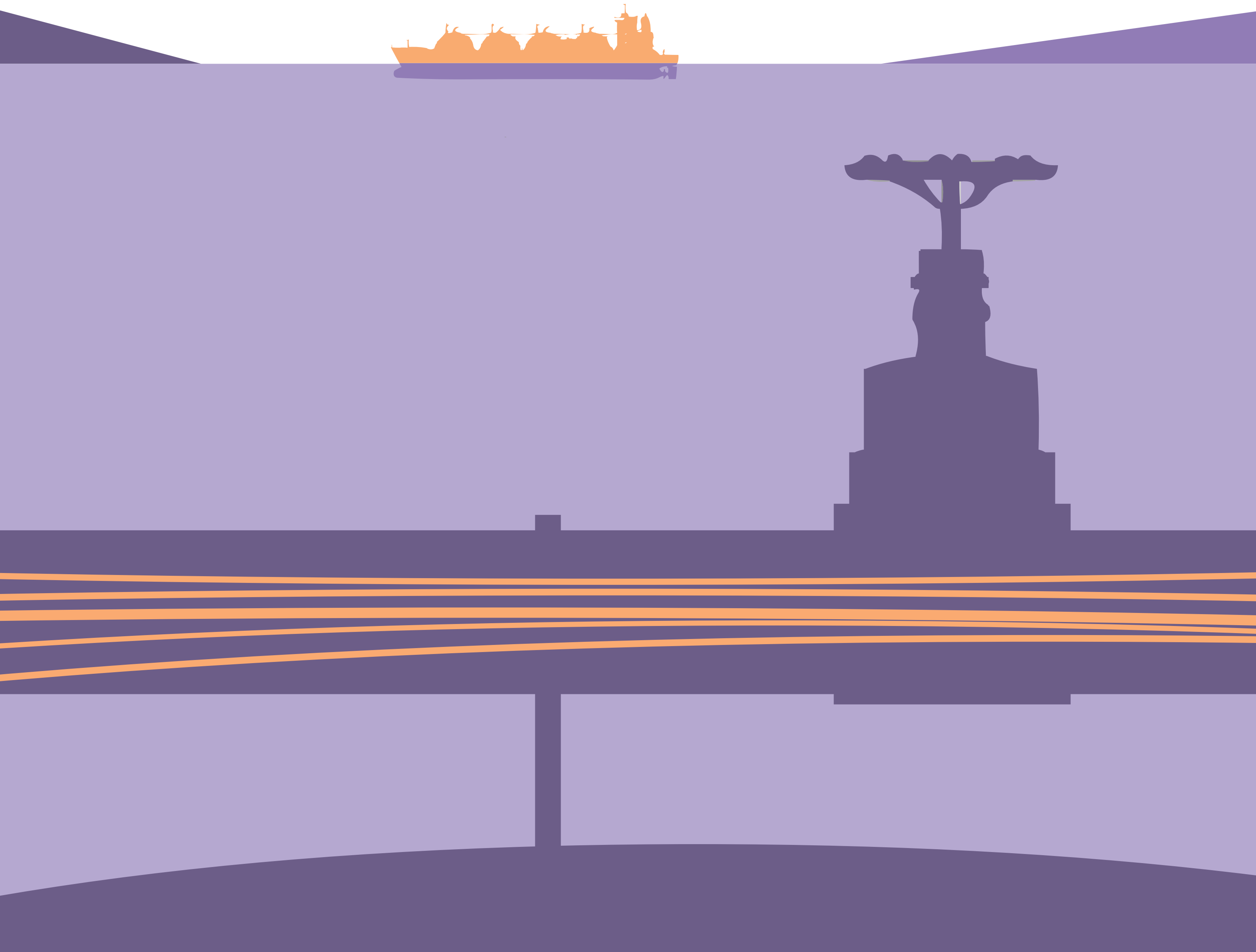
- **New OG21 strategy.**
  OG21 is the advisory body on strategy for the government's technology and research commitment in the petroleum industry. It unveiled a new strategy in November 2021, which highlights research, technology development and innovation in eight priority areas – improved subsurface understanding, cost-effective drilling as well as plugging and abandonment, utilising existing infrastructure, unmanned installations and subsea return solutions, energy efficiency and cost-effective electrification, CCS, world-leading HSE and the environment, and digitalisation.

- **New Maritime21 strategy.**
  Maritime21 is the advisory body on strategy for the government's research, development and innovation commitment in the maritime industry. It unveiled a new strategy in March 2022 which identifies three priority areas: low- and zero-emission technologies and solutions, Maritime 4.0, and green and safe maritime transport.

43 Climit (2021), Programme for Climit.

The Ocean Space Centre in Trondheim will play a central role in developing tomorrow's solutions for the NCS

Norway is well positioned to remain a long-term energy supplier. That makes continued exploration for and discovery of more natural gas on the NCS important

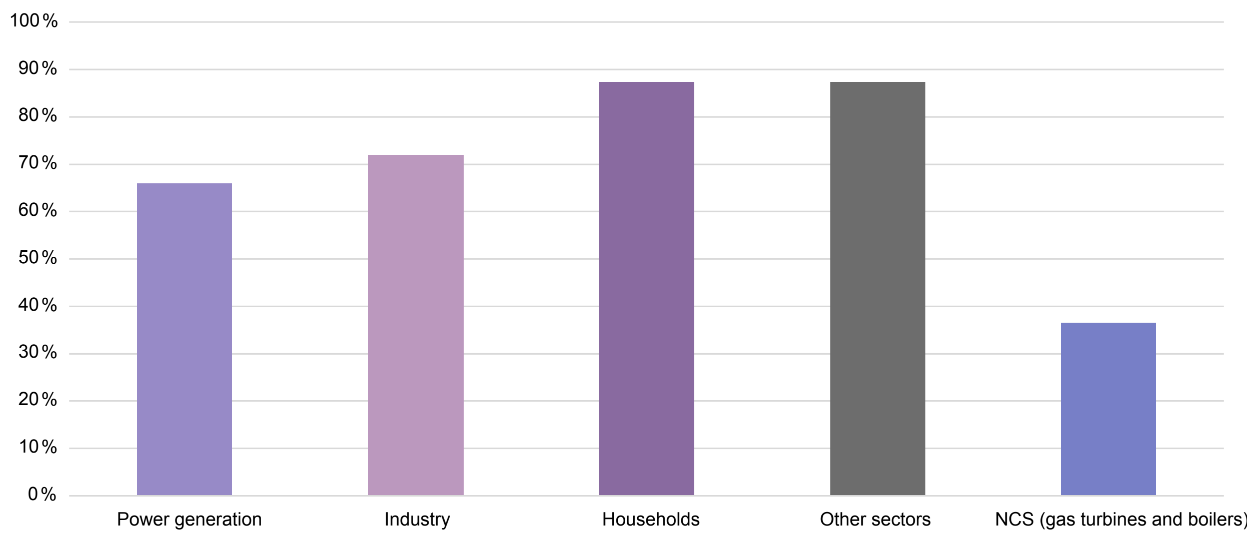


6

THE ROLE OF GAS

Norwegian natural gas is used more efficiently in end-user sectors, such as industry and households in Europe, and emissions per unit of power and heat are lower there than from gas turbines on the NCS. The European market for natural gas and LNG is growing. So is demand for Norwegian deliveries, partly because of the post-pandemic recovery in activity as well as a desire to reduce dependence on Russian imports in response to Russia's invasion of Ukraine in February 2022. Norwegian gas deliveries could also contribute in the longer term to decarbonisation, since production on the NCS has the world's lowest carbon footprint.

FIGURE 18 ESTIMATED AVERAGE TOTAL ENERGY EFFICIENCY FOR VARIOUS SECTORS USING NATURAL GAS IN EUROPE AND FOR GAS TURBINES ON THE NCS.



6.1 Gas is used more efficiently in Europe

Natural gas produced in Norway is primarily exported to continental Europe and the UK for use in a number of sectors, such as households, manufacturing and electricity generation. It also serves as a principal fuel for generating power on the NCS. However, offshore electrification can wholly or partly replace the use of natural gas on the installations. That frees this resource for export, so that more of Norway's gas production can be utilised elsewhere.

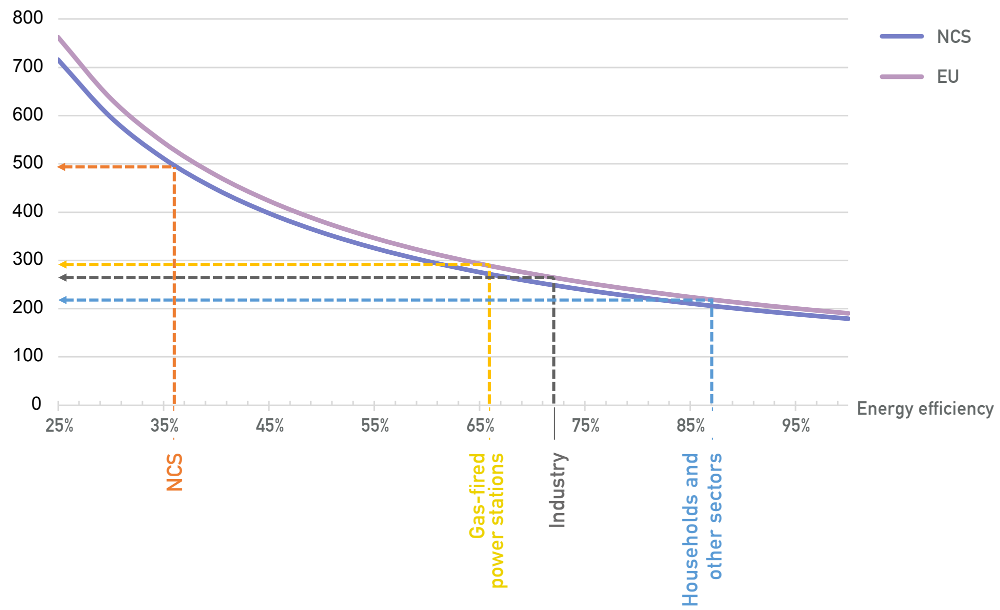
Considering various solutions from a system perspective is important when seeking to reduce global emissions of GHGs, such as CO_2. In discussing whether exports from the NCS are a more appropriate use of natural gas than fuelling turbines, the energy efficiency of these alternatives needs to be compared. Such a comparison looks at how large a proportion of the energy consumed has been utilised. A facility with low efficiency makes less effective use of the energy and releases relatively more CO_2 than one which operates more efficiently.

Endrava's calculations in its report on European gas use show that exports are by and large the more appropriate option.[44] Figure 18 shows that average energy efficiency is estimated to be 36 per cent on the NCS and 66 per cent in European power generation.

Even when losses and emissions along the value chain are taken into account, utilising natural gas in the EU and the UK is much more energy-efficient than on the NCS. Figure 19 shows that average GHG emissions from power generation on the NCS are 70 per cent higher per kWh than from a power station in the EU28, even allowing for emissions along the value chain. Compared with households and other sectors, emissions per kWh generated on the NCS are more than twice as high.

44 Endrava (2021). Bruk av gass i Europa. Commissioned by Offshore Norway.

FIGURE 19 EMISSIONS FROM GENERATING ONE KWH OF POWER AND HEAT ON THE NCS AND IN VARIOUS SECTORS IN THE EU28 (EMISSIONS IN THE VALUE CHAIN INCLUDED IN THE BLUE CURVE). (CO_2e/kWh power and heat)



6.2 Gas market in 2021 and natural gas in Europe towards 2035

An analysis of the gas market in 2021 and natural gas in Europe towards 2035 was conducted by Rystad Energy in 2022 for Offshore Norway. Understanding the big price surge in 2021 requires detailed knowledge of the global market for natural gas and other energy. Natural gas can be liquefied for shipment worldwide and, because any country can buy LNG, global prices for it will be relatively similar. Possible differentials largely reflect varying transport distances. As a marginal source of supply, LNG will largely determine local gas prices in markets dependent on importing it. Europe and Asia are the biggest importers.

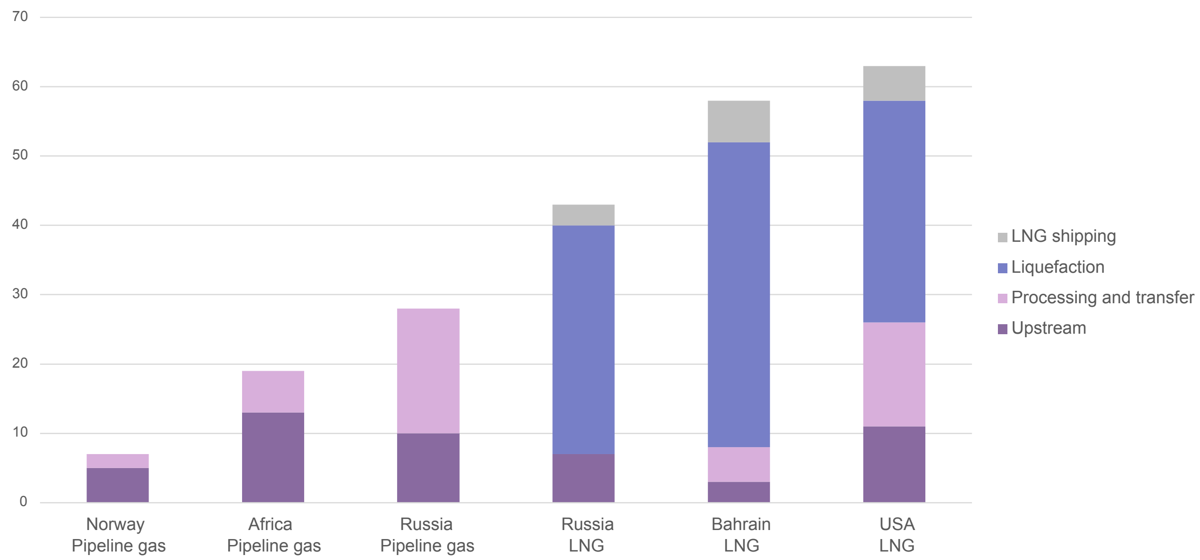
Because more production facilities than planned were shut down, LNG supply came under pressure in 2021. The demand side experienced an upturn as a result of increased energy utilisation in several parts of the world – including Asia and particularly China. European demand for natural gas rose from 2020 to 2021, driven particularly by higher consumption in the construction sector attributable partly to a cold winter in Europe. Russian pipeline deliveries in 2021 were down considerably from the year before. These factors meant that prices in the European gas market rose to levels never seen before, and the EU ran down gas stocks in an attempt to compensate for the increase. Since the publication of the Rystad analysis, the Russian invasion of Ukraine in February 2022 has drastically altered the outlook for Europe's gas market. The EU wants to reduce its dependence on Russian natural gas rapidly, in part through imports from other countries.

The pressure to decarbonise the gas sector is set to rise, partly because coal consumption will fall and gas will acquire a more central role in the energy mix. Such decarbonisation can be achieved either by offering consumers gas with lower emissions, or by capturing the CO_2 released at the consumer. Natural gas supplies can be decarbonised by replacing them with renewable or low-carbon gases.

Renewable gases include both biogas and hydrogen bearers such as H_2, NH_3 or CH_3OH produced from

FIGURE 20 UPSTREAM AND MIDSTREAM EMISSIONS FROM EUROPE'S COMPETING IMPORT SOURCES. (Kg CO_2e/boe)

Source: Rystad Energy



Norway has low emissions in part because of electrification and energy efficiency improvements.

Laying the Baltic Pipe pipeline. Photo: Baltic Pipe Project.

renewable energy sources. Green and blue hydrogen are regarded by the EU as renewable and low-carbon respectively. For some time, the EU has been pursuing an overall strategy of reducing GHG emissions through a range of initiatives. These have increased in number, scope and strength in recent years. The EU's goals are a 55 per cent reduction in total GHG emissions by 2030 compared with 1990 and carbon neutrality by 2050. Its green drive, Fit for 55 package, taxonomy for sustainable investment and REPowerEU are some examples of initiatives for reaching the climate targets.

Four key consequences of these ambitions will be significant for the gas market in coming years – reduced natural gas consumption, increased hydrogen production, higher carbon taxes and the possible inclusion of gas projects in the EU taxonomy.

Gas output has been declining in the EU and the UK in recent years, and this trend is expected to continue. Demand is also likely to be fairly stable in coming years, which will increase the need to import gas. Norwegian supplies enjoy very competitive terms compared with other European sources of gas imports, owing to low delivery costs and existing infrastructure. Pipeline deliveries from Norway also have the lowest emissions of all the regions selling gas to Europe. That reflects lower flaring, energy efficiency gains, low methane emissions and a high level of electrification in gas production on the NCS.

Distance and transport method are significant for emissions. Norwegian pipeline gas delivered to Europe releases seven kilograms of CO_2 per barrel of oil equivalent (boe) between reservoir and import terminal. The corresponding figures for Russian pipeline gas and LNG are 28 and 50-61 kilograms of CO_2 per boe respectively. Liquefaction and ship transport are the most important drivers for LNG. This means that pipeline gas will continue to be less emission-intensive, with transport distance as the most important driver of energy consumed and emissions. Norway is closer to Europe than the Russian fields, giving it a lasting advantage. Methane has not been included in the analysis, but the differences between the various sources are even more in Norway's favour if this is taken into account.

Even if all Norwegian gas were exported to continental Europe and the UK, additional imports from other sources would be required. A scenario which assumes that all gas consumption by the power generation sector ceases by 2035 still calls for annual EU gas imports to rise by 120 billion cubic metres – more than Norway exported in 2021. Even with drastic reductions in European gas demand, Norwegian pipeline gas will still be required.

The new Baltic Pipe facility for exporting Norwegian natural gas to Denmark and Poland will play an important role for the latter country in reaching its climate goals. By replacing coal, oil and wood for space heating, this project will help to reduce particulate emissions by 54 per cent. That could also help to reduce the negative effects of local air pollution on quality of life and expected longevity for several thousand Poles.

Exploiting Norwegian pipeline gas in combination with wind power will reduce annual CO_2 emissions in Poland by 70 million tonnes. That will make a substantial contribution to the Polish goal of reducing such emissions by 120 million tonnes in 2030. Gas from Norway can thereby play a significant role for countries like Poland in meeting their climate goals. The pipeline system also has the potential to transport biogas and hydrogen in the future.

While Europe is implementing its green shift, Norway will be a reliable and stable supplier of natural gas which helps other countries to move forward towards their climate goals. In the long term, Norway can also deliver decarbonised natural gas in the form of hydrogen through its existing pipeline system to Europe. This means the county is well positioned to remain a long-term energy supplier. That makes continued exploration for and discovery of more natural gas on the NCS important.

Norway delivered 113.2 billion cubic metres (bcm) of natural gas through its pipeline network in 2021, an increase of six bcm from 2020. These exports were worth NOK 475.8 billion in 2021, more than four times the figure for the year before and by far the highest ever.

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