THE ENERGY INDUSTRY OF TOMORROW ON THE NCS

CLIMATE STRATEGY TOWARDS 2030 AND 2050

STATUS REPORT 2023

KonKraft

KonKraft

ABOUT KONKRAFT

KonKraft is a collaboration arena for Offshore Norge, the Federation of Norwegian Industries (NI), the Norwegian Shipowners' Association (NSA), 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 · Fellesforbundet · INDUSTRI ENERGI

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50%

KonKraft remains committed to and is working towards attaining the more ambitious climate goal of cutting emissions by 50 per cent in 2030

SUMMARY

As Norway's largest industry, the oil and gas sector bears a great social responsibility. Its expertise and technological capabilities also provide an important basis for helping to reach the goals set in the Paris agreement.

Over the past year, the Norwegian petroleum industry increased its deliveries and contributed to strengthening energy security in Europe. The players in the sector are also building up new and forward-looking value chains for offshore wind power, hydrogen, and carbon capture and storage (CCS) which will ensure green jobs and the competitiveness of the NCS. This report provides a update for 2023 on the status of KonKraft's work to reach the ambitious goals specified by the climate strategy established in 2020.

Emissions remained stable in 2022 and the goal of a 50 per cent reduction by 2030 is still within reach

This year's forecast shows it is still possible to reduce emissions by 50 per cent in 2030, compared with 2005. Figure 1 illustrates that they can be reduced by 52 per cent to 6.5 million tonnes of CO_2 equivalent ($MtCO_2e$). Despite the Melkøya plant coming back on stream, emissions in 2022 were at roughly the same level as in 2021 – in other words, about 12 $MtCO_2e$. The resumption at Melkøya was offset in part by cuts from

FIGURE 01 UPDATED OPPORTUNITY SPACE AT 31 MARCH 2023
Emissions in $MtCO_2e/y$

Source:KonKraft

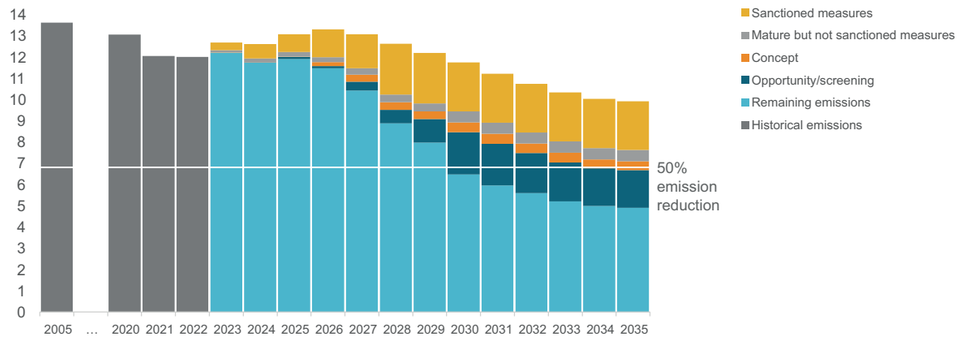


Figure: Updated opportunity space at 31 March 2023 with projections for emissions and the estimated effect of large sanctioned climate measures and measures under assessment. The projections also include planned new field developments, which means that the total effect of emission-reduction measures at the various levels of maturity varies somewhat over time.

the offshore installations, and emissions in 2022 were down by 11 per cent compared with the 2005 base year. Looking ahead, emissions are not expected to decline until after 2025 because of current developments coming on stream and continued operation of fields. They will then decline more rapidly as large projects with long planning horizons are brought into production. It takes time to realise electrification projects and see the benefit of continuous energy efficiency improvements, and the big reductions are expected to emerge gradually towards 2030.

Electrification with power from shore is the industry's most important climate measure, and predictable operating parameters are crucial for reaching the 2030 climate target

To meet the national climate goals in the most cost-effective way, electrifying parts of the NCS with power from shore will be unavoidable. A review of the effects on the power, gas and emission trading markets shows that a substantial global climate effect can be achieved by power-from-shore projects. Compared with electrification projects in land-based industry and the transport sector, many of the petroleum-industry projects are highly efficient in terms of power consumption (tonnes of CO_2 per megawatt-hour – tCO_2/MWh) and abatement cost (NOK/tCO_2). This year's status report shows that a 50-per-cent emission reduction by 2030 is still possible, but has become more demanding because of increased costs, pressure in the supplier market, a more difficult power-supply position, and challenges over sufficient grid capacity. Electrification of petroleum installations with power from shore is crucial for meeting the target.

Lead times for major emission-reducing measures, from identification to start-up, are close to six years. Implementing sufficient cuts by 2030 may be demanding, given higher inflation, pressure in the supplier market and inadequate development of new renewable power, unless support programmes are strengthened and both grid and generating capacity are increased. The industry needs predictability from the government if emissions are to be halved in 2030.

The government intends to establish climate partnerships as an instrument for securing the implementation of socioeconomically profitable measures in industry which help to meet Norway's climate goal. A letter of intent has been signed by the government and business organisations which makes provision for entering into sector-based climate partnerships. KonKraft believes the petroleum industry has good preconditions for fulfilling the principles underlying the letter of intent through its climate strategy and annual status reports, which document progress towards the goals, describe the measures being pursued at any given time by the companies, and identify how support programmes should be strengthened to reach the climate targets.

Emissions from offshore maritime operations are also in decline

Together with shipping companies and rig owners, the Norwegian oil and gas sector will be a driving force for ensuring that vessels delivering services to the NCS contribute actively to meeting the emission target in the government's action plan for green shipping. This seeks a 50 per cent cut by 2030 from domestic maritime transport and fishing. Players on the NCS are working actively to reduce emissions from the maritime sector by enhancing energy efficiency, optimising operations and implementing new technology. Many of them have set ambitious climate goals for their own operations, and have already achieved good results. In this year's report, real-time data have been acquired for the first time on emissions and the use of technology by the offshore ships. That provides a much better basis for measuring emissions from petroleum-related maritime operations on the NCS. This figure is estimated at 1.84 $MtC0_2e$ for 2022, down by 13 per cent from the 2008 base year. Not only are emissions lower in absolute terms, but offshore vessels also improved their emission intensity in 2019-22.

Projects in new value chains on the NCS are in the start phase, with a substantial potential towards 2035

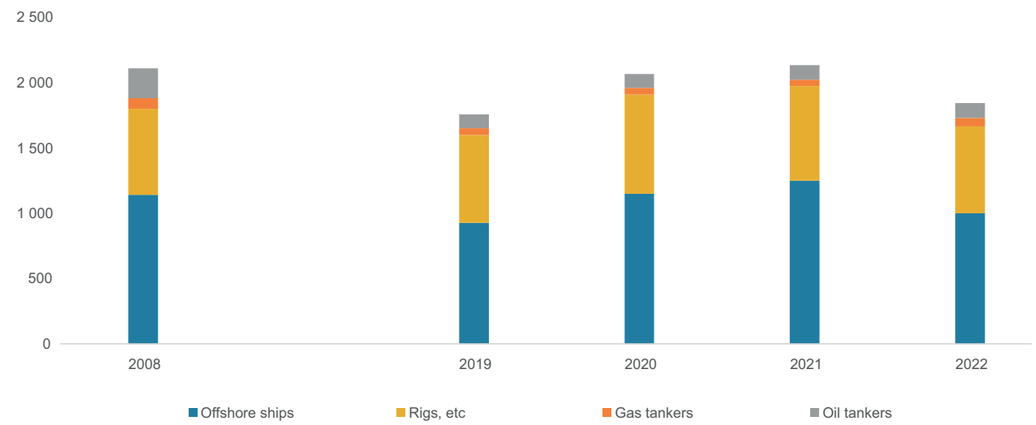
At the start of an adaptation phase, Norway's oil and gas industry is applying its expertise to developing new value chains on the NCS. To manifest the work initiated, KonKraft has extended the time frame for this year's status report to 2035 and acquired data from Offshore Norge's members on projects related to the expected development of large-scale hydrogen production and CO_2 storage capacity on the NCS. The forecasts are based on company assessments at 31 March 2023. Project volumes and time frames call for substantial investment, have long lead times and will probably change somewhat over time. Green industrial development on and in association with the NCS offers substantial potential and attracts much market interest. The Norwegian government entered into long-term and strategic collaborations with the EU and Germany during 2023 in such areas as hydrogen, offshore wind and CCS.

Plans for large-scale offshore wind development on the NCS are under way – to ensure further upscaling, new areas must be put on offer soon

Specific plans are being pursued for upscaling electricity generation from offshore wind on the NCS. Hywind Tampen, the world's largest floating offshore wind farm, became operational in November 2022 and will reduce annual emissions from Gullfaks and Snorre by 200 000 tCO_2e. The Southern North Sea II and Utsira North areas were put on offer in March 2023 for offshore wind development. These projects alone could generate more than 15 terawatt-hours (TWh) around 2030. In April 2023, the Norwegian Water Resources and Energy Directorate (NVE) presented a survey of 20 areas along Norway's entire coast which are relevant for further offshore wind developments. These will ensure that Norway reaches its goal of awarding acreage with the potential to generate 30 gigawatts (GW) of offshore wind by 2040. The NVE has also identified a potential for expanding capacity by up to 8.5 GW for Southern North Sea II and 750 MW for Utsira North. KonKraft has recommended that the government makes provision for developing two-three GW in offshore wind per annum during the 2030s and 2040s to ensure a rapid upscaling of the offshore wind commitment on the NCS.

FIGURE 02 GHG EMISSIONS 2008 AND 2019-22 FROM DOMESTIC OFFSHORE MARITIME TRAFFIC IN THE NORWEGIAN ECONOMIC ZONE (NEZ), 1 000 tCO_2

Source:VPS



Between 40 and 50 million tonnes of CO_2 could be stored beneath the NCS in 2030

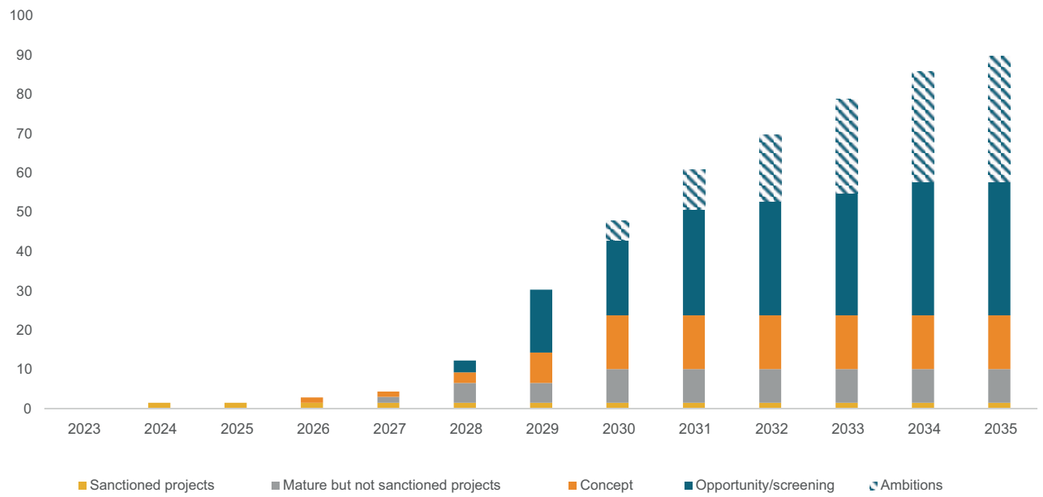
A number of players on the NCS are working to establish CO_2 storage as a separate business area, while European interest in this activity is growing. In the spring of 2023, the European Commission presented the Net Zero Industry Act for a new green industrial commitment, which identifies CCS as a strategic technology for achieving the EU's goal of net zero emissions. The Commission proposes setting a target of almost 50 $MtCO_2e$ in annual EU injection capacity by 2030. Several players on the NCS are currently in dialogue with European industrial enterprises and electricity generators investigating opportunities for storing their emissions on the NCS.

For the first time, KonKraft has produced an overview of the potential for annual CO_2 storage on the NCS. See figure 3. This shows a rapid escalation in capacity from 2026 and an overall storage potential of 40-50 million tonnes in 2030. Almost equalling Norway's total greenhouse gas (GHG) emissions, that figure is based on planned injection capacity related to the storage licences awarded and long-term ambitions. Northern Lights phase 1, the only NCS storage project currently sanctioned, will be able to receive and store 1.5 $MtCO_2e$ per annum by 2024. To realise the overall potential, it is important to establish competitive operational parameters quickly, with the necessary financial incentives.

A number of countries already have strategies, subsidies and incentives for CCS projects, including the USA with its Inflation Reduction Act (IRA), the EU through the Commission's Green Deal Industrial Plan, Canada, the Netherlands, Denmark and Sweden. In order to maintain Norway's international competitive edge in this area, the country must ensure that the gap between necessary investment in the CCS value chain and the carbon cost is closed so that new projects can be realised.

FIGURE 03 ANNUAL CO_2 STORAGE CAPACITY FOR NCS PROJECTS AT VARIOUS STAGES OF MATURITY
Million tCO_2/y

Source:KonKraft



Substantial upscaling potential for large-scale hydrogen in the early 2030s

Several large-scale hydrogen and ammonia production plants are planned in Norway, based in the first instance on natural gas with CCS. Project kick-offs for large-scale hydrogen output related to players on the NCS are in an early phase at present, and production volumes are not due to be scaled up until the early 2030s. KonKraft has produced its first production forecast for hydrogen, which shows that NCS-related output could exceed one million tonnes in 2031 and potentially double by 2035. Realising the identified potential will depend on establishing competitive operating parameters with the necessary risk reduction in Norway and Europe. Interest in Norwegian hydrogen exports is high. A strategic collaboration on climate, renewable energy and green industrial development was established by Norway and Germany in January 2023. That includes working together to secure the necessary infrastructure for supplying hydrogen from Norway to Germany on a large scale by 2030. Together with industry partners in Norway and Germany, Gassco is studying the technical and financial feasibility of large-scale transport of Norwegian hydrogen to German users.

Areas should be opened to prospect for seabed minerals

Increased supplies of minerals and metals are crucial to the green transition for reaching the global climate goals. A commitment to seabed minerals could potentially yield big value creation and new jobs, both through recovering these resources and for Norwegian industry to build on existing expertise from the supplier and maritime sectors. KonKraft supports the step-by-step approach planned for opening, seeking and possibly recovering seabed minerals.

The oil and gas industry is also working to map and reduce emissions in the value chain

KonKraft's climate strategy aims to reduce direct emissions from Norwegian oil and gas operations (scope 1), and to measure and report progress. At the same time, many operators are also increasingly reporting the indirect emissions which occur in other parts of their value chain (scopes 2 and 3[1]). Mapping and reporting indirect emissions could help to highlight the potential for reducing GHGs across players in the value chain, and emissions related to using oil and gas are an important indicator of adaptation risk. For the first time, the 2023 status report also includes a description of how the companies work to measure, report and reduce emissions in the value chain.

1 Scope 2 emissions relate to producing the energy used in a given activity – such as power generation for an industrial enterprise utilising electricity as an input factor. Scope 3 refers to other emissions in the value chain for a given product or service. These can occur either upstream or downstream. Where an industrial enterprise is concerned, scope-3 emissions will relate upstream to production, pre-processing and transport of an input factor, and downstream to use of the goods – in the consumer part of the chain, for example.

The Norwegian petroleum industry increased its deliveries over the past year to a Europe struggling with reduced gas imports from Russia

1

BACKGROUND

Norwegian gas deliveries to Europe increased in 2022 to the second highest level in the history of the NCS. Energy and climate collaboration with Europe was strengthened at both national and company levels, with several agreements related to new value chains such as hydrogen, CCS and offshore wind. KonKraft remains committed to and is working towards attaining the more ambitious climate goal of cutting emissions by 50 per cent in 2030.

1.1 The Norwegian oil and gas industry's climate goals remain unchanged

As Norway's largest industry, the oil and gas sector bears a great social responsibility. Its expertise and technological capabilities also provide an important basis for helping to reach the goals set in the Paris agreement. Over the past year, the Norwegian petroleum industry increased its deliveries to a Europe experiencing a big drop in gas imports from Russia. Norway's gas supplies to Europe in 2022 were up by eight per cent from the year before to the second highest level in the history of the NCS.[2] During the first three months of 2023, virtually all Norwegian petroleum deliveries went to European countries. While production has risen to meet increased demand, the oil and gas companies are due to halve their emissions in 2030 compared with 2005.

Norway's energy collaboration with the EU and European players has become closer and more important not only in the oil and gas sector, but also for new value chains such as offshore wind, CCS and hydrogen.

Norway and the EU issued a joint statement on closer energy collaboration in the summer of 2022,[3] followed by an agreement in April 2023 to establish a Green Alliance on the climate and implementing the green transition.[4] Agreements have also been signed by Norway with certain member states, including one in January 2023 on a strategic energy partnership with Germany in such areas as CCS, hydrogen and raw materials.[5]

At company level, closer ties are also being forged between Norwegian and European players, with plans announced for large-scale infrastructure and establishing new value chains across national frontiers. One example is Equinor and Wintershall Dea, which plan a pipeline between Norway and Germany able to transport 20-40 $MtCO_2e$ per annum from 2032 for storage beneath the NCS.[6]

2 Norwegian government (2022), *Updated estimate for Norwegian gas deliveries in 2022.*
3 European Commission (2022), *Joint EU-Norway statement on strengthening energy cooperation.*
4 Norwegian government (2023), *Norway and EU establish Green Alliance.*
5 Norwegian government (2023), *Joint Declaration – German-Norwegian Partnership on Climate, Renewable Energy and Green Industry.*
6 Wintershall Dea (2022), *Wintershall Dea and Equinor partner up for large-scale CCS value chain in the North Sea.*

1.2 KonKraft's original climate strategy and raising the emission target to a 50 per cent cut by 2030

The KonKraft partnership developed *The energy industry of tomorrow on t*he *Norwegian continental shelf. Climate strategy towards 2030 and 2050* in 2020, with the following targets.

- 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.

After KonKraft published its climate strategy in January 2020, the Storting (parliament) 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 reducing its GHG emissions by 50 per cent in 2030. KonKraft thereby assumes that emissions must be halved by that year. In addition to the goal of cutting emissions from its own operations, the Norwegian petroleum sector has ambitions of creating a new and forward-looking energy industry on the NCS which also helps other players to reduce the GHGs they release. The KonKraft partners want to develop new value chains for offshore wind, hydrogen, CCS and seabed minerals on the NCS. Predictable policies and operating parameters, collaboration with government and a strengthening of support programmes will be important for reaching the raised target and accelerating the development of renewable and low-emission value chains on the NCS.

Annual status reports provide an updated picture of the opportunity space for emission reductions and new value chains, based on planned projects by the players for offshore wind, CCS and hydrogen. This report is the third since the climate strategy was unveiled in 2020.

The report's time frame has been extended to 2035 because infrastructure planning and development as well as the establishment of the new value chains have long lead times. Results from a number projects now in an early phase will first emerge in the run-up to 2035. The goal of a 50 per cent emission reduction in 2030 is unchanged, but extending the time frame also manifests the potential for further emission reductions and realising of offshore wind, hydrogen and CCS projects after 2030.

Predictable policies and operating parameters, collaboration with government and a strengthening of support programmes will be important for reaching the raised target

While production is growing to meet increased demand, the oil and gas companies remain committed to the climate goals

2

STATUS AND PROGRESS FOR EMISSION REDUCTIONS IN 2023

This year's status report shows that it remains possible to cut emissions by 50 per cent in 2030, but that this has become more demanding. Electrifying oil and gas installations with power from shore is crucial for meeting the target.

This year's review of identified climate measures in the petroleum sector reveals a reduction potential of 5.3 $MtCO_2e$ in 2030, which corresponds to a 52 per cent decline from the 2005 level. Power from shore remains the measure which offers by far the biggest potential for emission cuts up to 2030, and has an overall reduction potential in the project portfolio of almost four $MtCO_2e$. A high level of activity, pressure in the supplier market, rising inflation and power supply issues are challenges the industry is encountering en route to realising the climate goal in 2030. Predictable parameters from and risk reduction by the government will be crucial for companies now set to make large, long-term climate investments which must also be financially viable in 2030.

Electrification of oil and gas installations with power from shore is crucial for meeting the target

2.1 Reduced emissions from petroleum operations on the NCS

To ensure good follow-up of the climate strategy, KonKraft produces an annual status report which presents progress towards the 2030 goal. This analyses the opportunity space across the operator companies on the basis of planned emission-reducing measures at various stages of maturity.

According to the opportunity space at 31 March 2023, Norway's oil and gas industry still has the potential to reduce emissions by 50 per cent in 2030 compared with the 2005 figure of 13.6 $MtCO_2e$. Reaching the climate target accordingly requires a cut to less than 6.8 $MtC0_2e$. Emissions in 2022 were 12 $MtC0_2e$ and, if no further climate measures are realised, will be at roughly the same level – 11.7 $MtCO_2e$ – in 2030.

The overall potential for emission-reducing measures is 5.3 $MtC0_2e$. Realising that whole amount would leave a residual 6.5 $MtCO_2e$, down by 52 per cent compared with the 2005 level. *Sanctioned* measures represent 2.3 $MtCO_2e$ of the overall potential. If these alone are realised, the petroleum sector's emissions would have declined by an estimated 29 per cent in 2030 compared with the 2005 level. If *mature but not sanctioned* measures – amounting to 0.8 $MtCO_2e$ – are also implemented, the cut achieved would be 35 per cent. To achieve the 50 per cent goal, it will be crucial to mature and sanction measures which are currently at an *opportunity/screening* or *concept* stage. Trends for emissions and the effect of possible reduction measures at various stages of maturity towards 2035 are presented in figure 4.

KonKraft's opportunity space and analysis are based on a review of all operators on the NCS in February 2023 and also takes account of the companies' climate goals, emission forecasts, reduction measures, planned new developments and cessation of existing fields. The figures cover overall emissions from operations on the NCS, from the processing plants at Kårstø, Kollsnes, Nyhamna and Melkøya, and from the Sture terminal.

FIGURE 04 UPDATED OPPORTUNITY SPACE AT 31 MARCH 2023
Emissions in $MtCO_2e/y$

Source:KonKraft

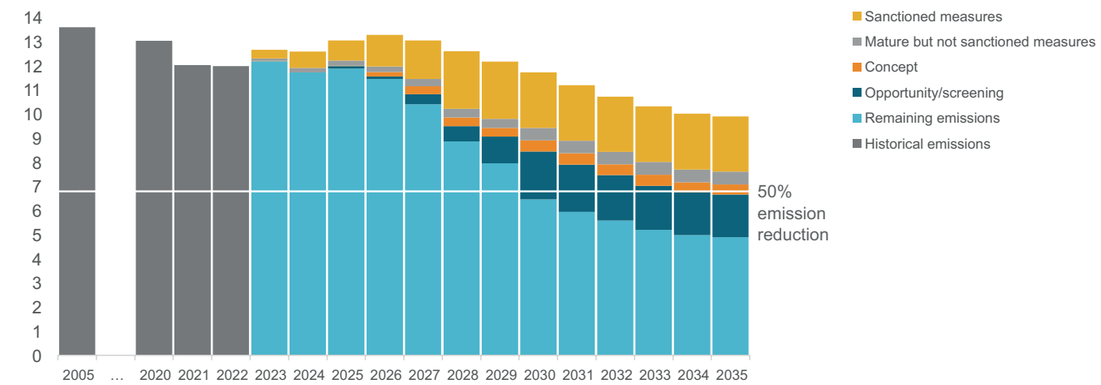


Figure: Updated opportunity space at 31 March 2023 with projections for emissions and the estimated effect of large sanctioned climate measures and measures under assessment. The projections also include planned new field developments, which means that the total effect of emission-reduction measures at the various levels of maturity varies somewhat over time.

Measures 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 preliminary decision on implementation
- opportunity/screening:
  opportunities for the measure are being developed and assessed at a preliminary level (great uncertainty).

Emissions from petroleum operations declined by almost eight per cent from 2020 to 2021, mainly because of the shutdown of the Melkøya plant in September 2020. This facility came back on stream in May 2022, but emissions remained at the same level as the year before and were offset by emission reductions from offshore facilities. Emissions are not expected to decline significantly until after 2025 as current developments come on stream. Sanctioned climate measures will nevertheless help to avoid a further rise in emissions, which would otherwise have increased to 13.3 $MtCO_2e$ in 2026. The companies are working systematically and continuously to identify emission-reducing measures.

Emissions will begin to decline considerably from 2026 as a number of climate measures come into effect.

Substantial and mature reduction measures planned towards 2030 include:

- electrification of Troll West from 2024, reducing emissions by more than 400 000 tCO_2e per year when reaching full effect in 2026.
- electrification of Oseberg, giving a reduction of 300-350 000 tCO_2e per year from 2026.
- electrification of Draugen, giving an annual reduction of 210-220 000 tCO_2e from the same year.
- electrification of Hammerfest LNG, cutting annual emissions by 850 000 tCO_2e from 2028.

Cessation of existing fields and installations in 2028-31 will also contribute substantial emission cuts. In addition, realising climate measures currently at the opportunity/screening stage or as yet unidentified could contribute substantial emission cuts towards the end of the 2020s.

A substantial proportion of the emission-reduction potential closer to 2030 lies in projects which are currently right at the start of the development trajectory – in other words, the opportunity/screening phase. Climate measures now at an early stage must secure sufficient emission cuts for the companies to meet their own climate goals and for ensuring attainment of the industry's reduction target of at least 50 per cent compared with 2005. Projects in the opportunity/screening phase will lay claim to substantial resources in the companies. Emission reductions between 2030 and 2035 are expected to derive primarily from planned cessations. This picture will change over time, and further measures after 2030 are expected to be included in future status reports.

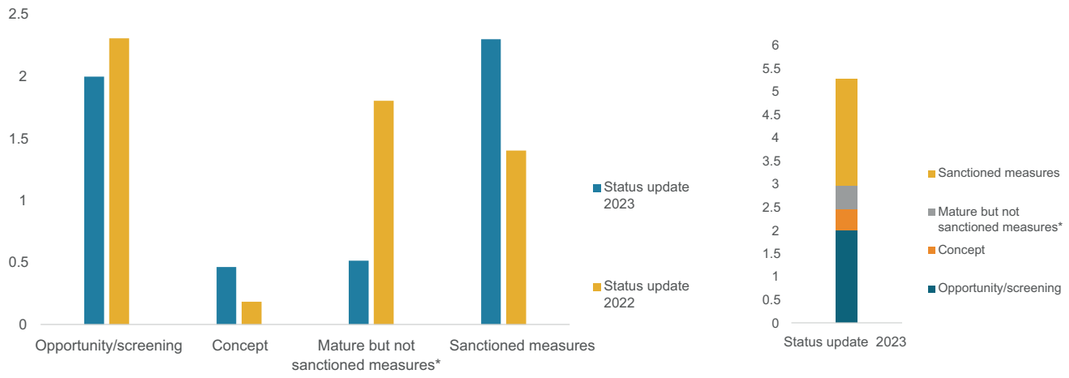
2.1.1 A number of mature measures have been sanctioned from 2022 to 2023

Figure 5 compares the overall emission-reduction potential of climate measures measured by level of maturity in this year's report with the 2022 status update. The biggest difference is that many measures have moved from mature but not sanctioned to sanctioned. A substantial reduction potential – almost two $MtCO_2e$ – remains at an opportunity/screening stage, while projects at the concept stage represent a small potential.

Expiry of the 31 December 2022 deadline in the temporary tax package probably helped to motivate, mature and sanction projects compared with last year's status review. Developing these climate projects has called for substantial resources – and will go on doing so – at the companies, which are now continuing to mature projects in the opportunity/screening phase which could yield emission reductions of almost two $MtCO_2e$ and ensure goal attainment in 2030. It takes about six years for major climate measures to move from feasibility studies (decision gate 1) to execution (DG4). A number of the measures required to meet the 2030 goal should therefore enter the choice of concept phase (pass DG1) in early 2024 if they are to be realised in time. The companies must thereby already identify project portfolios now which provide adequate and predictable emission reductions by 2030 from a technical, financial and climate-policy standpoint.

FIGURE 05 CHANGES IN MATURITY LEVEL FOR MEASURES IN THIS REPORT COMPARED WITH LAST YEAR'S STATUS UPDATE. $MtCO_2e$ in 2030.

Source:KonKraft



* Long-term work to improve energy efficiency is included in mature but not sanctioned measures.

2.1.2 Power from shore is by far the most important measure for meeting the industry's climate goal in 2030

Figure 6 presents the emission-reduction potential for various categories of measures. Power from shore is the one with by far the biggest potential to cut emissions in 2030, amounting overall to almost four $MtCO_2e$. Sanctioned projects account for almost half of this total. A substantial reduction potential of around 1.5 $MtCO_2e$ is offered by power-from-shore projects which need to be further matured in the opportunity/screening phase. The companies are experiencing growing uncertainty over new electrification projects as Norway's power surplus is reduced and pressure on grid capacity increases.

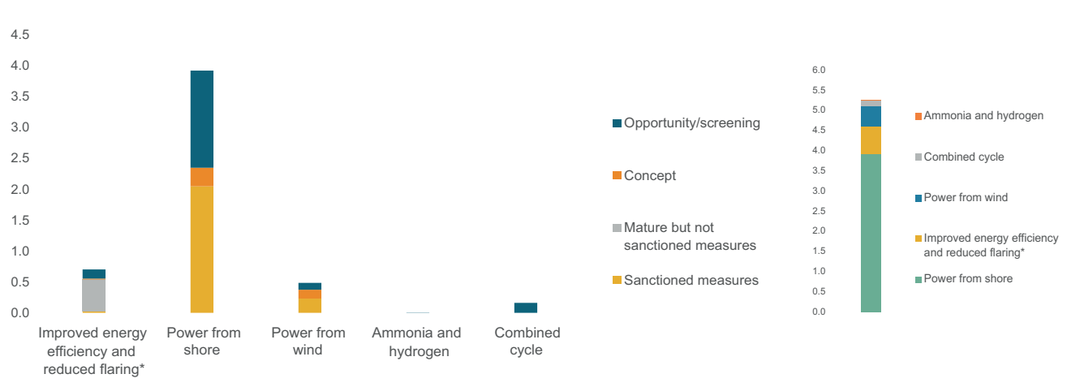
Enhanced energy efficiency and reduced flaring

After power from shore, enhancing energy efficiency and reducing flaring offer the biggest potential for emission reductions, at 700 000 tCO_2e by 2030. The bulk of this potential comprises mature but not sanctioned measures.

Enhancing energy efficiency through consolidation could be relevant at equipment level for installations on stream with, for example, production or power generation/consumption concentrated on fewer turbines. Consolidation at installation level could, for example, concentrate production from several fields at a single installation. This is relevant for new developments, where tie-in to existing installations consolidates production and improves capacity utilisation and energy efficiency.

FIGURE 06 CATEGORISATION OF CLIMATE MEASURES SANCTIONED AND MEASURES UNDER ASSESSMENT, EXPECTED EFFECT TO 2030. Abatement effect in $MtCO_2e$ in 2030.

Source:KonKraft



*Long-term work to improve energy efficiency is included in mature but not sanctioned measures.

Offshore wind power

Offshore wind facilities connected directly to NCS installations also represent a substantial source of potential emission reductions, at about 500 000 tCO_2e. Excluding Hywind Tampen, which is being implemented, this category comprises one or a few wind turbines tied back to an installation. With such solutions, gas turbines must be retained to ensure a stable power supply in calm conditions. While emission reductions are thereby restricted, this is regarded as a relevant climate measure for installations with a limited remaining commercial life.

Other measures

A new development in 2023 is the assessment of combined cycle systems for floating production, storage and offloading (FPSO) units, which are difficult to electrify. The reduction potential for 2030 is estimated at 160 000 tCO_2e. Utilising ammonia and hydrogen for gas-fired power turbines is also being assessed in this year's report for installations with a limited remaining commercial life. Such projects are at an early stage in maturity terms and have a limited reduction potential.

2.1.3 Reduced weight could contribute to more combined-cycle use on offshore installations

Most emissions on the NCS derive from power generation and gas compression offshore using gas turbines. Exploiting exhaust heat to drive a steam turbine in a gas-fired power plant will typically improve energy utilisation from 30 to 60 per cent. Such combined cycle facilities therefore reduce gas consumption and release less CO_2 than traditional gas-fired generation. The weight and size of combined cycle plants have constrained their use offshore, and they are confined to three NCS installations today.

Sintef's LowEmission Centre is working on compact and efficient combined cycle plants to reduce their weight and space limitations. This project on compact offshore steam bottoming cycles (Compacts) aims to cut weight by 50 per cent and reduce the footprint. These power plants can cut gas-turbine emissions by 25 per cent. High internal temperatures make their design challenging, but developments in Compacts include alternative heat exchangers and water treatment equipment. Greater use of aluminium in the framework will further reduce weight. Results so far show fuel cuts of 22 per cent in individual cases and weight reductions of 40-50 per cent for the whole unit, with the bulk of the saving coming from a lighter heat-recovery plant.

ConocoPhillips is among the companies which have provided operating data and examples of failure modes experienced. It has also contributed offshore measurements and analyses of thermal stress, integrity testing and fault-seeking. In addition, the company has made recommendations for good design solutions. In the next phase, Compacts Demo, a scaled-down pilot unit will be built and tested with smaller-diameter heat recovery piping. Process conditions, output and integrity will also be tested.

> Power from shore is by far the most important measure for meeting the industry's climate goal in 2030

2.1.4 Power turbines in dump lines

In collaboration with Framo, Neptune Energy is assessing the installation of a power turbine in a dump line for produced water discharged to the sea from the Gjøa semisubmersible platform. The power generated can then be used on board. According to the latest calculations, this could provide some eight GWh per annum, equivalent to the consumption of roughly 400 Norwegian households.

This technology is new and unproven offshore, and developing it could have a particularly positive climate effect if adopted on petroleum installations generating power from gas turbines.

2.1.5 Projects at Sintef's LowEmission Centre

Most of the operator companies on the NCS are partners in this Sintef facility, together with many suppliers and research institutes. It is now halfway through a programme period, and the Research Council of Norway has just decided to provide funding for the coming years.

The centre concentrates on such aspects as improving gas turbine efficiency, alternative fuels (hydrogen and ammonia), electrification, energy-efficient processing (subsea and topside), field solutions for reducing energy consumption and integrating renewable power, and low-emission logistics solutions. KonKraft believes this to be a good instrument, which can play an important role in meeting the petroleum sector's climate goals.

33
industry partners

2
research partners

316
mill NOK

8
years

Goal: Develop technologies and solutions for reducing GHG emissions on the NCS by 50 per cent in 2030 and moving towards zero emissions by 2050.

2.2 Electrification and power requirements

2.2.1 Updated forecast for power from shore to the NC

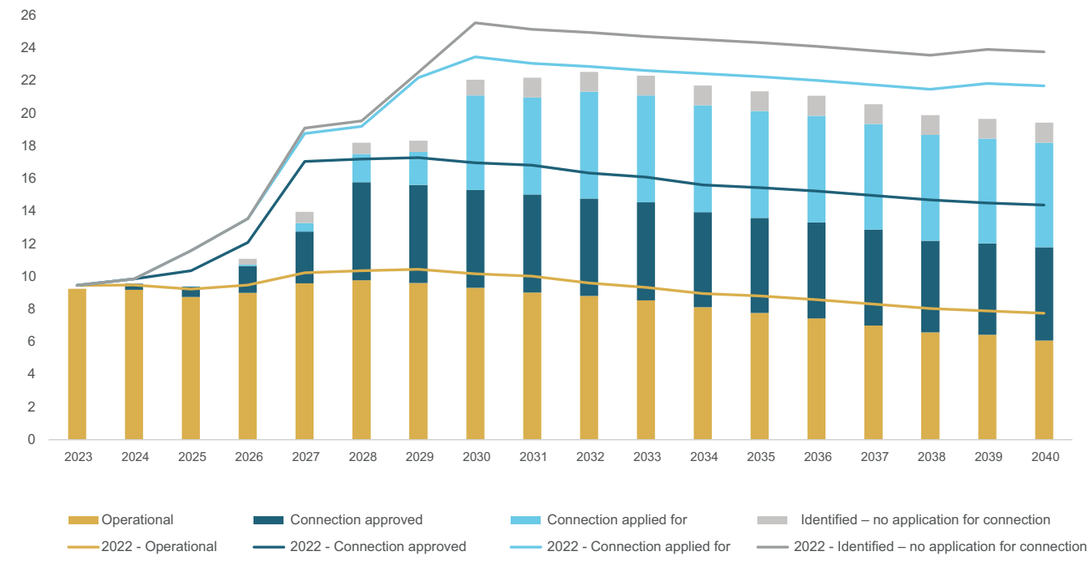
The updated forecast for power from shore to the NCS at 30 April 2023 shows that offshore electricity usage will rise substantially from 2026 to 2030 as more electrification projects are implemented. Furthermore, consumption will probably peak early in the 2030s, depending on which projects in the planning phase are implemented and when that might happen. Figure 7 presents this year's 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 in the process of being matured, and expectations for gas exports in the spring of 2023. It is based on expected power consumption by facilities broken down into the following categories: operational, connection approved, connection applied for, and identified – no application for connection. The gas processing plants at Nyhamna, Melkøya, Kårstø and Kollsnes are included in the forecast.

Compared with last year's forecast, power requirements from installations on stream have been downgraded by almost one TWh in 2030. Furthermore, expected consumption which has been allocated grid capacity in 2030 is down by almost two TWh. Reasons include the

FIGURE 07 FORECAST POWER REQUIREMENTS ON THE NCS
TWh

Source:Offshore Norge

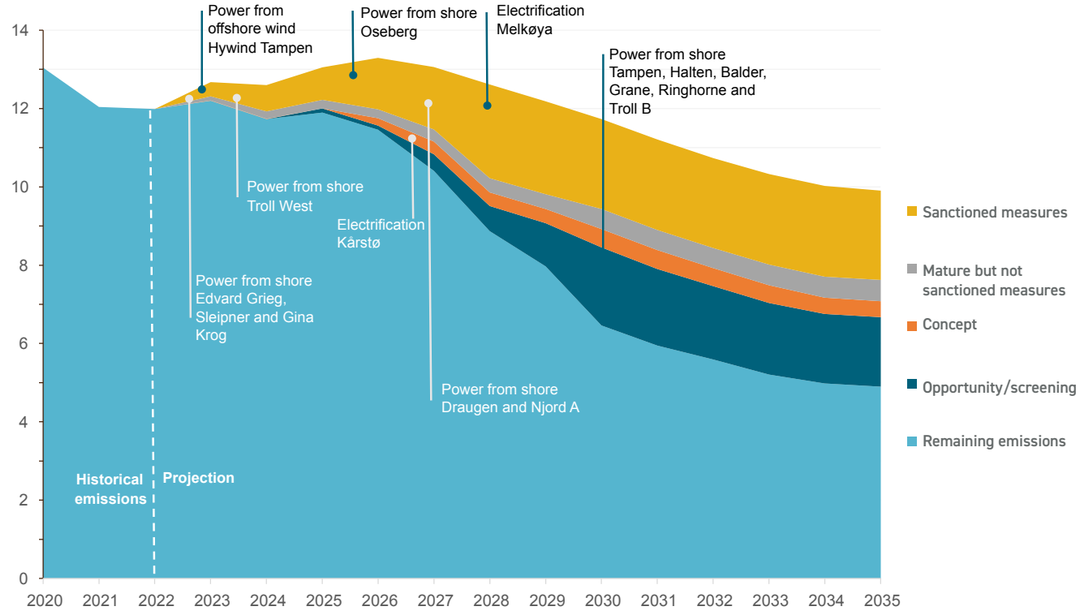


postponement of Wisting and Linnorm. Total electricity demand for installations on stream and those with connection approved in 2030 is estimated at 15 TWh. Power requirements for other electrification projects which have applied for connection or are identified but no connection has been sought could vary in line with project maturity, and uncertainty has increased about estimates further into the future.

The substantial growth in power requirements on the NCS up to 2030 relates to electrification projects intended to ensure sufficient emission cuts to reach the industry's target. Figure 8 presents the relationship between the increased power demand illustrated in figure 7 and the effect of electrification projects on the emission forecast. Higher demand in 2026, for example, can be linked to the electrification of Oseberg. Many similar projects which the industry wants to implement to meet the 2030 climate goal, including on Tampen, the Halten Bank, Grane, Ringhorne and Troll B, will also mean a substantial rise in power demand by that year. No electrification projects with power from shore are planned at present beyond 2030, and demand will accordingly decline gradually as production falls.

FIGURE 08 OVERVIEW OF VARIOUS ELECTRIFICATION MEASURES WITH SUBSTANTIAL EFFECT ON TOTAL GHG EMISSIONS. Million tCO_2e/y.

Source:Konkraft

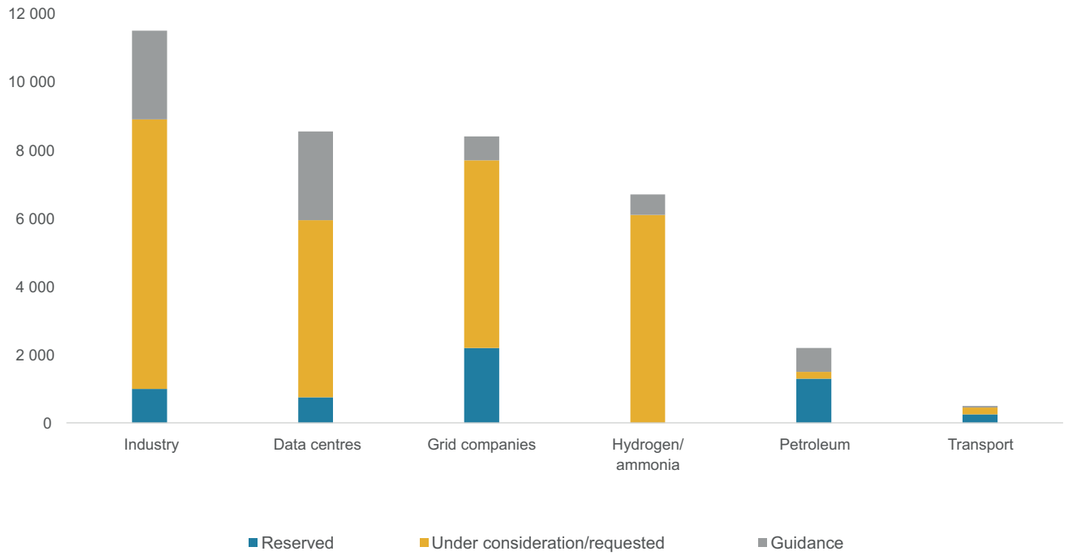


2.2.2 Electricity demand is rising in all sectors

Electrification in a number of sectors and ambitions to establish new power-intensive industries are leading to a big rise in Norwegian electricity demand. Figure 9 presents Statnett's collation of grid-connection requests by various sectors from the third quarter of 2022. This overview shows big demand from industry and new industrial enterprises such as data centres and the production of hydrogen and ammonia. Requirements for the petroleum sector are relatively small by comparison with other industries, and many of its electrification projects have been matured before connection is sought over a long period compared with applicants in other industries.

Norwegian power usage is set to rise in virtually all sectors. Figure 10 presents Statnett's base forecast,[7] which shows consumption growing from 140 TWh in 2022 to 178 TWh in 2030, and 220 TWh in 2050. Where the petroleum industry is concerned, the Statnett forecast accords with KonKraft's prediction that its power consumption could reach 20 TWh in 2030 but decline thereafter. Statnett assumes a rise of 10 TWh for transport and seven TWh for power-intensive industry by 2030, with further growth of nine and six TWh respectively to 2040. According to the base forecast, consumption by hydrogen production, data centres/batteries, transport and petroleum in 2040 will be at roughly the same level, with a requirement of 15-22 TWh.

FIGURE 09 STATUS OF CONSUMER APPLICATIONS FOR CONNECTION TO THE TRANSMISSION GRID AT 30 SEPTEMBER 2022 *Source:Statnett, 2023*
MW



7 Statnett (2023), *Langsiktig markedsanalyse Norge, Norden og Europa 2022-2050.*

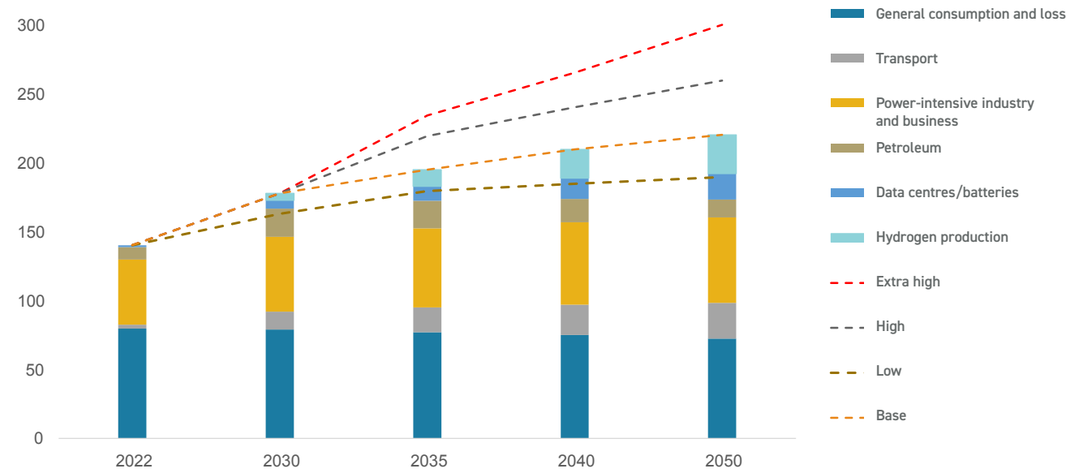
2.2.3 Electrification measures have a global climate effect and are crucial for reaching the industry's climate goal

The global emission effect of electrifying oil and gas installations in Norway has been a matter of dispute. Agreement has prevailed that Norwegian emissions must be reduced, but views have differed over the global effect of such cuts on the NCS. In a report for Offshore Norge published in January 2023, Thema Consulting Group concluded that such electrification not only reduces emissions from Norwegian petroleum installations but also cuts GHGs released in Europe and globally via effects in the electricity, gas and emission trading markets.

Increased power requirements for electrification projects will primarily be met by new generating capacity in Europe which, given climate-policy parameters and goals, release little or no GHGs. Emissions on the NCS and from petroleum plants on land are covered by the EU emission trading system (EU ETS). Overall, electrification projects cut European emissions because the surplus of ETS allowances grows and their price falls. That increases the likelihood of allowances being cancelled and a further contraction in the allowance cap. The most important global emission effect is that Norwegian pipeline gas displaces European imports of liquefied natural gas (LNG), whose climate footprint from production and transport is several times larger (Rystad Energy, 2021). Possible carbon leakage effects are small, and positive in any case.

Thema estimates a net fall in demand for ETS allowances of 78-87 per cent of the local emission reduction on the field, depending on the policy scenario. See figure 11. The net effect will depend in part on local factors, such as the installation's energy efficiency in the non-electrification alternative and energy losses in the offshore-to-land cable.

FIGURE 10 BASE CONSUMPTION FORECAST FOR NORWAY 2022-50 BY SECTOR *Source:Statnett, 2023*
TWh



KonKraft believes that establishing a CO_2 fund should form part of a climate partnership between the industry and the government

With a reduction potential of four $MtC0_2e$ in 2030, electrifying Norwegian offshore installations and petroleum plants on land accounts for almost 20 per cent of the total emission cut required to meet Norway's climate goal in that year. Failure to implement profitable electrification projects will make climate policy more expensive and the targets harder to reach.

Compared with electrification schemes to cut emissions in land-based industry and transport, many of the petroleum-sector projects are efficient in terms of both power consumption ($MtCO_2e$/MWh) and abatement cost (NOK/tCO_2). See figure 12 for a selection of electrification projects in the sector. Big variations in both power consumption and abatement cost exist between the various schemes. The profitability and efficiency of offshore electrification are lower for fields with a limited remaining commercial life, technical challenges, space restrictions or longer distance to land.

FIGURE 11 MODELLED EMISSION EFFECTS IN THE ETS SECTOR FROM ELECTRIFYING A SAMPLE FIELD

Uncertainty range for three different power market scenarios are shown hatched

Source:Thema

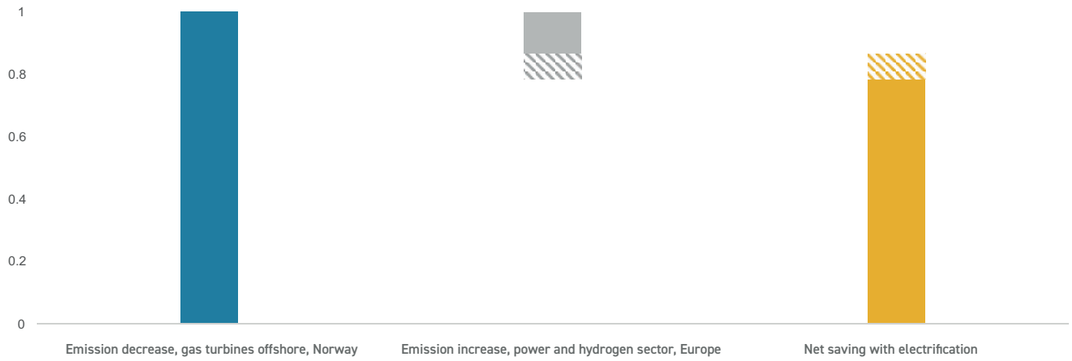
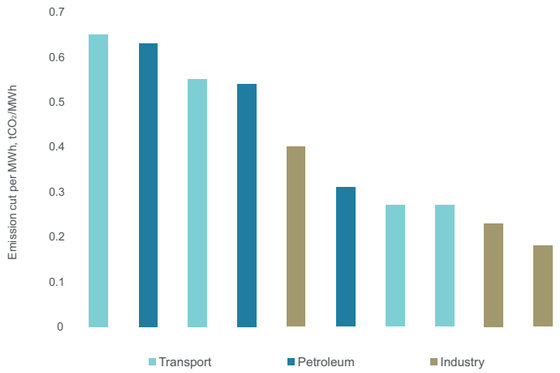
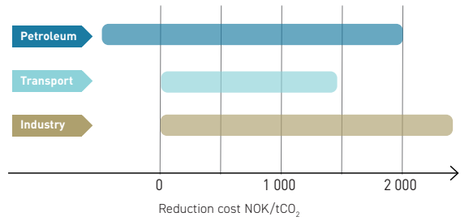


FIGURE 12 EMISSION REDUCTION PER UNIT OF POWER AND ABATEMENT COST FOR VARIOUS ELECTRIFICATION PROJECTS

Source:THEMA 2023



Emission reduction per unit of power and abatement cost for a sample of electrification projects either implemented or assessed in land-based industry, transport and petroleum.



2.3 Barriers and support programmes

2.3.1 Predictable operating parameters are crucial for realising the 2030 climate goal

Predictable operating parameters and strengthened support programmes are important for realising projects which halve petroleum-industry emissions by 2030. Over the past year in particular, the industry has been characterised by a high level of activity, pressure in the supplier market and rising inflation which make it more demanding to implement projects as planned. Lead times for large emission-reducing measures, from identification and start-up to completion, are almost six years. Electrification with power from shore is the most important climate measure for the companies, yielding big emission reductions and often being both commercially and socioeconomically profitable. However, one challenge is that increasing uncertainty has been created for power-from-shore projects by a more demanding electricity supply position, which has produced growing public and political opposition. Stable and predictable operating parameters are crucial for companies making large and long-term investment.

The coalition government's Hurdal platform specifies that electrification of oil and gas installations must be based as far as possible on offshore wind or other renewable power generated on the NCS, but offshore wind projects are very unlikely to become operational on a sufficient scale to meet the industry's climate goals in 2030.

Predictability for and strengthening of the Business Fund for Nitrogen Oxides and Enova are also important for the industry. The support period for the NO_x fund was extended last year from 2025 to 2027, but its continued maintenance thereafter is unclear. That contributes to uncertainty in project planning at the companies. Extending the support period by longer intervals is recommended in order to ensure predictability. Projects which reduce NO_x emissions often also help to cut the amount of CO_2 released.

Enova is currently unable to support measures which cut emissions in sectors subject to the EU ETS, except for cases with a large innovation content. This support programme is important for reducing risk and implementing measures which do not lead directly to increased production.

KonKraft believes that Enova should be able to help realise measures which also yield emission cuts in the EU ETS sector on the basis of existing technology, in order to reduce risk and costs for strategically sensible and qualified technology with a potential to be disseminated, but which is currently too expensive for individual companies to take on. Such schemes should be organised so that Enova can provide support beyond the demonstration of an initial facility. This means low and zero-emission technology which can help to trigger emission-reducing measures in the industry should also be able to receive implementation support.

2.3.2 Climate partnership with government

In its Hurdal platform, the government commits to making Norway a driver for a more ambitious international climate policy with the aim of restricting global warming to 1.5°C above pre-industrial times. The overall aim of establishing climate partnerships as an instrument is to ensure business implementation of socioeconomically profitable measures which help to cut GHG emissions in line with Norway's climate goals for 2030 and 2050 and the government's target for adapting the whole national economy.

KonKraft takes the view that the petroleum sector currently fulfils the principles which form the basis for entering into climate-partner agreements through its work on the climate strategy and the annual status reports produced. The latter document the industry's progress towards this goal and describe the measures being pursued at any time by the companies to realise the climate targets.

When KonKraft adopted its climate strategy in 2020, the goal for 2030 was a 40 per cent reduction to be achieved within the framework of the existing support programmes. The strategy noted that a CO_2 fund could contribute to further cuts, and referred to the good experience with the NO_x fund. When the Storting, in connection with the temporary changes to the petroleum tax regime, raised the climate goal for 2030 to 50 per cent, KonKraft's 2021 status report concluded that this was possible, but would be much more technically complex and demand significantly higher investment. In its 2022 report, KonKraft showed that it would be possible to halve emissions by 2030, but emphasised the significance of creating a CO_2 fund for GHG reductions on the NCS.

KonKraft has worked to promote such a fund as an important source of support for the industry, not only in realising emission cuts but also in scaling up new value chains. In its view, establishing a CO_2 fund should form part of a climate partnership between the petroleum industry and the government.

> KonKraft believes that establishing a CO_2 fund should form part of a climate partnership between the industry and the government

Maritime offshore activity contributes actively to meeting the emission target in the government's action plan for green shipping

3

REDUCED EMISSIONS FROM MARITIME OPERATIONS

The players on the NCS are working actively to cut emissions from maritime operations by improving energy efficiency, optimising operations and adopting new technologies. Many companies have set ambitious climate goals related to their own business, and have already achieved good results. This year's report is the first to present detailed real-time data for emissions and technology utilisation on the offshore vessels – a significant improvement. Emissions from maritime operations are estimated at 1.84 $MtCO_2e$.

3.1 Emission goal for maritime operations

The Norwegian government's action plan for green shipping has set a 50 per cent reduction in emissions by 2030 as the target for domestic maritime transport and fishing, which includes activities in the petroleum sector. In 2020, the NSA also introduced its own climate goals for 2030 and 2050.[8]

Konkraft's climate strategy commits the Norwegian oil and gas industry, including ship and rig owners, to making active efforts to ensure that vessel categories involved in offshore maritime operations contribute to achieving the government goal specified above.

3.2 Real-time data give new insights into emissions from maritime operations

In the 2022 status report, the KonKraft partners described the difficulties faced in estimating maritime emissions. Producing estimates for historical emissions in the 2008 reference year presents a challenge for the whole shipping industry, and was calculated to be 2.1 $MtCO_2e$. That is still considered the best available approximation for historical emissions.

Emission estimates in earlier status reports (2020-22) were based on automatic identification system (AIS) data for vessel movements and ship information about installed engine output and design speed. This method provided a relatively good first approximation for total emissions, but failed to capture the effect of measures to enhance energy efficiency or the actual operating profile. Its findings were also considered too uncertain for use in analysing changes from year to year, and the method is inappropriate on its own for effectively measuring real progress towards 2030.

8 Norwegian Shipowners´ Association, *Klimastrategi* (2020).

This year's status report presents new estimates, including for 2019-21, based on real-time monitoring in the offshore fleet. These figures provide greater precision about overall emissions and, even more importantly, insights into operating patterns and actual use of measures to improve energy efficiency, such as the use of onshore power supply (OPS).

3.3 Status and prospects for emission reductions

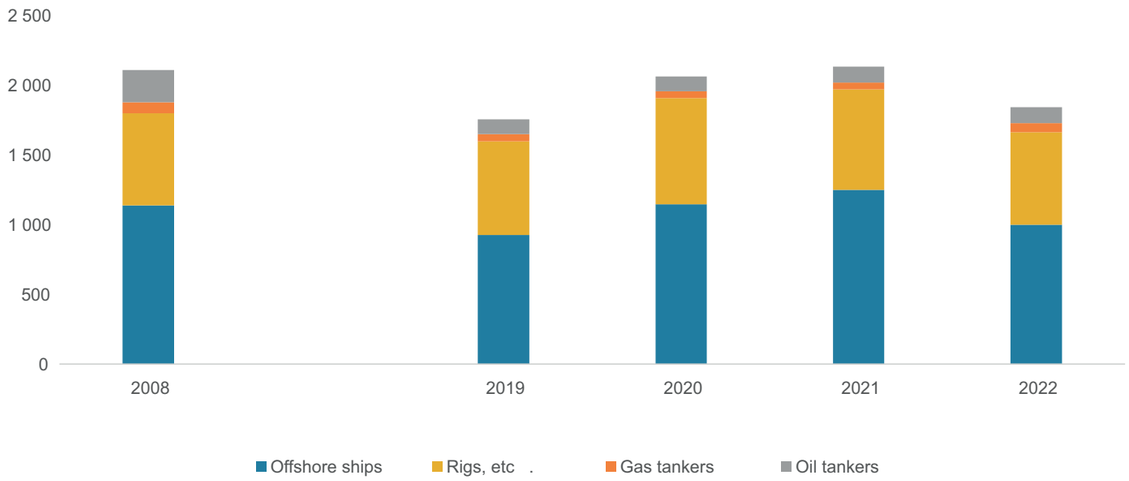
Figure 13 presents estimated CO_2 emissions from domestic maritime activities[9] related to Norway's oil and gas sector for the 2008 reference year and 2019-22. Overall emissions declined from 2.1 $MtC0_2e$ in 2008 to 1.76 $MtCO_2e$ in 2019 before rising again to about the 2008 level and then falling to 1.84 $MtCO_2e$ in 2022.

That corresponds to a 13 per cent reduction from 2008. Offshore supply ships and rigs accounted for the bulk of emissions in every year.

Figure 14 presents the development of annual domestic emissions in the Norwegian economic zone (NEZ) from vessel segments in the 2008 reference year and 2019-22. The offshore ship and oil tanker segments, in particular, showed substantial CO_2 reductions of 140 000 and 117 000 tonnes respectively in relation to 2008. Rig emissions were virtually unchanged in 2022, while gas tankers recorded a small decline.

FIGURE 13 GHG EMISSIONS 2008 AND 2019-22 FROM DOMESTIC OFFSHORE MARITIME TRAFFIC IN THE NEZ. CO_2 emissions in 1 000 tonnes.

Sources: VPS, DNV og Footprint[10]

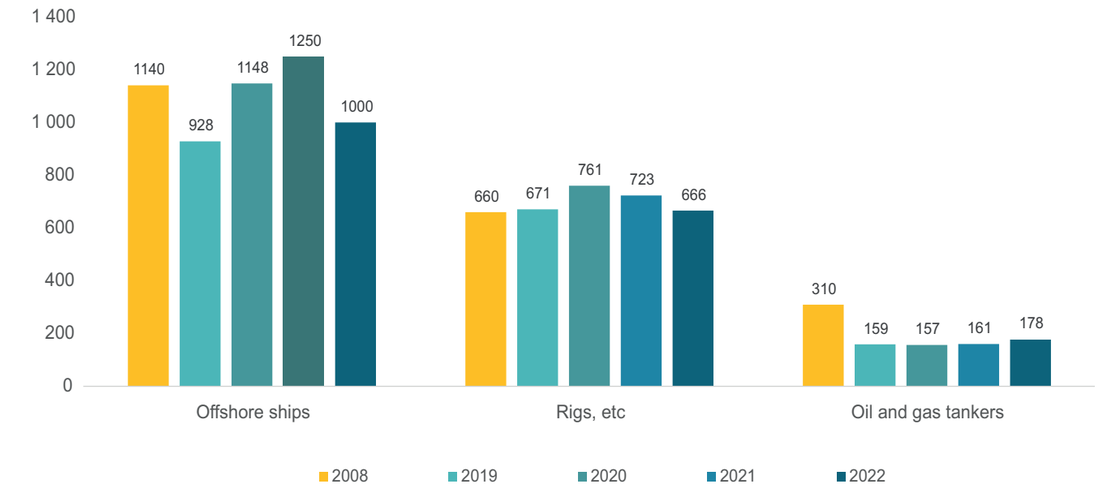


9 Domestic maritime activities related to Norwegian petroleum operations are defined as traffic between ports in Norway and/or installations on the NCS. They thereby include sailings between ports in Norway, between offshore installations, between ports and installations, and time spent in port or at installations.

10 Data related to offshore ships have been provided by VPS, DNV has supplied estimates for oil and gas tankers, and the rig data come from the Footprint emission database.

FIGURE 14 DEVELOPMENT IN ABSOLUTE EMISSIONS PER VESSEL SEGMENT (DOMESTIC EMISSIONS IN NEZ)
1 000 tCO_2

Source:Konkraft



3.4 In depth – emissions from and activity by offshore ships

Offshore ships account for more than half the overall emissions from the petroleum-related maritime sector. An analysis by VPS provides increased insights into activity and emissions from this segment.[11]

3.4.1 Three sub-groups of offshore ships

A new element in this year's report is that emissions from the offshore ships can be broken down into three sub-groups:

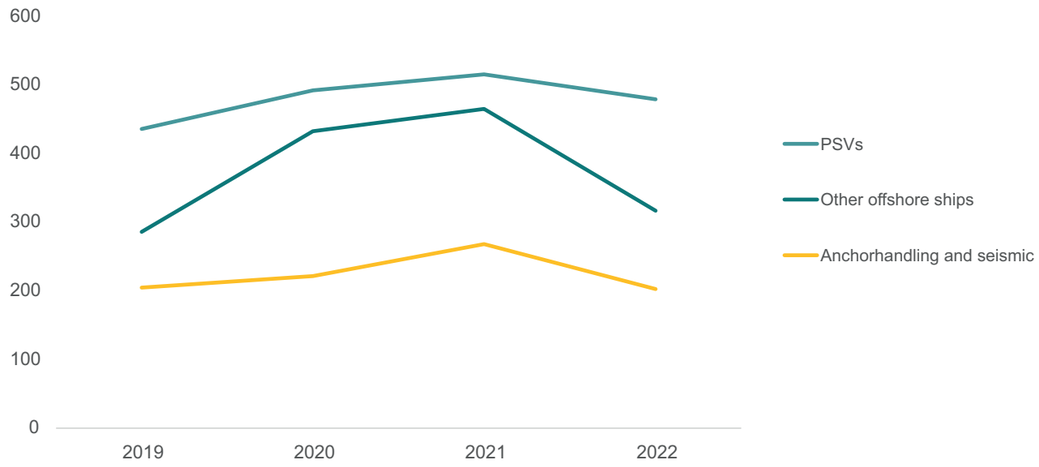
- anchorhandling and seismic survey ships
- platform supply ships (PSVs)
- other – including construction support vessels, standby ships, cable-layers and well intervention vessels.

Emissions from the offshore ship segment vary from year to year with the level of activity. This covariation emerges clearly from figure 16, which presents operating hours and emissions for domestic offshore ships in 2019-22.

The level of activity also varies a great deal for each sub-group from year to year. Figure 17 presents annual operating hours for the three sub-groups in 2019-22. Among other factors, both the anchorhandler and seismic survey vessels and other offshore ships enjoyed far higher levels of activity in the NEZ during 2020-21 than in 2019 and 2022.

FIGURE 15 DEVELOPMENT IN EMISSIONS PER SUB-GROUP FOR OFFSHORE SHIPS 2019-22
1 000 tCO_2

Source:VPS



11 VPS (2023) - *CO_2 emissions estimate for maritime activity related to Norwegian oil and gas operations, within the Norwegian Economic Zone (NØS) 2019-2022.*

FIGURE 16 OPERATING HOURS AND EMISSIONS FROM OFFSHORE SHIPS 2019-22
1 000 tCO_2/1 000 operating hours

Source:VPS

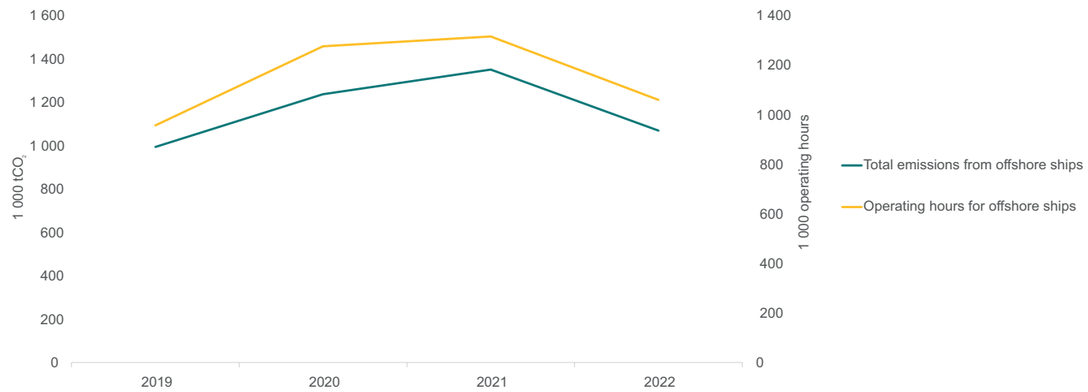
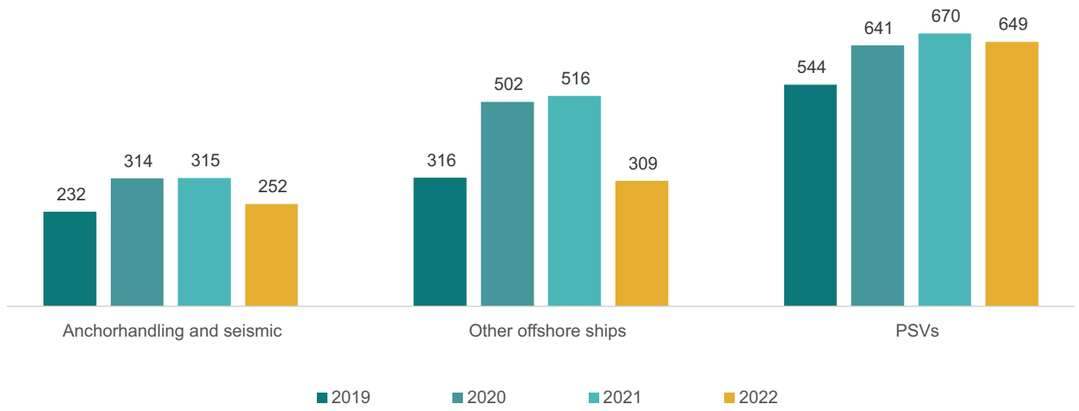


FIGURE 17 OPERATING HOURS PER OFFSHORE SHIP SUB-GROUP 2019-22
1 000 hours

Source:VPS



3.4.2 Emission intensity has declined for offshore ships

Total emissions vary with the level of activity, and the VPS analysis of the offshore ships shows that their emission intensity (emissions per hour) fell in 2019-22 for all three sub-groups and in each of the four operating modes.

Figure 19 presents a breakdown of how ships spend their time and where emissions take place. While the offshore fleet spends about 40 per cent of its time in port, almost 50 per cent of emissions occur during transit. This distribution was more or less constant in 2019-22.

FIGURE 18 EMISSION INTENSITY FOR OFFSHORE SHIPS 2019-22
Per cent of CO_2/h in 2019

Source:VPS

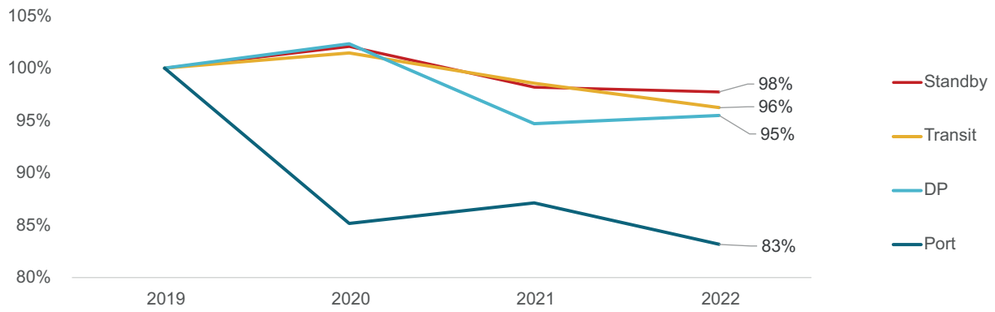
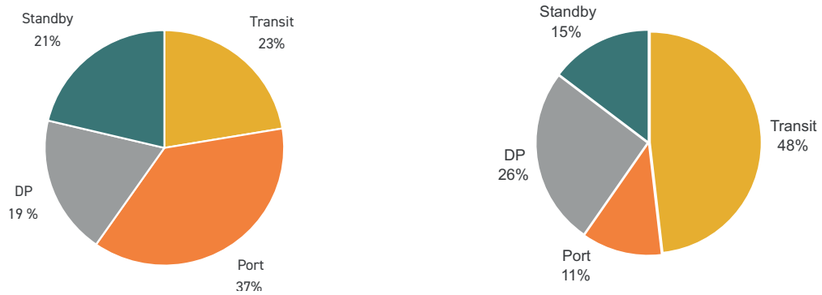


FIGURE 19 DISTRIBUTION OF HOURS AND EMISSIONS
BETWEEN THE FOUR OPERATING MODES FOR OFFSHORE SHIPS

Source:VPS



Proportion of operating hours for offshore ships 2022

Proportion of emissions for offshore ships 2022

3.4.3 Measures for reducing emissions from the offshore fleet

Onshore power supply (OPS)

Utilisation of OPS by the offshore fleet increased substantially in 2019-22. Based on information from the approximately 500 vessels in the VPS Maress database, usage rose from two per cent in 2019 to 35 per cent in 2022. Figure 20 presents this trend. The VPS analysis shows that ships connecting to OPS increased their use of this electricity source from 20 per cent of their time in port to 80 per cent in 2019-22.

Figure 21 presents hours using shore power and associated electricity consumption for offshore ships in 2019-22. While the time rose from 53 000 hours to 236 000 over the four years, usage increased from two GWh to 27. During the same period, emissions during port stays declined by 17 per cent.

FIGURE 20 HOURS USING OPS AS PROPORTION OF TOTAL PORT TIME IN 2019 AND 2022
FOR A SELECTION OF NORWEGIAN PORTS

Source:VPS

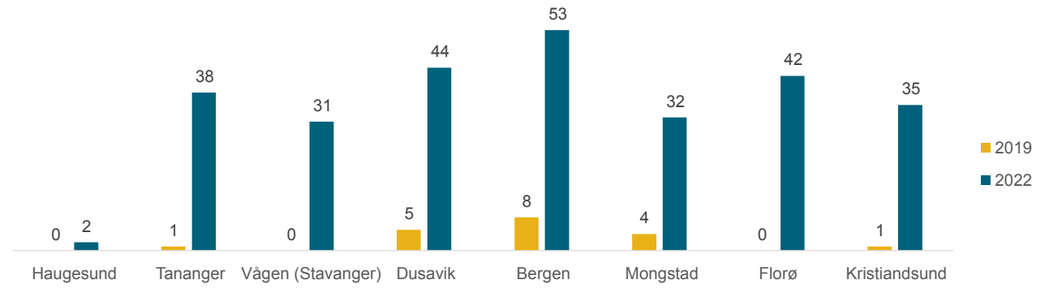
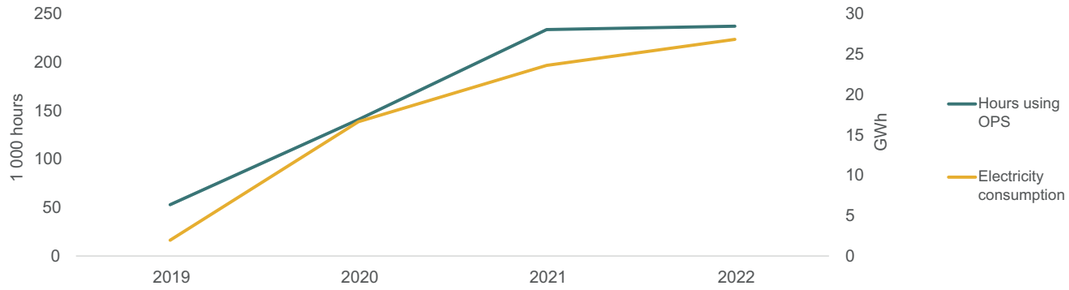


FIGURE 21 USE OF OPS BY OFFSHORE SHIPS
1 000 hours/GWh

Source:VPS

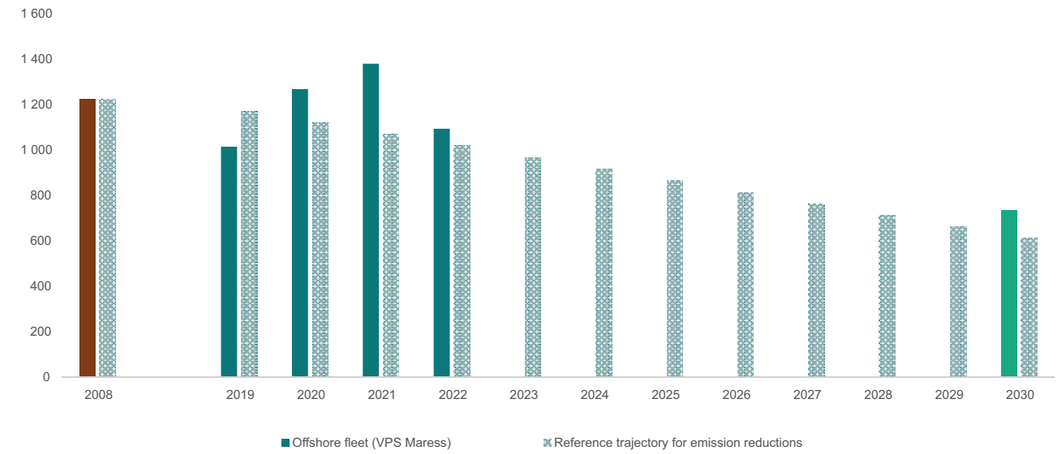


Batteries

The Norwegian offshore fleet is the world leader for installing batteries, allowing some vessels to cut fuel consumption by up to 25 per cent. On average, however, a VPS analysis shows that the improvement achieved after battery installation is only seven per cent – well below the design target of 14-18 per cent. Better routines and use of analysis tools could help to release further potential.

FIGURE 22 VPS ESTIMATE OF OVERALL REDUCTION POTENTIAL FOR OFFSHORE SHIPS BY 2030
CO_2 emissions in tonnes

Source:VPS



Assessment of further reduction potential

VPS estimates a total reduction potential for the offshore fleet of 40 per cent in 2030 from operational measures (such as speed and route optimisation) as well as by using shore power and batteries. This potential varies between operating modes, from 100 per cent for time in port, 70 per cent for standby ships, 30 per cent for dynamic positioning (DP) and 20 per cent for transit. Viewed overall, realising this potential could cut offshore ship emissions by 40 per cent in 2030.

Figure 22 illustrates a possible reference trajectory for GHG emissions from the offshore ships. Further reductions can be achieved by using alternative fuels once these are available, and by phasing in more energy-efficient ship designs.

Alternative fuels

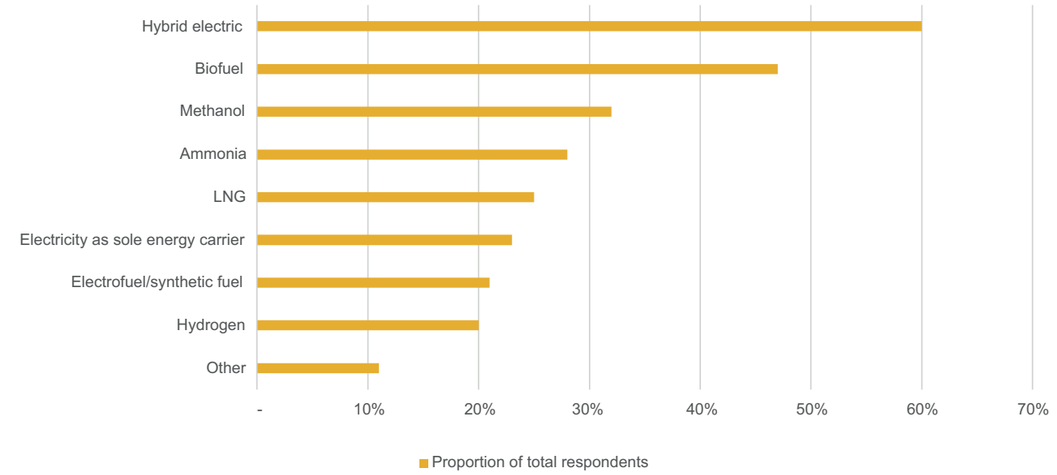
The NSA's annual member survey identifies the types of fuels and energy carriers which shipowners are thinking of adopting to meet their climate goals. Figure 23 presents the figures from the 2023 survey. Rankings given by companies in offshore shipping are the same as in other trades, but they regard hybrid electricity as even more relevant than the average respondent – at close to 80 per cent. The ammonia and biofuel categories have increased the most over the past four years.

Newbuilding and replacing old ships

The offshore fleet on the NCS is getting steadily older, and the climate potential from greater energy efficiency and converting to alternative fuels in an ageing fleet will be limited. Newbuilds with zero-emission technology and an energy-efficient design will therefore be relevant in the years up to 2030.

FIGURE 23 FUEL TYPES AND ENERGY CARRIERS BEING CONSIDERED BY SHIPPING COMPANIES TO CUT GHG EMISSIONS BY 50% IN 2030

Source:Norwegian Shipowners Association member surveys (2020-23)



Norwegian shipping companies plan to order 215 new ships over the next five years, with growth in such intentions particularly strong for offshore service. From 25 vessels in 2020, this segment now has plans to build 84 – a large proportion of them for the offshore wind industry. Nine of 10 companies report that they will equip the ships with climate-neutral technology.

VPS estimates a total reduction potential for the offshore fleet of 40 per cent in 2030 from operational measures (such as speed and route optimisation) as well as by using shore power and batteries

Solstad

Installing battery and charging system

Upgrading Solstad's *Normand Ocean* has cut its fuel consumption by 25 per cent after installing a battery and charging system. The company has also installed battery hybrid solutions in nine PSVs.

Eidesvik

First offshore ship to run on ammonia

Supply ship *Viking Energy* will be converted to run for long distances on green ammonia. The EU has awarded NOK 100 million to the project, which will pave the way to zero-emission vessels. Owned and operated by Eidesvik, *Viking Energy* will continue to ship supplies to Equinor's installations after the conversion.

Eidesvik first installed propulsion systems based on LNG a number of years ago. In recent years, the company has invested in battery packs for a number of its ships.

Island Offshore

Supply ship running on biogas

Island Crusader ranks as the world's first carbon-neutral supply ship and the first on the NCS to run on biogas. Its fuel is derived from fish waste and cattle dung. Owned by Island Offshore, *Island Crusader* is a 10-year-old supply ship displacing 8 500 tonnes fully laden. It has previously run on LNG, with maximum annual emissions equivalent to 2 000 fossil-fuel cars. It made its first voyage with net zero operating emissions in November 2021.

3.5 Future measures and support programmes

3.5.1 Maritime climate partnership

In January 2023, the government and business organisations signed a letter of intent on a climate partnership intended to identify new solutions to these challenges. Shipping is one of three industries selected as priority sectors. The maritime industry has made it clear that a common arena is needed to give a boost to climate policy, and that making the climate partnership a good setting for collaboration will be important in 2023. A crucial measure for meeting the 2030 goals will be scaled production and availability of alternative fuels for the maritime sector, including its offshore segment. In collaboration with Norway's Zero environmental organisation, the NSA has identified contracts for difference as a tool which can reduce risk by cutting the price differential between traditional and climate-friendly fuels and by helping to increase production.

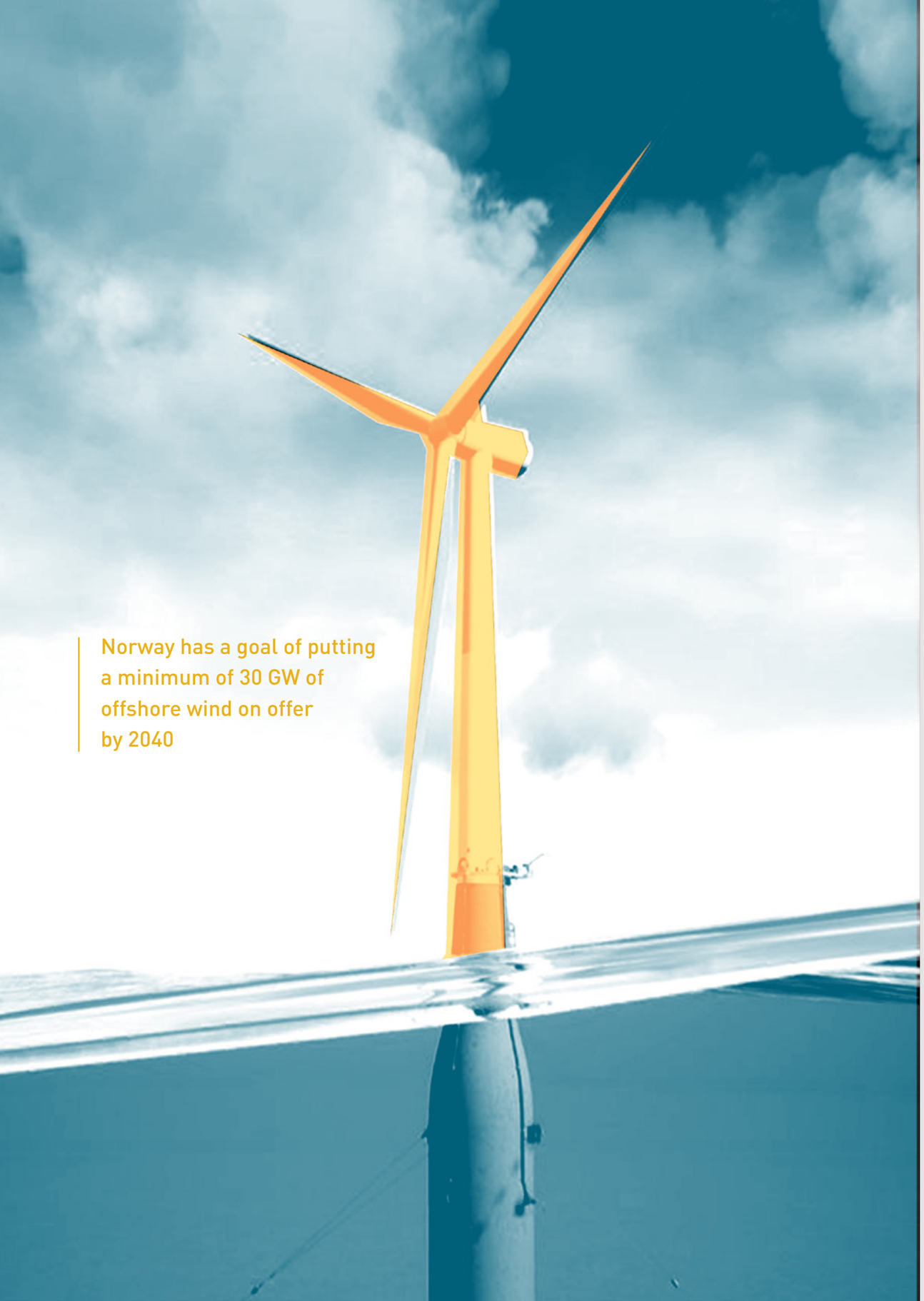
3.5.2 Including the maritime sector in the EU ETS

The shipping industry will be incorporated in the EU ETS from 1 January 2024, with the offshore fleet being included gradually. It will be required to report to the MRV emission database from 2025, and big offshore vessels over 5 000 gross register tons will need to have emission allowances from 2027. A decision on whether smaller vessels should be liable to have allowances will be taken by the end of 2026. Allowance costs are likely to be a further driver for emission cuts offshore, and a legal reporting duty will provide new information. The shipping industry believes that revenues from allowances should be earmarked for adapting the maritime sector, including in Norway.

3.5.3 R&D and support programmes

Government support schemes, including those channelled through Enova and the Research Council, are key adaptation tools in the maritime sector. By funding pilot projects, they help to develop new technology. Direct financing from the EU also plays an important role here. One challenge is posed by new technology being considered ready for the market before it actually is, so that further support is withdrawn. To ensure that new green solutions make headway in the market, public funding must continue for longer than it does today. In that way, innovative technology can outcompete less climate-friendly alternatives.

Government support schemes, including those channelled through Enova and the Research Council, are key adaptation tools in the maritime sector



Norway has a goal of putting a minimum of 30 GW of offshore wind on offer by 2040

4

NEW VALUE CHAINS ON THE NCS

KonKraft is well on the way to realising its ambitions for building new value chains on the NCS. Plans exist for large-scale hydrogen production in Norway, and are also being pursued for hydrogen-ready power stations in Germany as well as transport infrastructure between Norway and Europe. Norwegian capture plants for CO_2 at a cement mill and a waste incineration facility are under construction, if somewhat delayed, and the Northern Lights transport and storage infrastructure is on schedule to receive and store CO_2 from 2024.

A number of other projects also exist for developing storage capacity on the NCS. Planned schemes which have been licensed will collectively be able to store more than 40 $MtCO_2e$ in 2030. Where offshore wind is concerned, several oil and gas companies are participating in Norway's first licensing round for such developments in close cooperation with other industrial and electricity-generation players. Ambitions and plans also exist for a number of other large offshore wind projects on the NCS.

4.1 Goals of the climate strategy

Through a commitment to new value chains which facilitate a zero-emission society in Norway and Europe, KonKraft aims to develop a forward-looking energy industry on the NCS. Norwegian expertise and experience from operators, suppliers and shipping companies will be used to develop these value chains in order to ensure further value creation and jobs related to activities on the NCS. KonKraft's climate strategy concentrates in particular on value chains for offshore wind, hydrogen and CCS. During recent years, seabed minerals have also been identified as a possible important new value chain in the longer term.

In its climate stategy, KonKraft has resolved to work on realising the following ambitions related to new value chains.

KonKraft's ambitions	Status
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.	Shell, Equinor and Horisont Energi are pursuing several plans for large-scale hydrogen production projects related to the NCS. Gassco is now working on a feasibility study for a hydrogen value chain which includes pipelines from Norway to Germany. An RWE-Equinor collaboration involves building new hydrogen-ready gas-fired power stations.
Two carbon capture plants in Norway – Norcem Heidelberg's cement mill in Brevik and Fortum's energy recovery plant at Klemetsrud – carbon transport infrastructure and storage on the NCS, Northern Lights, are in operation by 2024.	The capture plants at Brevik and Klemetsrud are under construction, if somewhat delayed, and Klemetsrud is currently on hold. The Northern Lights transport and storage infrastructure is on schedule to receive and store CO_2 in 2024.
CO_2 is transported for storage on the NCS from at least five European industrial companies by 2030.	Planned storage projects licensed for the NCS are set to store more than 40 $MtCO_2$ by 2030. The players have already secured storage contracts from a number of European power and industrial companies.
The oil and gas industry will work for the further development of Norway's strong position in renewable energy from offshore wind.	Several companies which also produce oil and gas are participating in Norway's first offshore wind licensing round in collaboration with other players. Norwegian suppliers are taking part and also winning contracts abroad. Nevertheless, the pace of offshore wind development in Norway is also slower than the rest of the European commitment.

4.2 Offshore wind

Much has happened in the offshore wind sector on the NCS over the past year. Hywind Tampen, the world's largest floating wind farm, became operational in November 2022. Once all its turbines are in place during 2023, it will reduce annual emissions from the Gullfaks and Snorre fields by 200 000 tCO_2. The first sites for offshore wind farms in the Southern North Sea II and Utsira North areas were put on offer in March 2023. These projects alone could generate more than 15 TWh if they come on line around 2030.

4.2.1 Specific plans are under way for upscaling offshore wind output from the NCS

The KonKraft partners submitted proposals to the government in January 2022 on what will be required to trigger a large-scale commitment to offshore wind.[12] That included calls to initiate the processes for awarding licences for Southern North Sea II and Utsira North, formulate support programmes for Utsira North, launch the process of preparing more areas in order to achieve more regular licence awards, and intensify the work of overcoming the grid and market challenges which large-scale offshore wind development present.

Many of these requests have been met over the past year. The first offshore wind acreage on the NCS was put on offer in late March, covering one area in Southern North Sea II for 1 500 MW using fixed technology and three in Utsira North for 500 MW apiece based on floating technology. Each of the latter includes a possible option to expand by 250 MW.

Consortia seeking to bid for Southern North Sea II must pre-qualify to participate. Where Utsira North is concerned, three areas will be awarded by the end of the year. Licences will be awarded on the basis of qualitative criteria determined by the government.

The NVE was commissioned by the Ministry of Petroleum and Energy (MPE) in the spring of 2022 to identify new areas for offshore wind development in order to ensure that Norway reaches its target of putting 30 GW on offer for 2040. This work also covered proposals for a study programme, developing a timetable and work programme for the next licensing round by 2025, and assessing possible capacity expansions in the opened Southern North Sea II and Utsira North areas. Presented in April 2023, the study identified 20 possible offshore wind areas for further investigation. The NVE headed a broadly-based group drawn from the NPD, the Directorate of Fisheries, the

Hywind Tampen, the world's largest floating wind farm, became operational in November 2022

12 KonKraft (2022) . comments on the supplementary report. *Økende behov for havvind – det haster med å komme i gang.*

Norwegian Environment Agency (NEA), the Norwegian Coastal Administration, the Norwegian Defence Estates Agency and the Norwegian Directorate for Civil Protection. These bodies agreed on additional investigations in 19 of the 20 areas, while some dissent was expressed over the Sønnavind A area in the Skagerrak. Spread along the whole coast, these sites add up to 54 000 square kilometres or six to 13 times more than required to develop 30 GW, depending on capacity density and level of utilisation.

One of the 20 areas covers Southern North Sea II and the supplementary South-West F acreage. Estimates suggest that they could be developed to provide a total capacity of 5.7-11.5 GW, which is 2.7-8.5 GW more than specified in the decision to open Southern North Sea II.

Where Utsira North is concerned, the NVE group also identified supplementary acreage which would yield a capacity increase of 750 MW for the opened area (250 MW extra for each of the three areas offered for licensing).

4.2.2 Big potential for offshore wind, but operating parameters will determine how much can be utilised

This year's status report includes for the first time figures on expected power generation from offshore wind projects. Now operational, Hywind Tampen will have an annual output of 0.4 TWh from 2024. Other mature but not sanctioned projects cover the connection of one-two freestanding floating turbines for partial electrification of platforms. A substantial potential in 2030 could have been realised by Equinor's Trollvind project, with a planned capacity of one GW generating 4.4 TWh annually from 2029. As explained below, however, this scheme has now been postponed.

Southern North Sea II phase 1 could generate 6.6 TWh per annum, and the government's ambition is to have this operational in 2030. Where Utsira North is concerned, the government has announced that two of three projects will receive support through a competition. In that event, they could generate 4.4 TWh in 2030 with a capacity of 500 MW each. Expanding that by 250 MW for each project would increase output to 6.6 TWh. Realising all three Utsira North projects by 2030 could generate close to 9.9 TWh if capacity is increased in each case. Overall, the Southern North Sea II phase 1 and Utsira North projects could thereby provide more than 15 TWh if they become operational around 2030.

4.2.3 Trollvind postponed because of high costs

Equinor and the other licensees in the Troll and Oseberg fields – Petoro, TotalEnergies, Shell and ConocoPhillips – indicated in June 2022 the possibility of building an offshore wind park close to the Troll field and west of Kollsnes and Bergen. This would have an annual output of 4.4 TWh, which could be transmitted to shore and help to alleviate a regional power shortage. Equinor has postponed further work on this project indefinitely for various reasons, including availability of technology, high cost inflation and a tight schedule for delivery on the originally proposal.

4.2.4 Single wind turbines for rapid emission cuts

BW Ideol, BW Offshore and Fram Wind Solutions are jointly developing protects for electrifying platforms on the NCS with floating wind power. They are looking at a concept utilising one or more individual floating turbines with capacities up to 15 MW. These are integrated on separate floaters with the most important electrical equipment, including converters/equalisers.

4.2.5 Returning power to shore

Through their GoliatVIND AS joint venture, Odfjell Oceanwind and Source Galileo Norge have entered into an agreement with the Goliat licence operated by Vår Energi to study opportunities for installing three-five floating wind turbines on this Barents Sea field. A possible project would require the licence to make its power-from-shore cable and associated infrastructure available, with GoliatVIND acting as developer and responsible owner of the offshore wind facility. Each 15 MW turbine would be based on Odfjell Oceanwind's technology for floating wind power in rough-weather areas. Electricity generated would pass via the platform and thereby reduce power offtake from Hammerfest. Under good wind conditions, the facility is expected to export a net 25 MW of power to shore. If the necessary cost-efficiency can be achieved, such a solution could also be interesting for other fields using power from shore. An important precondition is a clarification of the regulatory parameters for realising such a project.

Equinor has postponed further work on Trollvind indefinitely for various reasons, including availability of technology, high cost inflation and a tight schedule

4.2.6 Constraints and requirements

Key constraints

- No overall plan for realising 30 GW of offshore wind is in place. Regular licence awards are required, along with a plan for grid connection which includes how a hybrid solution can be established with appropriate market and grid design. This will ensure predictability for offshore wind developers and suppliers who want to invest in Norway.
- Capacity and investment in yards and ports for the construction, assembly and completion of floating turbines. Lack of an overall plan and predictability for future offshore wind volumes and grid development constrain investment ahead of capacity requirements and make it risky to put industrial capacity in place.
- Slow-moving processes mean that Norway is lagging behind its neighbours and failing to gain full benefit from its advantage in offshore operations.

What the industry wants for offshore wind development and parameters

- The government must make provision for the development of two-three GW of offshore wind per annum during the 2030s and 2040s, and start opening new areas for such projects before the next general election.
- The government must establish a commercial framework which supports offshore wind development.
- Strengthen the commitment to research and innovation related to industrialisation and upscaling of offshore wind.
- The government should emphasise a high Norwegian HSE standard and base location in Norway when awarding acreage, so that value creation occurs regionally and nationally.
- Facilitate a grid development in the North Sea which helps to strengthen value creation and supports a Norwegian commitment to offshore wind with an efficient and integrated power market in the littoral countries.
- Licensing and application processes and administrative capacity must be adjusted to ensure shorter lead times for offshore wind projects on the NCS.
- The Norwegian authorities, 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 future offshore grid in the North Sea. Furthermore, the government must work actively towards countries which are relevant for connection to a hybrid project. It is particularly important that Norway is an active partner in the regional collaboration bodies planning coordinated infrastructure development in the North Sea, such as the North Seas Energy Cooperation (NSEC). A clarification of the relationship to the TEN-E regulation is important in this context. If offshore wind farms in hybrid projects are not to receive direct support, they must be given a share of the bottleneck revenues to strengthen project profitability.

4.3 Hydrogen

4.3.1 The EU is strengthening its hydrogen ambitions, and guidelines for a single market are starting to fall into place

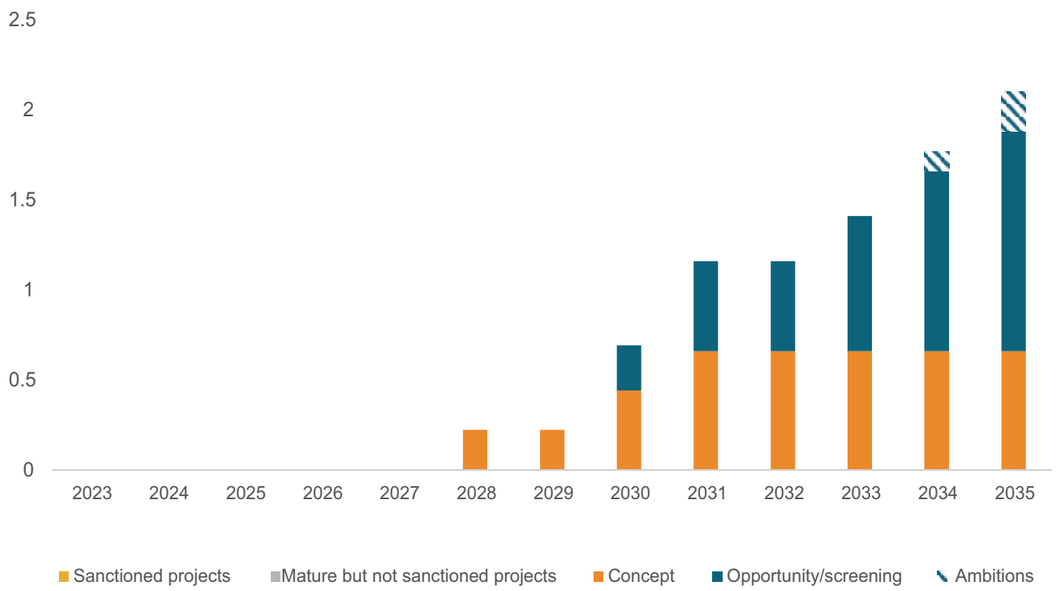
In the spring of 2022, the European Commission launched the RePowerEU strategy for reducing the EU's dependence on Russian gas. That highlights the importance of renewable hydrogen as an important measure for cutting natural gas imports from Russia, and proposes 20 million tonnes of this commodity annually as a target for 2030, with half obtained through imports. Through a new and updated energy collaboration, including with Norway,[13] the EU is opening for increased hydrogen cooperation and strengthening the Norwegian role as a key energy supplier.

Over the past year, the EU has finalised a number of key operating parameters for establishing a single hydrogen market in Europe. Updating existing EU legislation and preparing new provisions are defining classification requirements for various forms of hydrogen production. The revised directive on promoting the use of energy from renewable sources includes agreement on a requirement that 42 and 60 per cent of industry's hydrogen consumption must be renewable by 2030 and 2035 respectively.

In addition, the EU has resolved that the new regulations for the carbon border adjustment mechanism (CBAM) will also include hydrogen in order to reduce the risk of carbon leakage associated with its production. This move could strengthen the competitiveness of Norwegian and European hydrogen production in relation to non-EU suppliers in that all producers will face a virtually identical carbon price for emissions related to the production process.

FIGURE 24 EXPECTED ANNUAL HYDROGEN PRODUCTION FROM LARGE-SCALE PROJECTS AND PLAYERS ON THE NCS
Million tonnes of H_2/y

Source:Konkraft



13 Norwegian government (2022), *Increased energy cooperation between the EU and Norway.*

4.3.2 Industrial plans for hydrogen production in Norway from 2030

Several large-scale hydrogen and ammonia plants are planned in Norway, initially based on natural gas with CCS and aimed at the EU market. This year's status report for the first time collates ambitions for hydrogen production from large-scale projects and players involved on the NCS. Figure 24 presents a compilation for expected annual hydrogen output up to 2035. These projects are in an early phase, with the uncertainty which that involves. Their production volumes will not be scaled up substantially until the early 2030s.

With start-up planned for 2028, Horisont Energi's Barents Blue project has come furthest along the development trajectory. This aims to produce blue hydrogen as an intermediate stage in ammonia production. The first train is in the concept phase. Ambitions of doubling capacity towards 2035 are also included.

Together with partners Aker Horizons and CapeOmega, Shell is planning a hydrogen plant in Aukra on the west coast. Equinor also has plans for large-scale production of this commodity in western Norway. For the moment, these projects are looking to start producing blue hydrogen in 2030, with capacity continuing to expand in later years. Plans also call for renewable hydrogen to be produced further down the road. This year's forecast shows that hydrogen volumes related to the NCS will pass one million tonnes in 2031, with the potential to double that by 2035.

Equinor has also launched a feasibility study on producing blue hydrogen at Mongstad. Initially, the concept being studied would primarily utilises flue gases from the refinery – where the hydrogen is to be used as an energy source. This could substantially reduce CO_2 emissions from the refinery because of the CCS solution due to be implemented. Depending on the installed capacity, further hydrogen could be produced from natural gas and utilised as an input factor for local hydrogen-based industry (such as sustainable aviation fuel) and/or transported to other markets. The hydrogen value chain which could thereby be established would have a commercial life far beyond the refinery's. This project is in an early development phase, and will be both technically and commercially challenging, but represents a concept with the potential to bring the Mongstad industrial area through the energy transition.

Several large-scale hydrogen and ammonia plants are planned in Norway

4.3.3 Developing large-scale infrastructure for hydrogen has begun

The heads of the Norwegian and German governments signed an agreement in January 2022 on strengthening cooperation between their countries in the energy transformation, and on establishing a long-term and structured dialogue around energy. This collaboration was reinforced in January 2023, and the countries confirmed a joint intention of creating a large-scale value chain for hydrogen with associated infrastructure from Norway to Germany by 2030. In addition to developing large-scale hydrogen transport, the countries will work to develop a framework for establishing a well-functioning European market for this commodity. Norway wants to position itself as a producer and provider of hydrogen, and the collaboration with Germany will help to develop the demand side of this market for Norwegian players. In a step-by-step approach, the two nations will be blue-hydrogen producers and consumers respectively. Green hydrogen can also be phased into this infrastructure.

As a first step in this collaboration, a study has been commissioned into the technical and economic feasibility of large-scale transport of hydrogen from Norway to Germany, with CO_2 moving in the opposite direction. Gassco and the German Energy Agency (Dena) are jointly pursuing the work in consultation with industrial players in their respective countries. Through its role as the architect for hydrogen infrastructure in Norway, Gassco will assess this value chain from an NCS perspective.

At the same time as the governments signed their joint declaration on energy collaboration, Equinor and Germany's RWE energy company announced a broad project collaboration. They will work together on replacing German coal-fired generating capacity with hydrogen-ready gas-fired power stations by 2030 and build up production of blue and green hydrogen in Norway. The power stations in Germany will be owned jointly by the two companies, and will run initially on natural gas. Production plants for blue hydrogen will be developed at the same time in Norway (Clean Hydrogen Europe), with more than 95 per cent of the CO_2 in the natural gas feedstock extracted from the process and stored on the NCS. The joint aim of the two companies is for the German power stations to run on hydrogen from 2035. As part of the project, the partners also have ambitions of developing offshore wind farms to generate power for green-hydrogen production in both Germany and Norway. Phasing in more green hydrogen will help to reduce emissions even further.

> The Norwegian and German governments want to secure a large-scale value chain for hydrogen with associated infrastructure from Norway to Germany by 2030

4.3.4 Constraints and requirements

Key constraints

- Great uncertainty prevails about how national/regional goals and ambitions are to be met by committed demand.
- Operating parameters which determine how profitability can be achieved for those who invest in production.
- Safety aspects of transporting and using hydrogen and hydrogen derivatives.
- "Energy costs" for production could potentially consume energy required for other transition purposes.

What the industry wants for hydrogen value-chain development and parameters

- Support programmes are framed to encourage development and innovation in all parts of the hydrogen value chain. They must contribute to necessary risk reduction in order to ensure profitable development of ammonia and hydrogen production.
- Market development/demand for hydrogen as an energy product must be incentivised in parallel with production capacity.
- Hydrogen usage in Norway must be viewed in relation to potential exports to north-west Europe.
- Good collaboration solutions and arenas must be established between government and industry.

4.4 CCS

4.4.1 CCS is getting greater attention in European climate plans

CCS is important and attracting growing interest. In the spring of 2023, the European Commission proposed for a new Net Zero Industry Act, where CCS is identified as a strategic technology for achieving the EU's goal of net zero emissions by 2050. The Commission proposes setting a target of 50 $MtCO_2e$ in annual injection capacity by 2030, with a key role in meeting this goal assigned to the European oil and gas industry.

Since the MPE began offering acreage for CO_2 storage on the NCS in 2019, six licensing rounds have resulted in nine companies – alone or in partnership – receiving licences. A number of players on the NCS are working to build up such storage as a separate business area. Several of them have been contacted by European industrial enterprises and power generators investigating opportunities for disposing of the CO_2 they want to capture from their facilities.

4.4.2 Big CO_2 storage potential on the NCS in 2030 – but dependent on many factors

This year's status report presents for the first time an overview of potential capacity for CO_2 storage projects on the NCS up to 2035. Figure 25 indicates a rapid upscaling of storage capacity in the late 2020s, with the players potentially able to store 40-50 $MtCO_2$ in 2030.

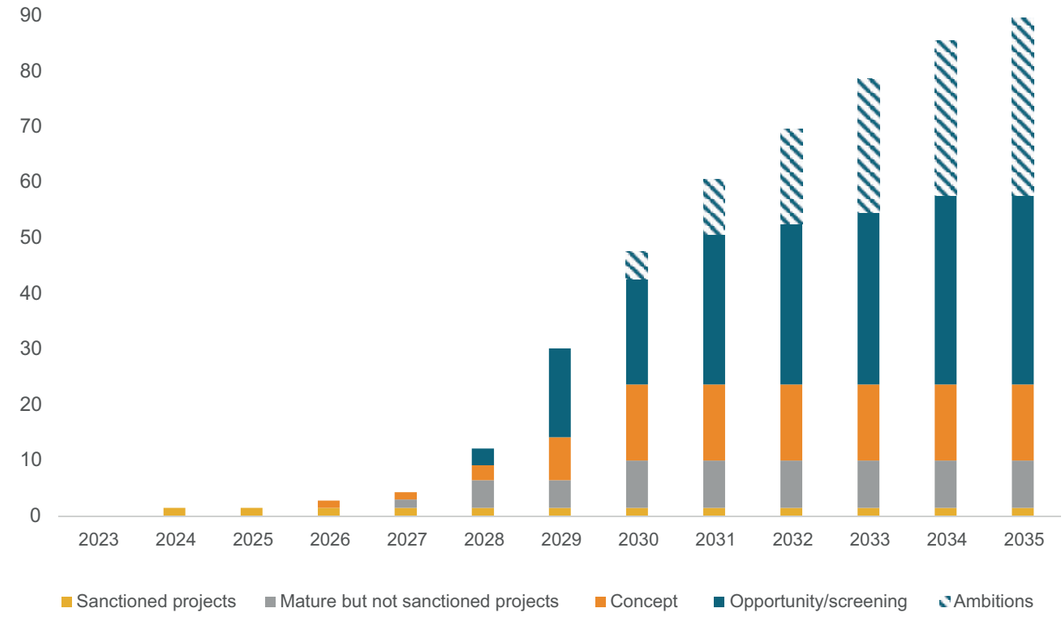
The compilation presented in figure 25 is based on planned injection capacity related to existing licences and one put on offer but not yet awarded. Sanctioned capacity in the figure relates to Northern Lights, where phase 1 is due to become operational as early as next year. Estimated upscaling of capacity in two further phases is also included, with phase 2 marked as mature but not sanctioned and phase 3 as concept. Luna is another mature but not sanctioned project, with Wintershall and CapeOmega aiming to begin storage in 2027.

Most of the storage projects on the NCS are currently at an early project stage in the concept or opportunity/screening phases, but the Trudvang, Havstjerne, Smeaheia and Polaris schemes as well as the Aker BP/OMV project in the Egersund basin all have planned start-up before or during 2030. Particularly large schemes are Sval, Storegga and Neptune's Trudvang – with an annual storage capacity of nine $MtCO_2$ – and Equinor's Smeaheia, which aims to hold 20 $MtCO_2$ per year in the longer term. Storage capacity in the ambitions category (hatched) is not linked to licences put on offer, but expresses individual companies' ambitions for CO_2 storage and relates to identifying appropriate areas and maturing projects internally.

Where most players are concerned, storing CO_2 from Europe is the most relevant option at present because of the big need for CO_2 capture and demand for such storage, as well as closeness to customers. One challenge for developing a complete CCS value chain in Norway is that Norwegian emission points are relatively small and scattered, making it difficult to achieve adequate economies of scale for upscaling.

FIGURE 25 ANNUAL CO_2 STORAGE CAPACITY FOR NCS PROJECTS AT VARIOUS LEVELS OF MATURITY
Million tCO_2/y

Source:KonKraft



4.4.3 The risk of leaks from CO_2 storage on the NCS is minimal

Typical geological formations for CO_2 storage are porous and permeable sedimentary rocks such as sandstones, where the gas is retained in the pores by an impermeable cap rock. Natural CO_2 deposits are often found in areas of active vulcanism around the world. The Bravo Dome in New Mexico, for example, contains 1.6 gigatonnes of CO_2 trapped for more than a million years.

CO_2 is usually stored in geological formations deeper than 800 metres to give it a high density and thereby increase storage capacity, while also preventing leaks because the seal becomes more effective with depth. Vertical upward migration is prevented by the overlying cap rock and other permeable strata.

All CO_2 injection and storage projects are subject to thorough project-specific risk assessments to clarify the risk of leaks and to initiate measures/design work for filtering out the best candidates. Regular monitoring is conducted during the operating phase in order to map and understand the movement and behaviour of the CO_2 in the formation, and to adapt operation accordingly. Published in 2023, *the Deep Geological Storage of CO_2 on the UK Continental Shelf* report provides the most up-to-date review and gives an updated estimate of the leak risk for CO_2 in such formations. Modelling of two storage projects, which have both undergone stringent licensing processes, after 25 years of injection and with 100 years of monitoring after gas ceases to be added indicates that 99.9 per cent of the injected volume would remain in the storage strata.

4.4.4 Northern Lights to store CO_2 as early as next year

Phase 1 of Northern Lights is the only storage project sanctioned so far, and could accept and store 1.5 $MtCO_2$ by 2024. An investment decision is due in 2023 for phase 2, which could increase annual storage capacity to five $MtCO_2$ from 2028. On the capture side of the Longship project, construction has begun at the incineration plant in Klemetsrud and the cement mill in Brevik. However, execution of this work is threatened by cost overruns and delays. Building the capture plant at the Heidelberg Materials mill is already well under way, with start-up planned in 2024. A final investment decision was taken for the Klemetsrud facility and construction started in the summer of 2022, but work is currently suspended because of cost overruns arising in part from increased energy and materials prices, currency effects and project changes. It will be completed at the earliest with a year's delay in 2027.

In addition to supplies from the two Longship facilities, Northern Lights will store CO_2 for European companies. Over the past year, the project has signed two commercial agreements with Yara and Ørsted covering storage of 800 000 and 430 000 tonnes of CO_2 per annum respectively. These deals provide clear signals of a shift in the CCS debate, where the market is moving from potential to actual demand.

4.4.5 Large-scale CO_2 infrastructure from capture in Europe to storage in Norway

As part of the European commitment to CCS, CO_2 infrastructure schemes can apply to become projects of common interest (PCIs). This status provides several benefits, including access to financial support and faster consideration of infrastructure development. Northern Lights is a PCI and, to achieve this, has worked to secure participation by other operator companies with storage licences as well as several industrial partners and transmission system operators (TSOs) in Europe. The project is a collaboration with Belgium, Finland, France, Germany, the Netherlands and Sweden in addition to Norway.

On the transport side in Europe, Equinor has entered into a partnership with Belgium's Fluxys to develop commercial infrastructure solutions for transporting CO_2 on land from customers to intermediate holding facilities before sending it for storage on the NCS. Northern Lights wants to develop a commercial network for CO_2 transport by sea from various capture facilities in Europe to NCS storage. Special carriers are to be developed for such shipments, and a terminal will be constructed in Norway for intermediate storage before piping the CO_2 to its final destination.

Northern Lights is one of several cross-frontier projects for large-scale infrastructure. They include a feasibility study by Gassco for CO_2 shipments from Germany to Norway in combination with an assessment of large-scale hydrogen transport in the other direction. Covering shipping and pipeline infrastructure, the feasibility study is due to be completed in the autumn of 2023.

At the same time, several large-scale projects are being pursued by companies collaborating on and developing transport infrastructure for CCS. Altera, for example, is developing Stella Maris CCS, a large-scale flexible maritime logistics solution for captured CO_2. Embracing the whole chain from capture to storage, Stella Maris recently secured a licence from the MPE to develop the Havstjerne CO_2 storage project in the North Sea. This solution includes collaboration with several companies to cover the whole value chain, such as Aker Carbon Capture's technology. The collaboration over Stella Maris is intended to promote cost-effective implementation of the whole value chain, while also giving the companies involved the flexibility to continue developing alternative CCS solutions and technologies outside this project.

4.4.6 Offshore gas-fired power with CCS

BW Offshore is developing a floating power generation unit (FPGU) based on natural gas with CCS which can provide a capacity of 300-500 MW. Positioning this offshore close to petroleum installations permits alternating current to be supplied directly without the need for high-voltage direct current (HVDC) conversion. The facility is based on a combined cycle solution with a CO_2 capture rate of more than 90 per cent from flue gases, in combination with injection in nearby sub-surface formations. The FPGU concept utilises BW Offshore's tested design for the Catcher FPSO, which has been in operation on the UK continental shelf since 2017.

4.4.7 Aker Carbon Capture delivers modular units for emission reductions in Norway and Europe

Norway's capture players are also well to the fore, with Aker Carbon Capture delivering such facilities to customers in Norway and Europe. Among other successes, this company won a contract in May to supply five capture plants plus facilities for CO_2 liquefaction and intermediate storage to Ørsted's Kalundborg Hub in Denmark. The modular Just Catch™ units involved offer fast delivery, and are to be installed at two bioenergy plants to provide an overall capture capacity of 500 000 tonnes per annum. Aker Carbon Capture's third-generation Just Catch™ solution offers increased energy efficiency, a smaller footprint and a reduced number of modules. The installations will form part of a 20-year subsidy deal between Ørsted and the Danish Energy Agency to realise the first large-scale CCS value chain in Denmark together with other partners such as Microsoft and Northern Lights.

Aker Carbon Capture is also delivering units to the Heidelberg Materials cement mill in Brevik and has installed further equipment in 2023 for this plant, which is due to be completed in 2024. Other large projects being pursued by the company in 2023 are completion of a Just Catch™ facility at the Twence energy recovery plant in the Netherlands, where the captured CO_2 will be reused in local greenhouses. Collaborations and letters of intent have also been entered into with a number of players, including Elkem, Finnish cement mill Finnsementti, German chemical manufacturer Röhm, UK gas-fired power stations for BP and SSE, and a British energy recovery plant for Viridor.

Photo: Aker Carbon Capture

4.4.8 Constraints and requirements

A substantial commitment is being made to CCS globally. Norway has a competitive edge today, but retaining this calls for schemes which help to close the gap between necessary investments in the CCS value chain and the carbon price in order for new projects to be realised. The USA's Inflation Reduction Act (IRA), which came into force on 1 January 2023 incorporates a big package of up to USD 369 billion in climate subsidies for promoting renewable energy and zero emission technology. To encourage investment in carbon capture, utilisation and storage (CCUS) projects, the USA has also introduced big tax credits (45Q) which are expected to increase such schemes 13-fold by 2030. That creates predictability and security for the investments. In part as a response to the IRA and after much pressure from EU member states and industry, the European Commission presented a Green Deal industrial plan in February 2023 which is intended to increase the competitiveness of net zero industry and ensure the transition to net zero emissions in the EU by 2050. The plan is divided into four pillars, with CCS identified as a key sector in two of these. Britain announced in March 2023 that it would spend GBP 20 billion over 20 years to scale up CCS projects across the UK. Other countries, such as Canada, the Netherlands, Denmark and Sweden also have strategies, subsidies and incentives for realising and industrialising the CCS commitment.

Key constraints

- A lack of clarity persists about the tax regime which will apply to these activities, what financial security must be offered, how long and in what detail emissions must be monitored, and what size of leaks can be accepted.
- Substantial financial and technical risk related to big investment in infrastructure, particularly in value chains and markets during an establishment phase.
- Regulations for CO_2 transport and storage are not fit for purpose, since they impose disproportionate restrictions, curb progress and do not accord with the government's expectations for work programmes taking no more than four years.
- Several licences have been awarded, but competition is sharp and maturing and preparing an application is hugely expensive with a big risk of losing the investment. A particularly high level of maturity is required for the application, which in turn calls for spending which might not be recovered. Furthermore, requirements and guidelines for the application process are continuously adjusted, which is turn contributes to uncertainty over the process.

What the industry wants for the development of CCS parameters

- The Norwegian government should set specific goals for the amount of CO_2 to be stored on the NCS.
- The Norwegian government should help to simplify the regulations related to CO_2 transport and storage.
- Support programmes should be tailored to help reduce financial risk and to facilitate maturing solutions to ensure necessary, scale, learning and cost cuts for both capture and storage of CO_2.
- Attention should be concentrated on the whole CCS value chain, and measures implemented to strengthen the commercial basis for emitters and incentives for capture and storage.

Seabed minerals could create as many as 21 000 jobs and annual revenues of up to USD 20 billion in coming decades.

4.5 Seabed minerals

If global climate targets are to be reached, demand for minerals and metals will rise in coming years. Current extraction and processing of important metals for the green energy transition are very concentrated geographically, primarily in Asian, African and South American countries. A supply side of this kind is vulnerable to sudden changes in trade policies or conflicts, which can lead in turn to volatile prices for these commodities. Recycling will make an important contribution to meeting future requirements, but not sufficient given expected growth of the world's population and economy as well as technological development. Investment will be required in new responsible extraction and processing of metals and minerals. Detailed resource mapping and research have identified interesting seabed deposits of minerals on the NCS, in the form of sulphides and manganese crusts. KonKraft believes that Norway, through long and good experience of resource management and technological expertise from the petroleum industry, can and should participate in developing a minerals industry on the NCS.

A number of studies have noted that seabed minerals could be an important sector for Norway. These include the *Marine Minerals – Norwegian Value Creation Potential* study carried out by Rystad Energy for Offshore Norge and others, which shows that recovering these resources could create as many as 21 000 jobs and annual revenues of up to USD 20 billion in coming decades.

During an early prospecting phase, large areas need to be mapped to obtain the best possible overview of their prospectivity. In that context, KonKraft supports the step-by-step approach planned for the opening of, prospecting for and possible recovery of seabed minerals. Opening an area will lead to a prospecting phase. If a player wants to recover a deposit in the future, a plan for development and operation (PDO) with associated impact assessment will need to be drawn up and approved by the government. A recovery permit will not be awarded until thorough studies and investigations of the relevant area have been conducted. Requirements for and local impacts on the environment must be assessed with each permit. This approach builds on established practice from the oil and gas industry.

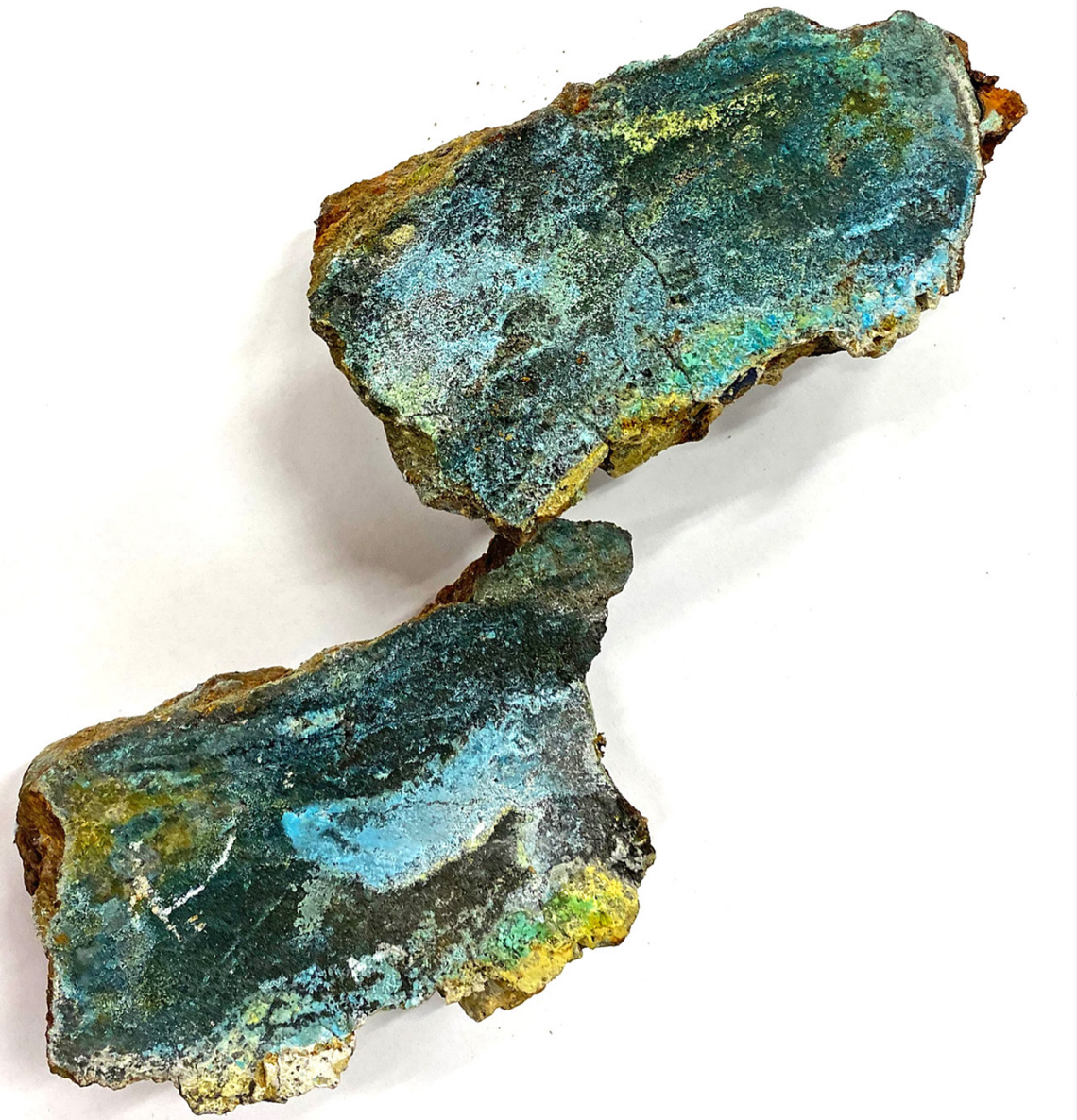
Activities in the prospecting phase primarily involve sampling and analyses as well as geophysical surveys (bathymetric, gravimetric, seismic and so forth). This involves few polluting discharges to the sea/seabed or physical impact on the sea bottom, and will largely utilise known technology and methods. It is important to emphasise that the acreage involved in recovering both sulphides and manganese crusts is expected to be very small compared with the area being prospected. As a result, only very limited areas will be affected by any future recovery of seabed minerals. Environmental mapping should be an integrated part of the prospecting phase, with particularly strong synergies related to the use of technology for remotely operated and autonomous underwater vehicles (ROV/AUV).

The industry acknowledges that a number of knowledge gaps still exist, particularly related to the environmental consequences of future mineral recovery, and is already working actively today to close these in cooperation with academia and other research institutions. Examples of such projects include Eco Safe Ridge Mining and Atlab. Adepth Minerals and its partners were also recently awarded NOK 70.8 million in support through the Green Platform for a project on seabed minerals accelerating the energy transition. This aims to establish the basis of an integrated value chain for recovering and utilising seabed minerals.

KonKraft believes that Norway should establish a national R&D strategy with dedicated funding on the model of OG21/Process21 or the like. Funds for state institutions working on environmental and resource mapping should be increased in order to strengthen the knowledge base. Although much research is currently being done, opening up for industrial activity and the supply of acreage will accelerate knowledge acquisition and form a good basis for future assessments of the basis for recovery from both commercial and environmental perspectives.

Norway has long experience with and leading-edge expertise in industries such as oil and gas, maritime operations, land-based mineral extraction and process industry. These will be crucial in building up a new industrial activity related to seabed minerals. Establishing financial, area-based and work-related parameters is key to ensuring predictability for a process which must be viewed from a cross-sectoral perspective.

A significant value-creation potential, with associated employment effects, is offered throughout the value chain. National strategies related to seabed minerals must acknowledge the potential offered by establishing complete value chains in Norway and Europe, since these developments could have substantial geopolitical significance for the green transition.



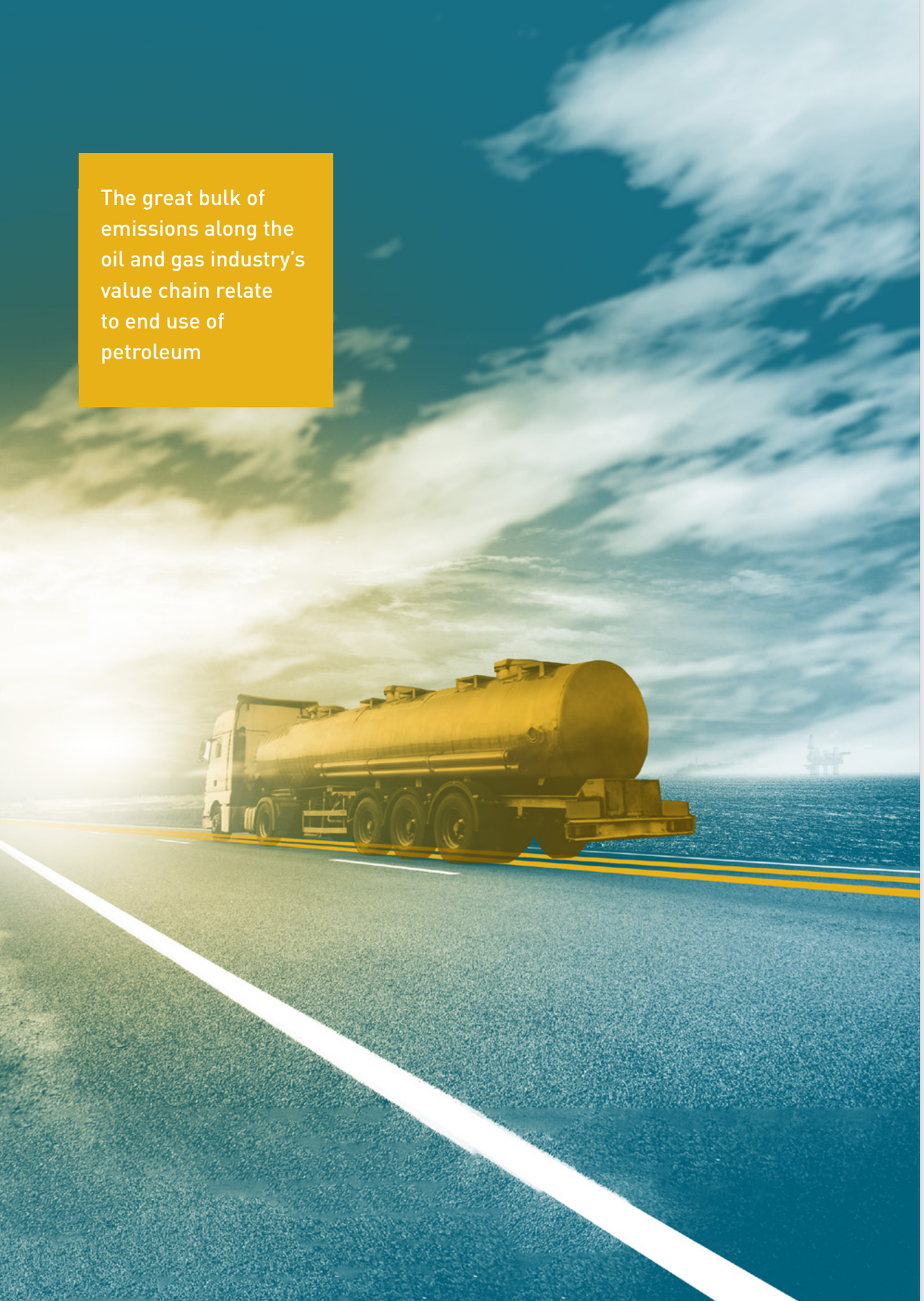
4.5.1 Constraints and requirements

Key constraints

- Seabed minerals may represent a completely new industry for Norway – right at the start of a step-by-step opening process – which means that constraints are still imposed by gaps in knowledge of the resource potential, profitability and the consequences of possible recovery. The financial, acreage and work-related parameters for prospecting and recovery, as well as progress with and predictability in opening processes, also represent key constraints on a possible subsea minerals industry.

What the industry wants for the development of seabed minerals

- An increase in the latitude for relevant government authorities through the ordinary budgetary process in order to support further resource mapping, data acquisition, industrial and environmental knowledge-building, and research and development in an early phase.
- Continue work on freeing up data from various expeditions on the NCS. Access to such information is a precondition for good resource mapping, and the industry should be given the opportunity to participate actively in building knowledge about the relevant areas.
- Rapidly clarify the financial, acreage and work-related parameters, and give the industry adequate opportunities to make proposals in relevant processes. Furthermore, it is desirable that licensing begins as soon as an opening decision has been taken. The players support a step-by-step process where necessary impact assessments are conducted, with relevant milestones.



5

THE OIL AND GAS INDUSTRY'S VALUE-CHAIN EMISSIONS

Licensees on the NCS are working not only on direct emissions (scope 1) but also on mapping and reducing indirect emissions related to the purchase and sale of goods and services (scopes 2 and 3). The great bulk of emissions along the industry's value chain relate to end use of petroleum. Most operator companies on the NCS already report scope 3 emissions to some extent in their annual reports, and some have set targets for reducing part of their value-chain emissions. The job of identifying and acquiring uniform data is demanding, but several companies are well under way with the mapping process. In the longer term, this will enable a number of them to establish clear and suitable emission-reduction targets for scope-3 emissions.

5.1 Emissions from products sold dominate value-chain emissions for petroleum

Attention in the status report on KonKraft's climate strategy is primarily concentrated on measuring, reporting and reducing direct emissions from the Norwegian petroleum industry (scope 1). At the same time, many operator companies are also increasingly providing information on their indirect emissions. Mapping and reporting these could help to exploit the potential for reducing GHG emissions across players in the value chain. The industry is also experiencing growing pressure from investors to report emissions related to petroleum utilisation because they are viewed as an important indicator of the inherent adaptation risk for the companies. From 2025, the EU's corporate sustainability reporting directive will require big companies to report both direct and indirect emissions (scopes 1, 2 and 3).

This chapter describes how the companies are working to measure, report and reduce emissions in their value chain.

5.1.1 A distinction is generally made between three different emission categories (scopes 1, 2 and 3)

Generally speaking, reporting of GHG emissions distinguishes between three different categories.

Direct emissions (scope 1)

These encompass GHGs released from equipment owned or controlled by the business. Operator companies on the NCS have been required to report these for many decades, including from gas turbines and drilling operations. Over time, they have improved their methods for quantifying and measuring direct emissions, and currently have good oversight of the way various activities affect these. Chapter 2 above presents the development of scope-1 emissions from Norway's petroleum sector.

Indirect emissions (scope 2)

These cover indirect emissions from energy deliveries purchased in the form of electricity and heat. Where the operator companies are concerned, this could be power from shore for electrifying offshore installations, or power and heat supplied to office buildings. Where scope-2 emissions are concerned, a distinction is often made between location-based and market-based methods. Most licensees report both.

- The location-based method means that scope-2 emissions are calculated on the basis of the physical power and heat mix in the country where the consumption occurs.
- The market-based method involves scope-2 emissions being calculated on the basis of the emission intensity of the company's contractually purchased power – certificates for renewable energy generated, for example. When purchasing such certificates, no physical relationship exists between the renewable electricity generated and power consumed by the user. If a company purchases renewable power certificates for its whole electricity consumption, its scope-2 emissions will equal zero with the market-based method.

Indirect emissions (scope 3)

These comprise indirect emissions upstream and downstream in a company's value chains which relate to production and transport of purchased goods and services, and emissions from consumption and further processing of goods and services sold. Upstream emissions for operator companies on the NCS, for example, relate to the production of steel, cement and chemicals or procurement of maritime services, while those downstream include refining, transport and end use of petroleum products.

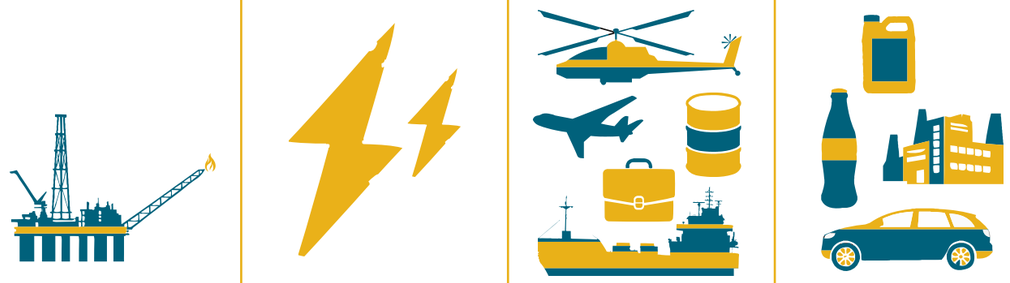
> The industry should be given the opportunity to participate actively in building knowledge about the relevant areas

5.1.2 Value-chain emissions for Norwegian oil and gas

End use of sold products (oil and gas) accounts for the bulk of emissions in the value chain for operator companies on the NCS. Figure 26 presents operator-company emissions for scopes 1, 2 and 3 in Norway. Direct emissions represent one-five per cent of total value-chain emissions, while indirect emissions from the use of sold products (scope 3) account for 94-98 per cent. Other scope-3 emissions, and scope-2 emissions from energy deliveries to oil and gas installations, represent only marginal proportions of the overall value-chain total. The relative distribution of emissions along the value chain will vary between regions.

FIGURE 26 OVERVIEW AND DISTRIBUTION OF EMISSIONS (SCOPES 1, 2 AND 3) FOR OPERATOR COMPANIES ON THE NCS

Source: Endrava 2021



Direct emissions – scope 1

Emissions from production facilities (such as oil platforms) and direct emissions from the company's own vehicles.

1-5% of total emissions

Indirect emissions – scope 2

Electricity consumption on production facilities (power from shore, for example) and at offices.

0-1% of total emissions

Indirect emissions – scope 3

Suppliers, products and services, business travel, emissions along the value chain.

0-1% of total emissions

Indirect emissions – scope 3

Use of products sold.

94-98% of total emissions

5.2 Operator companies are working to map, reduce and set goals for scope-3 emissions

5.2.1 Most operator companies are working to map and report scope-3 emissions

Most operator companies on the NCS already provide partial information on their scope-3 emissions in their annual reports, but the methods used and level of detail vary. Efforts are being made to improve mapping of value-chain emissions in order to obtain a more comprehensive picture.

To be operationalised, such work requires new solutions for reporting and information-sharing along the value chain. Various approaches to mapping scope-3 emissions are taken today. These are primarily based on general emission factors rooted in procurement costs for the quantity of the product or service purchased/sold. Some suppliers have already made provision to report GHG emissions from their goods and services for use in scope-3 reporting. Examples include providers of travel and maritime freight services, as well as suppliers of some types of products used in construction and maintenance.

Reporting scope-3 emissions has so far been voluntary, but expectations of and requirements for emission and sustainability reporting are constantly being expanded – and pose challenges for the industry and the value chain. At present, the companies face challenges in compiling good-quality base data which cover all the relevant scope-3 categories in the value chain. Suppliers upstream and downstream in the value chain have varying levels of maturity for reporting GHG emissions. Processes for data acquisition and validation from suppliers are often time-consuming and manual, and the lack of common standards means that data-sharing between players in the value chain is ineffective. Existing parameters for GHG reporting – such as the GHG protocol – cover all industries, which leaves room for interpretation. That in turn may create uncertainty about the quality of the information. The quality of emission estimates will also depend on which emission factors are applied and how far the estimate is based on "primary" data from the supplier's own processes. Several initiatives are underway to facilitate more effective exchange of data on GHG emissions in the value chain and improve reporting. The petroleum industry in Norway and globally is collaborating to establish updated guidelines for reporting scope-3 emissions, including through the IPIECA.[14]

5.2.2 Work by the operators to reduce scope-3 emissions

Efforts to reduce value-chain emissions normally start by addressing emission categories where data are easily accessible, measures can easily be implemented, the companies can exert substantial influence, and/or emissions are greatest.

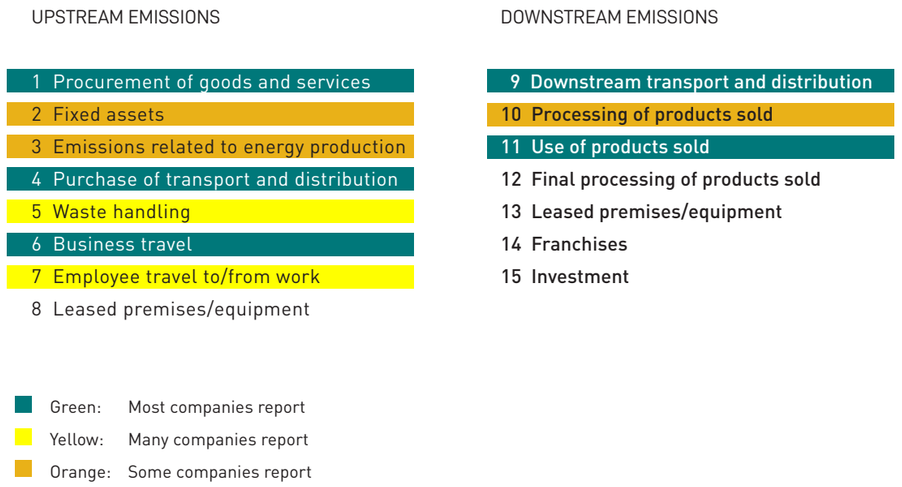
"Emissions from the use of products sold" is a straightforward category of scope-3 emissions which are easy to report on and substantial. But influencing emissions related to the use of the products they sell is demanding for the companies. A number of them have accordingly opted to work with their suppliers and influence emissions upstream. At the same time, working in an integrated way with scope 3 is important for securing change in the longer term.

A survey of operator company reporting of their scope-3 emissions by DNV (2022) shows how common it is for companies to report different types of scope-3 emissions. See figure 27. Many of the companies report on several categories, but data quality and level of detail for reporting in each category varies between them.

14 The global oil and gas association for advancing environmental and social performance across the energy transition.

FIGURE 27 OVERVIEW OF TYPES OF SCOPE 3 REPORTING BY OPERATOR COMPANIES

Source: DNV 2022



5.2.3 A number of companies have also set targets for reducing scope-3 emissions

After acquiring a good overview and data quality for specific emission categories, some companies have also chosen to set targets for reducing emissions from these. In several cases, the companies have included more categories over time. The mapping process under way on the NCS will eventually equip more companies to establish good and timed reduction targets for scope 3. A couple of them have already set goals which include emissions from oil and gas consumption. Such targets mean the companies will transition with time into energy enterprises based on renewable and low-carbon energy, such as the production of blue hydrogen.

The petroleum industry in Norway and globally is collaborating to establish updated guidelines for reporting scope-3 emissions, including through the IPIECA

6

SOURCES

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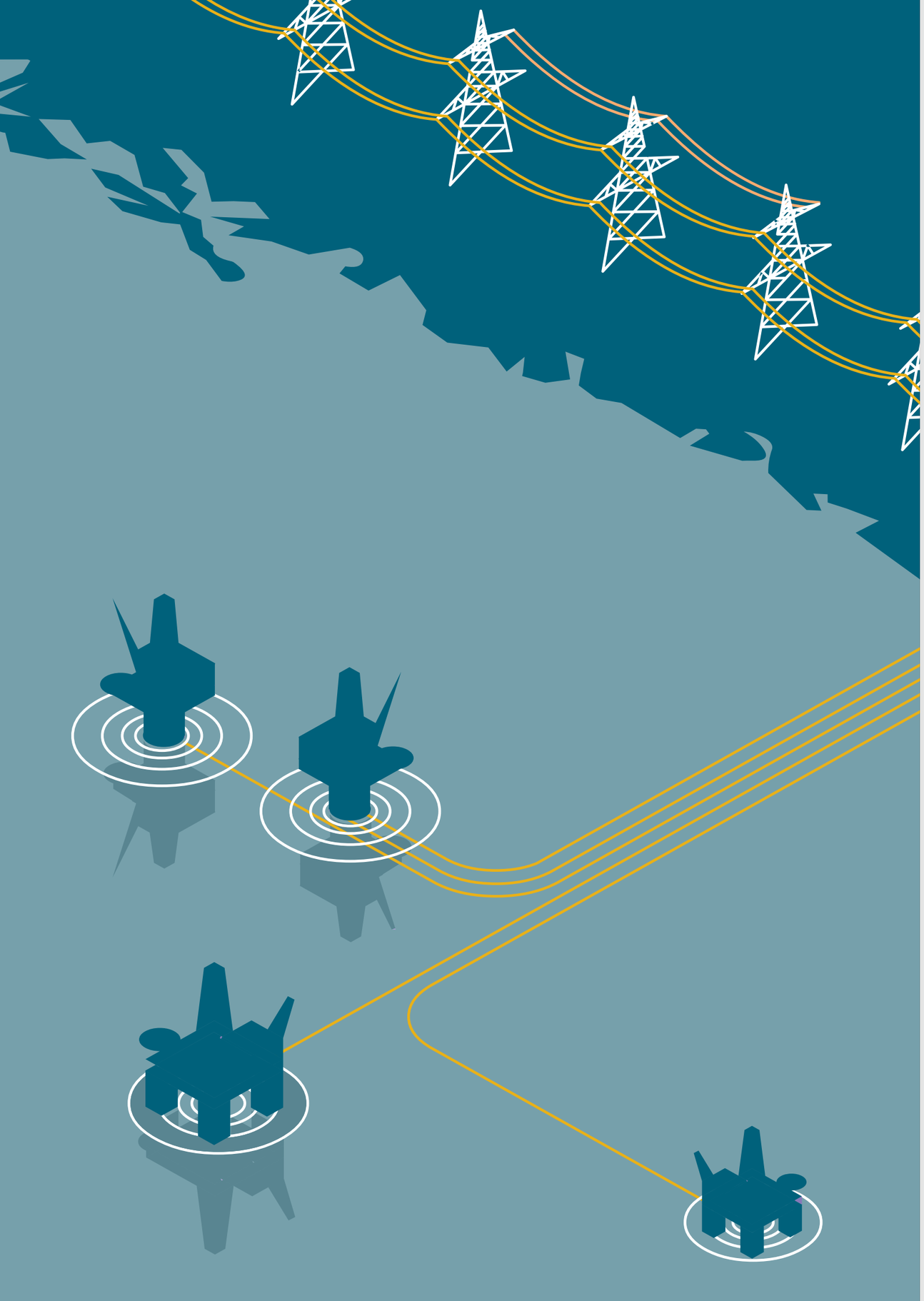

7

APPENDICES

7.1 Categorisation of fields/plants in power consumption forecasts

Table 1 lists the individual projects included in the power consumption forecast presented in section 2.2 above.

Operational	Connection approved	Connection applied for	No application for connection
Kårstø	Troll West electrification, first stage	Partial electrification of central North Sea fields	Full electrification of land plants
Utsira High power hub	Yggdrasil electrification	Heidrun electrification	Kårstø KREm CCS
Valhall	Oseberg gas capacity upgrade, incl partial electrification	Tampen electrification	Gjøa full electrification
Kollsnes	Ormen Lange phase 3	Kårstø reduced emissions (KREm)	Increased compression, Kollsnes
Troll A	Melkøya CO_2 reduction	Gjøa increased requirement	
Martin Linge	Halten South electrification	Wisting electrification	
Gjøa		Linnorm electrification	
Nyhamna		Troll West electrification, second stage	
Melkøya LNG		Oseberg further electrification	
Goliat		Halten North electrification	

7.2 Emission intensity for offshore ships by operating mode

	TRANSIT		PORT		DP		STANDBY	
	Emission factor ($MtCO_2$/h)	Change	Emission factor ($MtCO_2$/h)	Change	Emission factor ($MtCO_2$/h)	Change	Emission factor ($MtCO_2$/h)	Change
2019	1.654		0.2742		1.0406		0.5219	
2020	1.678	1.47%	0.2335	**-14.82%**	1.0651	2.35%	0.5327	2.08%
2021	1.630	**-2.87%**	0.2389	2.28%	1.9855	**-7.47%**	0.5124	**-3.81%**
2022	1.592	**-2.35%**	0.2280’	**-4.54%**	0.9937	0.83%	0.5101	**-0.46%**

Source: VPS

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THE NORWEGIAN CONTINENTAL SHELF –
STATUS REPORT 2023
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