Environment 2002

The Norwegian petroleum sector

Ministry of Petroleum and Energy

Visiting address:
Einar Gerhardsens plass 1

Postal address:
P O Box 8148 Dep, N-0033 Oslo

Tel +47 22 24 90 90
Fax +47 22 24 95 65

http://www.oed.dep.no
E-mail: postmottak@oed.dep.no

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Foreword

1

The Ministry of Petroleum and Energy produces an annual environmental review in cooperation with the Norwegian Petroleum Directorate. The purpose of this publication is threefold:

- to increase knowledge about the environmental aspects of Norwegian oil and gas activities
- to take a more detailed look at a specific topic which particularly concerns both the industry and the authorities, and identify the challenges and options faced
- to emphasise the government's goal of ensuring that Norway reconciles its role as a large energy producer with a pioneering position on environmental issues.

This year's edition focuses on the topic of "oil and fish – common sea". Both the petroleum and fishing industries depend on the waters off Norway. Ever since petroleum activities began on the Norwegian continental shelf more than 30 years ago, the authorities have been keen to ensure that these two sectors can work in the same sea areas.

What challenges and opportunities face the petroleum industry over discharges to the sea and living marine resources? How can the authorities ensure that this sector is able to coexist with the fisheries? These and similar questions about the relationship between the petroleum and fishing industries in their shared seas are covered in section two of this publication.

Environment 2002 also incorporates a factual section, which covers the status of emissions/discharges, environmental impacts and measures to reduce discharges to the sea and emissions to the air from petroleum activities. The MPE hopes that a publication of this kind can enhance basic knowledge about petroleum activities and environmental issues.

Special thanks are again due this year to the external reference group, which includes representatives from the Bellona environmental organisation, the Norwegian Oil Industry Association (OLF) and the Federation of Norwegian Engineering Industries (TBL), for its constructive contributions and comments during the work on *Environment 2002*.

Einar Steensnæs
Minister of Petroleum and Energy

Section 1
Facts

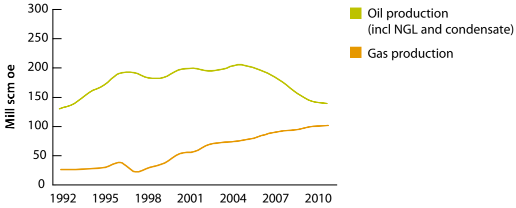

Figure 1 Production of oil and gas on the NCS.
(Source: MPE/NPD)

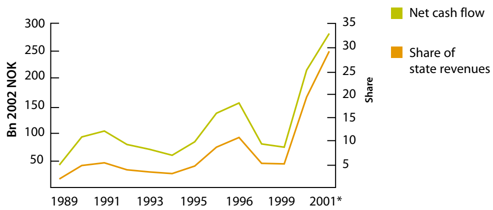

Figure 2 Government's net cash flow from petroleum activities 1988-2001. *(Source: MPE/NPD/Ministry of Finance) *estimate*

Petroleum activities in Norway

Facts about the petroleum sector

- Accounted in 2001 for 47 per cent of the value of Norwegian exports.
- Contributed 32.8 per cent of overall government revenues in 2001 through:
  - revenues from the state's direct financial interest (SDFI)
  - taxes from the oil companies
  - dividends from Statoil and Norsk Hydro.
- Gas will gain increasing importance compared with oil.
- Remaining oil and gas resources on the Norwegian continental shelf (NCS) are substantial. Forty-eight per cent of total resources lie in existing fields/discoveries, 28 per cent remain to be discovered and 24 per cent have been produced.
- That provides a basis for at least 50 years of oil production and 100 years of gas output.

Oil production from the NCS started on the Ekofisk field in 1971. Gas exports began from the same field in 1977. Bringing Draugen on stream in 1993 introduced the Norwegian Sea as a production province, and Snøhvit was approved this year as the first Barents Sea development.

Production has generally grown year by year (see figure 1) since activities began. Oil output averaged 3.1 mill barrels per day in 2001, and is expected to average three mill barrels per day for 2002 as a whole. This level is likely to be maintained over the next four years.

Gas and small quantities of natural gas liquids (NGL) are also produced. Sales of gas are expected to build up from the present level of 60 bn scm per year to an annual total of 100 bn scm in 2010.

In addition to offshore developments, land-based facilities have been built at Kårstø, Kollsnes, Sture, Mongstad and Tjeldbergodden in order to bring oil and gas ashore and process them to a greater or lesser degree.

Oil and gas are non-renewable resources, and their production often generates revenues in excess of those normally achieved in other industries. In Norway, much of these additional earnings accrue to the government through taxes and the SDFI. In addition, the government receives dividends from Statoil and Norsk Hydro.

Petroleum activities have contributed enormous revenues to Norwegian society. Total earnings from the sector have varied over time in line with changes in prices and production. See figure 2. Petroleum revenues are largely determined by world market prices for crude oil, the US dollar exchange rate and production costs. This means that the government loses considerable revenues when the price of oil is low. Annual government cash flow from the sector is reduced

by an estimated NOK 1 billion for each NOK 1 fall in the price of a barrel of oil.

Demand for goods and services generated by operations on the NCS has created major spin-offs for the community. A high percentage of the contracts for exploration, development, production, transport and removal of redundant equipment have been won against international competition by Norwegian companies. This has helped Norwegian offshore suppliers to become so strong that they have also gradually gained entry to the international market in recent years. Being competitive on the world market is vital for the industry's survival beyond the producing life of the NCS.

1

Environmental protection by the authorities

Environmental policy in Norway has historically been based on direct regulation of environmentally harmful emissions and discharges, but increased use is now been made of economic instruments such as taxes. The authorities in a number of other countries have shown greater preference for agreements with industry to limit the environmental impact of various types of emissions and discharges.

The Norwegian authorities regard close cooperation with the industry as essential for achieving established environmental goals without imposing excessive economic costs on society. Miljøsok was established in 1995 in order to promote such collaboration in the petroleum industry.

This initiative aimed to maintain the position of the NCS as an example of environment-friendly and competitive oil and gas activities. Oil companies, contractors, the authorities and other affected interests have participated in its work. Miljøsok ended in 2000, but is being followed up by a new organisation for collaboration, the Environment Forum.

Exploration phase

The objective of opening new areas for exploration is to find profitable petroleum resources for future development and production. The most important environmental impact of exploration work is the threat of acute discharges (spills) of oil, which are potentially dangerous to larvae, fish eggs, fish, seabirds, marine mammals and life along the shore. However, the likelihood of such spills is very low. No major acute discharges have occurred during exploration drilling on the NCS.

Before a new area of the NCS is opened for petroleum activities, detailed analyses are carried out on behalf of the government to assess the extent to which exploration could harm the environment. The obligation to carry out such impact assessments is laid down in the Petroleum Act. Studies are subject to public consultation and then presented to the Storting (parliament). Special impact assessments have been carried out for the Norwegian Sea, the Skagerrak and the southern Barents Sea.

The government also lays down specific requirements in opened areas which seek to restrict conflicts with environmental and fishing interests. These can include restrictions on when drilling is allowed to take place, and specific emergency response requirements to limit damage done by possible oil spills.

Once an area has been opened for petroleum activities, blocks in the area can be put on offer. Production licences are awarded to those companies which the government believes, after an overall evaluation, can best recover the predicted assets in the area.

1

The Barents Sea is an important area for several reasons. It ranks as one of Norway's best fishing areas while probably also containing substantial oil and gas resources. Extensive studies have been carried out in connection with the opening of the southern Barents Sea in 1989 and ahead of the development of the Snøhvit gas field.

Where further petroleum activities in these waters are concerned, the government wishes to investigate the overall impact of all commercial activity in the Barents Sea in order to establish a holistic management plan. This would take unified account of the environment, fishing, petroleum activities and maritime transport.

The Ministry of Petroleum and Energy (MPE) has taken steps to establish the consequences of year-round petroleum activities in the waters northwards from the Lofoten Islands as part of the work of drawing up the plan. This includes a review of previous studies in order to identify where the need for additional knowledge is greatest.

Development and production phase

Once commercially-viable discoveries have been made, the next phase covers development and operation to recover these assets.

Before the licensees can develop a discovery, the Petroleum Act requires that a plan for development and operation (PDO), and possibly a plan for installation and operation (PIO), is approved by the authorities.

As part of the PDO/PIO process, the operator must submit an impact assessment. This study will describe any environmental effects of expected emissions and discharges, and includes a systematic review of costs and benefits of any mitigatory measures. Both the programme and the actual impact assessment are subject to public consultation.

Depending on the scope of the development, the PDO/PIO is approved by the King in Council or the Storting on the basis of an overall evaluation. Environmental protection represents one of the criteria applied in this evaluation.

In addition to the danger of acute discharges, the production phase involves continuous emissions to the air and discharges to the sea. These primarily include:

- discharges of water containing residual oil and chemicals
- emissions of carbon dioxide (CO_2) and nitrogen oxides (NO_x) from energy production and flaring
- emissions of non-methane volatile organic compounds (nmVOC) during offshore loading of oil.

The following policy instruments are deployed by the authorities to limit the environmental impact of emissions and discharges during the operating phase:

Carbon dioxide

With effect from 1 January 1991, the Carbon Dioxide Tax Act imposed a carbon tax on the use of gas, oil and diesel oil in petroleum activities on the NCS. This tax is levied on all combustion of fossil fuels – primarily natural gas and diesel – which emit carbon dioxide. From 1 January 2002, the tax rate on the NCS is NOK 0.73 per litre of oil/scm of gas.

Gas flaring, other than volumes necessary for safety reasons during normal operation, is not permitted under the Petroleum Act without the approval of the MPE.

Nitrogen oxides

Apart from possible requirements imposed during consideration of the PDO/PIO, nitrogen oxide emissions are currently unregulated on the NCS during the operating phase. Norway signed a new international agreement, the Gothenburg protocol in 1999, which includes an undertaking to ensure that nitrogen oxide emissions in 2010 are 29 per cent lower than they were in 1990. Possible national instruments to meet this commitment are currently under consideration. In this context, the Norwegian Petroleum Directorate (NPD) has studied proposals for a nitrogen oxide quota system on the NCS as a possible instrument.

NmVOC

NmVOC emissions from offshore loading and storing crude oil are now governed by emission permits issued under the authority of the Pollution Control Act.

Oil, organic compounds and chemicals

Companies must apply to the Norwegian Pollution Control Authority (SFT) for permits to discharge oil and chemicals to the sea. These permits are issued in accordance with the provisions of the Pollution Control Act. This statute provides that operating companies have the responsibility and obligation to establish the necessary emergency response arrangements to deal with acute spills. Local and central government emergency response plans provide further protection.

Closing phase

Several Norwegian offshore fields have now ceased production or are nearing the end of their producing life. The authorities have reached decisions on the disposal of redundant installations on North-East Frigg, East Frigg, Odin, Mime, Tommeliten Gamma, 2/4-S, Yme, Lille-Frigg and Frøy.

A cessation plan for the Ekofisk I facilities was received by the MPE in the autumn of 1999, and it was resolved in the autumn of 2001 that these installations should be brought ashore for recycling. The MPE received a cessation plan for Frigg in November 2001, and this is under consideration by the authorities in both Norway and the UK.

The rules in the Petroleum Act on disposing of installations will be applied in accordance with relevant national and international commitments. In 1998, the ministerial meeting of the convention for the protection of the marine environment of the north-east Atlantic (Ospar) approved a general prohibition on the disposal of redundant offshore installations in the area covered by the convention. This ban makes exceptions for concrete platforms, the bottom section of large steel structures and installations which, for unforeseen circumstances, are better disposed of on site. Before a decision is taken on the need to make an exception from the Ospar ban, other parties to the convention must be consulted.

Otherwise, the main regulations derive from the 1982 UN Convention on the Law of the Sea, guidelines adopted under its authority, and the International Maritime Organisation (IMO). These rules mean that the bulk of Norway's redundant offshore installations will be brought ashore for recycling or disposal.

The Ospar resolution does not cover pipelines and cables. A three-year study was launched in 1996 to clarify the effect of various disposal options for such facilities, and this led to the presentation of Report no 47 (1999-2000) to the Storting on decommissioning redundant pipelines and umbilicals on the NCS.

As a general rule, permission to leave pipelines and umbilicals in place should be granted when they cause no inconvenience or pose no safety risk to demersal fisheries compared with the cost of trenching, covering or removal.

Disposal issues are treated in accordance with the above-mentioned Ospar regulations and the Petroleum Act, together with prevailing guidelines. Taken together, these provisions provide a well-structured framework for dealing with decommissioning.

Status of emissions and discharges

1

The petroleum sector accounts for a substantial percentage of Norway's emissions of carbon dioxide (CO_2), nitrogen oxides (NO_x) and non-methane volatile organic compounds (nmVOC). In addition, it generates minor emissions of methane (CH_4) and marginal emissions of sulphur dioxide (SO_2). Operations also cause discharges of oil and various chemicals into the sea.

The various emission components contribute to different environmental problems. In dealing with transnational pollution and emissions and discharges in common areas such as international waters, the countries involved must work together to achieve the desired environmental goals.

Several international agreements commit Norway to limit emissions of various substances. How this affects the petroleum sector depends on the terms of the specific agreement. Those relating to emissions to the air usually specify ceilings for each country. The terms are crucial in determining whether obligatory emission curbs must be implemented entirely within a country or whether they can also be achieved in other countries where reduction costs may be lower. The costs of reducing emissions and discharges, both nationally and internationally, will be crucial in determining the extent to which measures are imposed on the petroleum sector.

Global environmental problems

Both carbon dioxide and methane are greenhouse gases which contribute to global warming. They are regulated internationally through the UN framework convention on climate change. Norway's obligations under the Kyoto protocol mean that its average greenhouse gas emissions in 2008-2012 cannot be more than one per cent higher than in 1990. That involves a reduction of about six per cent from the current level. This commitment can be met through reductions both domestically and in other countries through the use of the Kyoto mechanisms.

Regional environmental problems

Nitrogen oxides, sulphur dioxide and nmVOC contribute to regional transboundary environmental problems, such as acid rain, eutrophication (over-fertilisation) and ground-level ozone. They also cause certain local pollution problems. Emissions of these gases are regulated through protocols under the convention on long-range transboundary air pollution.

Norway, other European countries, the USA and Canada signed a new Gothenburg protocol in December 1999, which seeks to solve the environmental problems represented by acidification, eutrophication and ground-level ozone. Under this agreement, Norway must cut its annual emissions of nitrogen oxides to 156 000 tonnes by 2010. That represents a 29 per cent reduction from the 1990 level.

The commitment for nmVOC is virtually identical to the obligation accepted by Norway under the earlier Geneva protocol. This required nmVOC emissions from mainland Norway and the Norwegian economic zone south of the 62nd parallel in 1999 to be reduced by 30 per cent compared with 1989. Under the Gothenburg protocol, overall national emissions cannot exceed 195 000 tonnes per year.

Local environmental problems

Oil and chemical discharges from offshore installations may have local effects around their source and are regulated nationally by emission permits issued under the Pollution Control Act. In addition, such discharges are regulated by the Ospar convention because they take place in international waters and thus concern more than one country.

A maximum oil content has been set internationally for discharges of water to the sea, and a target for reducing total oil discharges from the offshore sector. Chemical discharges are regulated internationally with the aid of a categorisation of the inherent properties of each chemical.

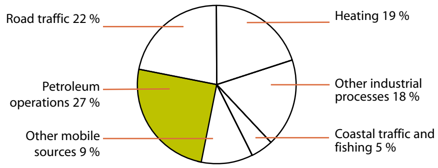

Figure 3 Sources of Norwegian carbon dioxide emissions, 2000. *(Source: Statistics Norway/SFT)*

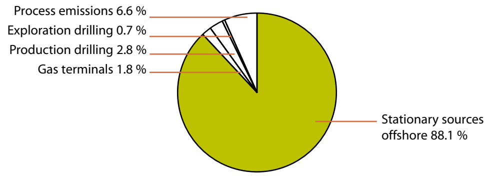

Figure 4 Carbon dioxide emissions from petroleum activities in 2000 by source. *(Source: MPE/NPD)*

Carbon dioxide (CO_2)

Environmental impact of carbon dioxide

- The most important gas contributing to the greenhouse effect, which can lead in turn to global warming.
- According to the UN's panel on climate change, "the balance of evidence suggests a discernible human influence on global climate".

Emissions of carbon dioxide from human activities derive largely from burning fossil fuels. Petroleum activities account for about 27 per cent of Norwegian emissions of this gas (see figure 3), and this percentage is expected to increase over time. The other major sources in Norway are road traffic and other mobile sources, heating, and various industrial processes.

As figure 4 shows, the bulk of carbon dioxide emissions by the petroleum sector derive from offshore installations. Other sources include gas receiving terminals on land and – indirectly – nmVOC emissions (process emissions). Virtually all taxed carbon dioxide emissions from installations on the NCS derive from gas combustion in turbines and through flaring, and burning diesel oil (figure 5). Natural gas releases the lowest volume of carbon dioxide per unit of energy of any fossil fuel.

Total carbon dioxide emissions from the sector have grown year by year, mainly as a result of increased activity. The trend in recent years and forecasts for the immediate future are shown in figure 6. Higher overall emissions do not mean there have been no environmental gains. However, improved energy utilisation and reduced flaring have not been enough to offset the rise in energy consumption to which increased activity has contributed.

One indication that operations have become more efficient is that carbon dioxide emissions per unit of oil equivalent produced declined by 24 per cent from 1990 to 2001 (see figure 7).

This can partly be attributed to:

- general improvements in technology
- measures to reduce emissions, partly prompted by the carbon tax imposed in 1991.

However, other factors – including a growing number of producing fields and the fact that key fields have reached a mature phase – could boost emissions.

Generally speaking, emissions from producing a unit of oil or gas vary both between fields and over a field's producing life. Reservoir conditions and transport distances to the gas market are factors which produce variations between fields in energy demand and consequently in emissions. Varying emissions over a field's producing life reflect the rising water cut (proportion of water in the well-stream) as production continues. Since energy requirements for processing are largely determined by the total volume of water, oil and gas in the well-

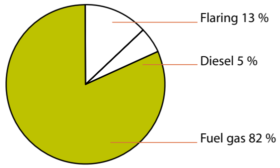

Figure 5 Taxed carbon dioxide emissions from oil and gas production by source. *(Source: NPD)*

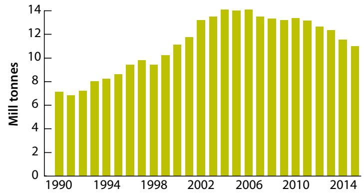

Figure 6 Total emissions of carbon dioxide from the Norwegian petroleum sector. *(Source: MPE/NPD)*

stream, emissions per unit produced will rise as a field ages. This is one reason for a slight increase in Norwegian emissions per unit produced in recent years.

The trend on the NCS towards more mature fields and the northward shift of activities encourage higher emissions per unit produced. Treatment and transport of produced gas require more energy than liquids production, and the proportion of produced gas in total Norwegian output is steadily rising. This makes an important contribution to the development of the "carbon dioxide emissions per unit produced" indicator. Figures from the NPD for 2001 show a slight increase in overall carbon dioxide emissions by the offshore sector from 2000 to 2001.

Some comparisons of emissions per unit of oil and gas produced in various countries have been made to gain some impression of how much greenhouse gas is released from activities on the NCS and in comparable regions elsewhere. It must be emphasised that considerable uncertainties attach to such comparative figures.

A study by the Sintef research foundation compared greenhouse gases on the NCS with similar emissions in other countries, including Russia, the Netherlands, Britain and the USA. Russian carbon dioxide emissions from gas production were not available.

Activities on the NCS came out well in the study. An oil or gas unit produced on the UK continental shelf - perhaps the area most directly comparable to Norway's offshore sector – generates more than three times the emissions of a similar unit on the NCS, for example.

Measures to reduce carbon dioxide emissions

The development of combined cycle solutions offshore, recycling of flare gas and injection of carbon dioxide from produced gas on Sleipner West help to show that Norway's offshore sector is well advanced in applying environmentally efficient technology.

Combined cycle systems, currently operational on Oseberg, Snorre and Eldfisk, involve using the waste heat in gas turbine exhaust fumes to produce steam for generating additional electricity. These units are unique in offshore terms.

The carbon dioxide content in Sleipner West output must be reduced in order to meet sales specifications for the natural gas. This field is the first on which carbon dioxide separated from the wellstream has been injected in a sub-surface formation. That in turn eliminates about one million tonnes of carbon dioxide emissions per year.

Injecting carbon dioxide to improve recovery

Carbon dioxide can to some extent replace or supplement injection of natural gas and water to maintain pressure in oil and condensate (light oil) reservoirs and thereby improve recovery. The largest potential for using carbon dioxide in this way is expected to be in tertiary production after waterflooding on the major oil fields.

This potential has two aspects. One is that part of the gas resources injected will be lost because

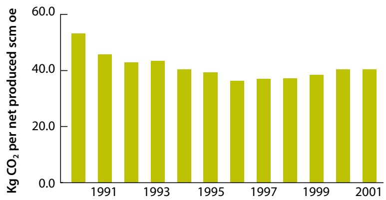

Figure 7 Emissions of CO_2 per unit produced.
(Source: NPD)

they cannot be produced again. The NPD estimates that this loss averages about 20 per cent of the injected gas. Some 40-50 bn scm of gas annually is due to be injected for pressure support in 2000-2005.

Second, some of the residual oil will be dissolved by injected carbon dioxide during tertiary production after waterflooding. Carbon dioxide can also drain areas unaffected by the water, such as the top of the reservoir. Injecting carbon dioxide to improve oil recovery has been practised in the USA for many years.

To follow up one of the measures proposed in the final report on *Common environment – common commitment* from the second Miljøsok phase, the authorities have established an action team with representatives from a number of the companies, the Norwegian Oil Industry Association (OLF) and the NPD to clarify the potential for using carbon dioxide to improve oil recovery. Initiated in the spring of 2001, this study is due to be competed in the autumn of 2002.

The work will be carried out in three phases:

- selection of fields for preliminary evaluation
- preliminary evaluation of the potential in the selected fields using classic methods
- full-scale compositional simulation on the basis of results from the preliminary evaluation.

Work will also cover the cost implications of modifications required to existing facilities. It has been decided to study Gullfaks, Ekofisk, Brage and Vigdis/Borg/Snorre North/Tordis. This provides a mix of large and small fields and of sandstone and chalk reservoirs.

Technology decided for use in reducing carbon dioxide emissions:

- carbon dioxide separation from the Sleipner West wellstream and subsequent deposition below ground
- utilising exhaust heat in the process system
- more efficient energy generation, such as the use of combined heat and power on Oseberg, Snorre and Eldfisk
- optimal dimensioning of pipelines
- replacing old installations, as on Ekofisk
- making greater use of more efficient gas engines in place of gas turbines
- optimising new fields for energy use and utilisation
- supplying electricity from land to Troll A
- recovering flare gas
- transferring power between Snorre A and B.

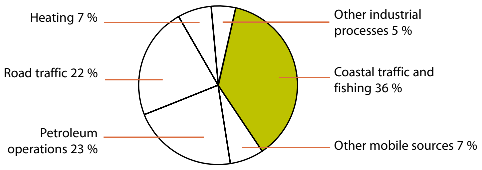

Figure 8 Sources of nitrogen oxide emissions in Norway, 2000. *(Source : Statistics Norway)*

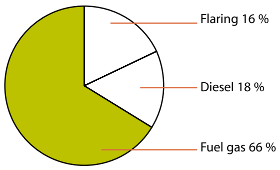

Figure 9 Nitrogen oxide emissions from oil and gas production by source, 2001.
(Source: NPD)

Nitrogen oxides (NO_x)

Environmental impact of nitrogen oxides

- Harm to fish and animal life through acidification of river systems and soils.
- Damage to buildings, stone and metals from acid precipitation.
- Eutrophication causing changes to the composition of the ecosystem.
- Damage to health, crops and building from the formation of ground-level ozone when nitrogen oxides and nmVOC are exposed to sunlight.

Nitrogen oxides are mainly formed by burning fossil fuels. Emission volumes depend on both combustion technology and fuel consumption. Gas turbines generate lower nitrogen oxide emissions than diesel engines, for instance.

Mobile sources account for the bulk of Norwegian nitrogen oxide emissions (see figure 8). The petroleum sector contributes 23 per cent. As with carbon dioxide, turbines, flaring and diesel engines on installations represent major offshore sources (see figure 9). Some emissions will also relate to exploration and gas receiving terminals on land.

As figure 10 shows, emissions of nitrogen oxides from the sector have grown steadily since 1990. This is primarity because increased activity has boosted energy consumption and thereby volumes released. The change in emissions per unit produced provides an indication of offshore efficiency gains. Emissions per unit produced are shown in figure 11.

Carbon dioxide and nitrogen oxide emissions are closely linked, since both derive from the same principal sources. The only exception is low nitrogen oxide burner technology for gas turbines, which can cut the release of these components by up to 90 per cent without affecting carbon dioxide emissions. In some cases, the amount of carbon dioxide given off can actually rise with this technology.

Emissions per unit produced of oil equivalent provide an appropriate way to compare emissions on the NCS with those from similar areas elsewhere. It must be emphasised that, for many reasons, considerable uncertainty attaches to such cross-national comparisons. A study for Miljøsok indicates that emissions of nitrogen oxides on the NCS are lower than in countries which offer an appropriate comparison.

Norway signed a new international agreement (the Gothenburg protocol) in 1999. This is dedicated in part to regulating nitrogen oxide emissions. Possible measures for reducing such emissions are listed below, but it is too early to say what impact this agreement will have on the petroleum sector.

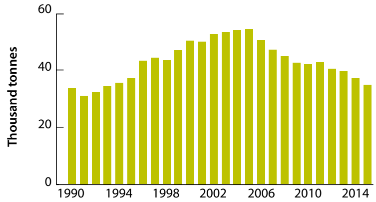

Figure 10 Emissions of nitrogen oxides from the Norwegian petroleum sector. *(Source: MPE/NPD)*

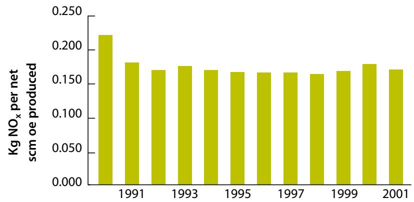

Figure 11 Emissions of nitrogen oxides per unit produced. *(Source: MPE/NPD)*

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Measures to reduce nitrogen oxide emissions:

- installing low nitrogen oxide burners in new gas turbines, with the potential to reduce emissions by up to 90 per cent
- the same measures for reducing carbon dioxide emissions, apart from separation
- catalytic cleaning
- steam injection in the combustion chamber.

The NPD established an action team in the autumn of 2000, with participation from the industry, to undertake a technical-economic impact assessment of retrofitting low nitrogen oxide burners on gas turbines and selective catalytic reduction (SCR) on gas engines. A final report was presented in the autumn of 2001. Low nitrogen oxide burners are regarded today as the most relevant way to achieve significant emission reductions from Norwegian offshore oil and gas activities.

Compared with earlier analyses, this study has provided a more sophisticated and diversified picture of the cost of measures. Costs associated with increased downtime on installations as a consequence of retrofitting low nitrogen oxide burners are a "new" and dominant consideration. Turbines with such burners also need more frequent and extensive maintenance than traditional machines. In a life-cycle perspective, this adds up to a substantial additional expenditure.

The study shows that the general level of costs for retrofitting low nitrogen oxide burners is substantially higher than was previously estimated. And the environmental benefit of retrofitting such units will vary from turbine to turbine. Generally speaking, burners on machines with high energy efficiency will yield a substantial environmental gain. Installing them on turbines running at partial load will increase carbon dioxide emissions while failing to achieve the same nitrogen oxide reductions as full-load operation.

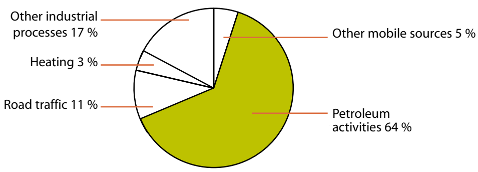

Figure 12 Sources of nmVOC emissions in Norway, 2000. *(Source: Statistics Norway)*

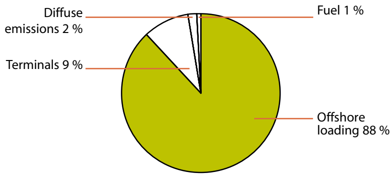

Figure 13 Sources of nmVOC emissions from the petroleum sector, 1999. *(Source: NPD)*

Non-methane volatile organic compounds (nmVOC)

Environmental effects of nmVOC

- Formation of ground-level ozone may damage human health as well as crops and buildings.
- Direct exposure may damage the respiratory system.
- Contributes indirectly to the greenhouse effect because carbon dioxide and ozone form when nmVOC reacts with air in the atmosphere.

NmVOC is a general term for volatile organic compounds other than methane which vaporise from crude oil and other substances.

The petroleum sector is the main Norwegian source for emissions of nmVOC, accounting for 64 per cent of the volume released in the country. Figure 12 shows that other industrial processes and road traffic are also major sources. The bulk of emissions in the petroleum sector derive from offshore storage and loading of crude oil and from receiving terminals on land. Some emissions also occur at gas terminals and from minor leaks (see figure 13).

Norwegian emissions from offshore loading of crude have so far derived largely from the loading buoys on Statfjord and Gullfaks. Other big fields, such as Oseberg, Troll and Ekofisk, pipe their oil to land. Emissions from loading a unit of oil differ widely between the various fields. Variations in the content of light components in the oil are one of the main reasons for this.

Several of Norway's new offshore developments utilise floating storage units. With oil held under atmospheric conditions, this kind of solution may release more nmVOC than fields such as Statfjord, Draugen and Gullfaks where crude is stored in the platform base. This is because emissions also occur when production is sent to storage.

The oil companies have worked for many years to make nmVOC recovery technology available to the shuttle tankers which ship oil from fields to port. One proven solution is now available for such recovery, based on returning the vapour to the cargo tanks. This can cut emissions by some 70 per cent. Other solutions are under development.

NmVOC emission forecasts from the petroleum sector show a sharp decline after 2002 (see figure 14). This reflects both an expected peaking in oil production within a few years, and the prospect that recovery equipment will be installed in line with requirements imposed under the Pollution Act. This will be crucial for Norway’s observance of the Gothenburg protocol.

Sture first

An nmVOC recovery plant was commissioned at the crude oil terminal on Sture in 1996. The plant has the potential to reduce such emissions by about 90 per cent for each loading operation, and is the first of its type to be installed at a crude oil terminal. To

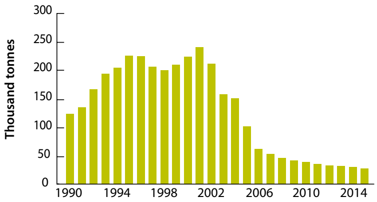

Figure 14 Total emissions of nmVOC from the Norwegian petroleum sector. *(Source: MPE/NPD)*

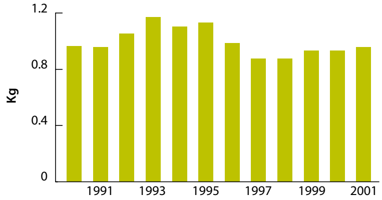

Figure 15 NmVOC emissions per produced unit. *(Source: MPE/NPD)*

use it, tankers must be equipped with the appropriate connectors.

Recovery actually achieved in the first year of operation was just under 40 per cent, since only a limited number of the tankers had the necessary equipment. To encourage installation of the latter, considerable reductions in port fees are being offered to ships with the relevant connectors. Most vessels now have recovery facilities, and all carriers must have installed nmVOC recovery systems by 1 January 2003. Technology problems and hot oil mean that only 50 per cent of emissions were recovered in 2001. Studies are currently under way to upgrade the plant to meet new operating conditions. The aim is a recovery factor of 80-90 per cent.

International comparisons indicate that emissions of nmVOC per volume of oil and gas produced are higher on the NCS than in other countries. The high proportion of offshore loading off Norway could be one explanation.

Measures to reduce nmVOC emissions:

- recovery of nmVOC at Sture
- recovery of nmVOC on the NCS:
  - return to the oil cargo
  - measures in process plants on the installations
  - recovery relating to storage
  - new concepts for recovery during loading
  - condensing for use as fuel on the shuttle tanker.

Chemicals, oil and other organic compounds

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Environmental effects of discharging oil and other organic compounds:

- Spills/acute discharges can harm fish, marine mammals, seabirds and shore zones.
- Considerable uncertainty exists about the environmental consequences of operational discharges. No environmental damage has yet been proven. Considerable research is under way, particularly into long-term effects.
- Great uncertainty also exists about the long-term effects of dissolved organic compounds, such as polycyclic aromatic hydrocarbons (PAH) and alkyl phenols. Considerable research is again being conducted in this area.

Environmental effects of discharging chemicals:

- Discharges embrace a variety of substances with very different potential effects on the environment.
- Most of the chemicals used (more than 99 per cent) are assumed to have little or no environmental impact.
- Little is still known about the possible long-term effects of chemical discharges.
- Several of the chemicals have some local toxic effect. Studies show they are diluted in the water column, and thereby do not represent a significant acute environmental hazard beyond the immediate vicinity of the discharge.
- Some of the chemical discharges could have extremely serious environmental consequences, including hormonal disturbances, and be bio-accumulative.

Oil and other organic compounds

Discharges from Norwegian petroleum activities are estimated to account for two per cent of the total oil entering the North Sea. The main sources are shipping and the mainland, via rivers. Oil discharges from the petroleum sector derive almost entirely from ordinary operations, although acute spills do occur.

Produced water consists primarily of formation water which has been in contact with the oil in the reservoir, and accordingly contains a number of organic compounds. The most important in an environmental perspective are PAH and alkyl phenols.

Chemicals

This is a generic term for all additives and other substances used in drilling and well operations and in oil and gas production. An efficient oil and gas business would be impossible without chemicals.

Substantial efforts are therefore being made to develop substances which cause the least possible harm to the environment when used. The Charm model, developed by the nations involved in Ospar, is applied to ensure that environmental considerations are taken into account when selecting chemicals for offshore use.

In considering the environmental impact of chemical discharges, it is important to distinguish between:

- largely harmless and more harmful chemicals
- the quantities used and discharged
- where discharges are made and under what conditions, and conditions in the recipient (water column).

More than 99 per cent of the chemicals used in Norwegian petroleum activities are thought to have little or no environmental impact. A large proportion exist naturally in seawater. The remainder are chemicals which have an impact on the environment or whose potential effects have not been sufficiently well documented.

Forty-one per cent of the chemicals used were discharged to the sea in 2001, including the water in

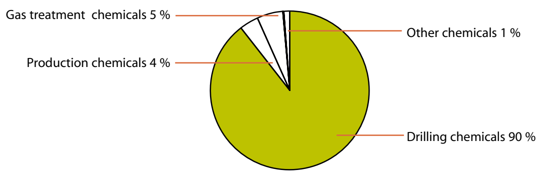


Figure 16 Chemical discharges on the NCS by activity, 2000.
(Source: SFT)

which these substances were dissolved. The figure for 1989 was 64 per cent (excluding the water). Chemicals not discharged were dissolved in the oil, deposited below ground or treated as waste.

Drilling and well operations

As figure 16 shows, drilling and well operations clearly rank as the biggest source of chemical discharges on the NCS. Year-on-year changes in the overall figure for such discharges therefore relate largely to variations in the number of wells drilled.

Discharging oily drill cuttings has been prohibited on the NCS since 1991. As figure 18 shows, this ban has contributed to a significant reduction in oil discharges from operations compared with the level if oily cuttings could still be discharged.

Combined with increasing injection of cuttings below ground, new drilling methods and technology have cut discharges per metre drilled in recent years (see figure 19). Since water-based drilling fluids use more chemicals, the switch to this type of fluid following the ban on discharging oil-based mud has pulled in the opposite direction. As mentioned above, cuttings contaminated with oil-based mud are no longer discharged on the NCS. Recycling, underground injection and disposal on land are alternative ways of avoiding discharges from drilling.

Produced water

Water produced together with oil and gas is the main source of oil discharges to the sea from daily operations (see figure 20). Even if such water is carefully treated before discharge, it still contains oil residues and dissolved organic compounds.

The average concentration of oil in produced water on the NCS has been declining slightly. Under the Ospar convention, the oil content in water discharged to the sea must not exceed 40 g/cu.m. In 2001, Ospar approved recommendations that this ceiling should be reduced to 30 g/cu.m from 2006, and that total oil discharges in produced water by member countries should be reduced by 15 per cent in the same year compared with the 2000 level. The annual average for Norwegian installations in 2000 was about 25 g/cu.m. This concentration has been fairly stable since 1990 (see figure 21).

Several of Norway's largest fields have now reached such a mature phase that their water cut is higher than before, boosting the volume of produced water and thereby oil discharges. Injecting produced water below ground has started on a growing number of Norwegian fields (see figure 22). Just under 13 per cent of all produced water was injected in 2001.

Discharges of production and injection chemicals have risen in recent years, primarily reflecting increased use of subsea templates and more water injection. Such operations normally depend on chemicals. However, no clear trend can be discerned in the content of production chemicals in produced water (see figure 23).

Acute spills

Harm caused to the natural environment by oil spills depends on various factors which are more important than the size of the spill. Spill site, season, wind strength, current and the effectiveness of emergency response are crucial for the scope of any harm. Most serious Norwegian oil spills have

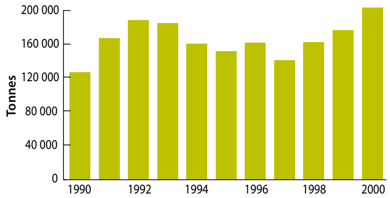


Figure 17 Total chemicals discharged from Norwegian petroleum activities. *(Source: SFT)*

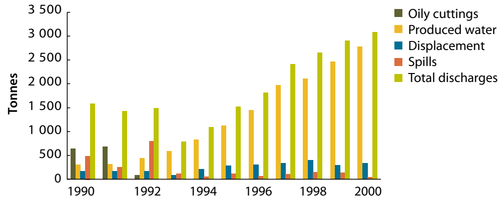


Figure 18 Total oil discharges by source. *(Source: SFT)*

involved ships close to the coast. Norway's petroleum sector has not been responsible for any major oil spills reaching the shore. Extending offshore activities towards coastal and more environmentally-sensitive areas will increase the risk of serious harm from oil spills caused by operations on offshore installations or loading into tankers on the field.

A relatively large number of oil spills have occurred on Norwegian offshore installations (see figure 24). As mentioned above, however, the total volume of oil involved in these spills is extremely limited compared with other sources.

Zero discharge strategy at sea

The "zero discharge" concept does not mean that all types of discharge will cease, and the term can consequently be somewhat misleading. It refers to a strategy for the continuous reduction of environmentally-harmful emissions towards a level which equals zero for all practical purposes. Any harm to the environment at this level will depend on the content of potentially harmful chemicals as well as the time and place of the discharge. The degree of harm will depend on the content of environmentally-harmful compounds and on field-specific conditions for discharge and recipient.

The general rule for new stand-alone developments will be zero discharges to the sea. It is important to carry out an overall evaluation of discharges to the sea, emissions to the air and energy conservation before final technological solutions are chosen.

This strategy will also be pursued for fields in production and for smaller developments tied back to existing installations. Local conditions on the various installations will affect which solutions are appropriate in such cases. The aim is for all fields to achieve zero harmful discharges by 2005.

New technology is important in successfully implementing the zero discharge strategy. Solutions for separating or blocking water before it reaches the installation will be key elements in achieving this goal. Separation can take place either downhole or on the seabed. In addition to reducing discharges to the sea, such technology could have favourable effects on emissions to the air (because energy consumption is reduced) and on oil production (because the water is used for pressure support to improve oil recovery).

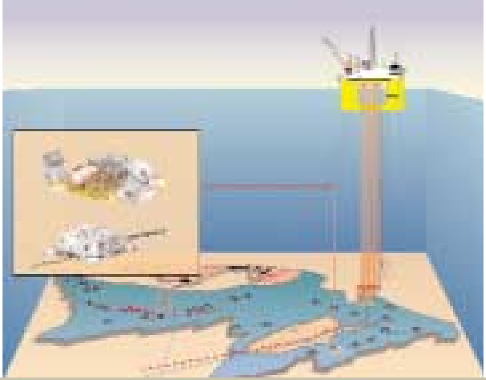
A pioneer on Troll

Troll Pilot is a subsea unit designed to separate produced water from the rest of the wellstream in one of the flowlines running to the Troll C platform. The water is then injected back into the reservoir, cutting both transport of produced water and discharges of oily water.

Such benefits can also be achieved by downhole separation, which has so far only been tested in fields on land.

Where appropriate, returning produced water below ground is another method which could help to reduce discharges. Such technology is used today on several fields, and will be implemented on several recently-approved developments. It will be particularly interesting on fields which need water injection for pressure support.

Injecting produced water when pressure



support is not required will boost energy consumption, and thereby emissions to the air. In such cases, an overall evaluation can determine whether the method is appropriate. Trials have been carried out on other fields with shutting off aquifers downhole, which could also reduce the water cut.

Technologies for eliminating or reducing discharges of environmentally-harmful compounds in produced water

- full or partial injection below ground after topside separation
- mechanical or chemical shut-off of aquifers in wells
- separation downhole or on the seabed, followed by injection back below ground.

Technologies to avoid discharges of drilling fluids

- recycling
- collection and injection below ground
- collection and disposal on land.

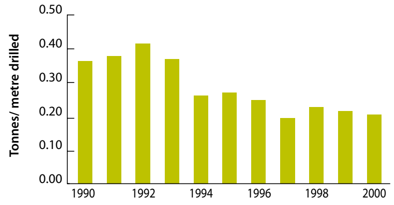


Figure 19 Discharges of drilling chemicals per metre drilled.
(Source: SFT/NPD)

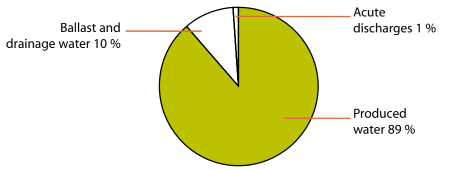


Figure 20 Oil discharges on the NCS by activity, 2000.
(Source: SFT)

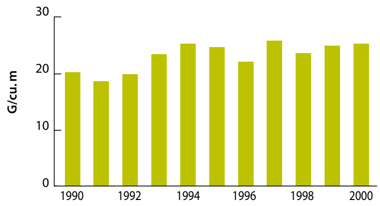


Figure 21 Discharges of oil per cubic metre of produced water. *(Source: SFT)*

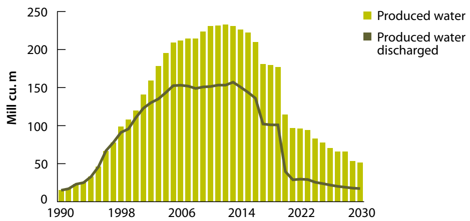


Figure 22 Volumes of produced water and produced water discharged, historical and forecast. *(Source: NPD)*

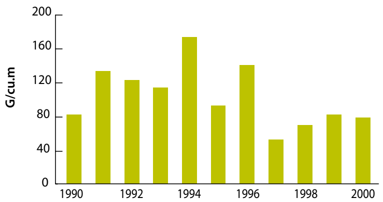


Figure 23 Content of production, injection and pipeline chemicals in produced water. *(Source: SFT)*

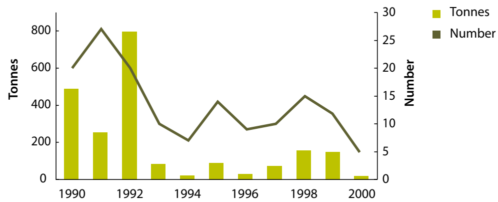


Figure 24 Acute oil spills over one tonne.
(Source: SFT)

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Section 2

Oil and fish – common sea

Introduction

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The petroleum industry has been an important players in the seas off Norway for several decades. Ever since it got under way on the NCS more than 30 years ago, the authorities have emphasised that this sector can and should work in harmony with other industries operating in these waters. And an important premise throughout the history of oil and gas activities in Norway is that this business should operate within acceptable environmental limits.

Petroleum and fishing are two of Norway's most important industries, and have a common responsibility to continue contributing to the biggest possible value creation. Over the past two decades, the petroleum industry has been highly important for the Norwegian economy and contributed significantly to value creation in the country.

The value it creates is higher than the total contribution from other Norwegian industry. During the 1990s, its average share of gross domestic production and total export value stood at 14 and 34 per cent respectively. These proportions were substantially higher in 2000-2001, at 24 and 47 per cent respectively. That largely reflects higher oil prices. The NCS has substantial remaining petroleum resources, which provide a basis for continued production of oil for about 50 years and gas for roughly a century.

The NCS is divided into three areas – the North, Norwegian and Barents Seas (see map 1). After the North Sea was opened to exploration in 1965, new acreage has been made available stage by stage for petroleum activities. The first licences in the Norwegian Sea and the southern Barents Sea were awarded in 1980.

Following many years of activity, the North Sea is now in a relatively mature phase. The largest fields are thought to have been found, and future discoveries will primarily be small.

Several relatively large discoveries have been made in the Norwegian Sea in recent years. Ormen Lange is a case in point. The Halten Terrace is a mature exploration province, but areas in deep water and off the Lofoten Islands remain little explored or have yet to be opened for petroleum activities.

In the southern Barents Sea, acreage around the Snøhvit field in the Hammerfest Basin is in a relatively mature exploration phase. The rest of this area has not been matured to any extent.

Areas currently open for petroleum activities account for about 60 per cent of the NCS. Production licences cover about nine per cent of the opened acreage. Those areas still closed to petroleum activities include parts of the Norwegian Sea close to the shore, parts of the Skagerrak to the south, and much of the Barents Sea.

Fishing and fish farming are crucial industries along much of the Norwegian coast. A large number of people are directly employed in these sectors. Norway's fisheries annually catch several million tonnes of fish in the North, Norwegian and Barents Seas. Seafood exports earned the country NOK 30 billion in 1999, or 8.7 per cent of total foreign sales. That makes fishing and fish farming a substantial export industry.

In some areas, petroleum activities are pursued in or near important breeding grounds for rich fish stocks. Breeding is a dynamic process, and the areas used for this purpose can vary from year to year. The most important of them are shown in map 2. These activities are by and large conducted in ways which avoid conflicts of interest between the oil and fishing. Since offshore activities got going more than 30 years ago, issues concerning the relationship between petroleum, fishing and the environment form an input to decision-making by the industry. The environmental impact of its activities and its relationship to the fishing sector were being debated as early as Report no 25 (1973-74) to the Storting on the role of petroleum activities in Norwegian society.

But the industry nevertheless presents challenges to the environment and fishing. Harmonious relations between offshore and fishing interests depend on good cooperation between these sectors and the authorities. Both the government’s regulatory tools and the sector's own commitment to better environmental management are key elements in protecting the interests of both industries.

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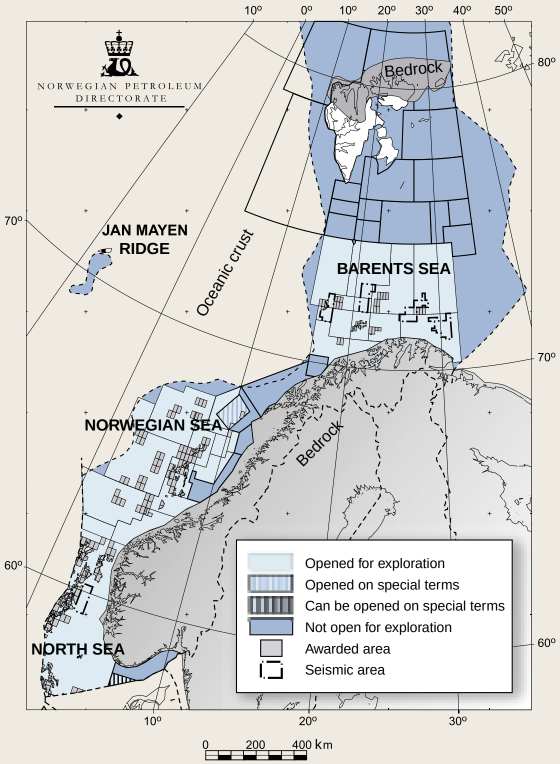
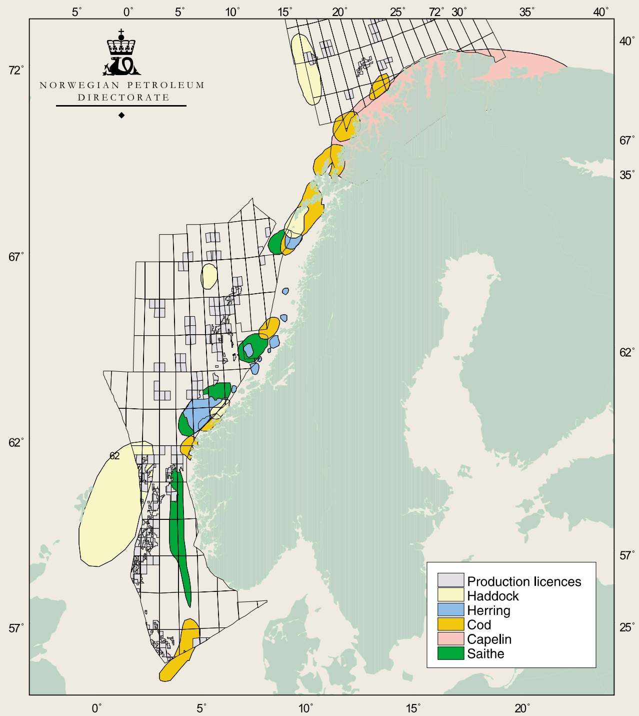
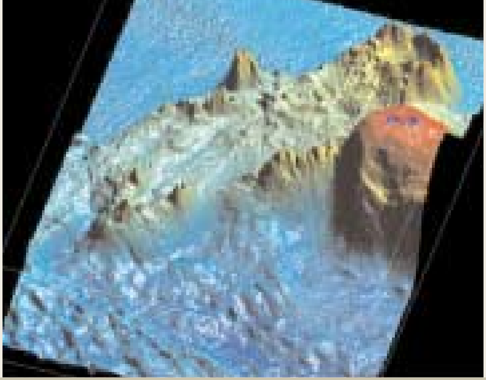


Map 1 Petroleum activities on the NCS.



Map 2 Breeding grounds for fish along the Norwegian coast.



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Challenges

Overlapping areas

Both industries are naturally dependent on being physically present where their resource bases are to be found. Balancing the interests of both sides in accessing areas can be relevant issues in every phase of petroleum activities.

This is particularly crucial when announcing blocks on offer for exploration drilling, defining safety zones around oil installations, laying pipelines and cables, and access for fish after petroleum activities have ceased.

Seismic surveying

Extensive research has been conducted by the petroleum industry into the environmental effects of seismic surveys over a number of years, including studies by Norway's Institute of Marine Research. This work has concluded that no direct physical damage can be identified to fish, fry or larvae from seismic data gathering. However, surveys could frighten marine life to a small extent and thereby reduce catches.

Substantial technological progress has been made in the quality of seismic information and the ability to handle large volumes of such data. This makes it possible to improve the quality of surveys substantially ahead of exploration drilling, which in turn increases the likelihood of making a discovery and thereby reduces the need for wells. That development represents an environmental gain in itself.

Discharges to the sea

Discharges to the sea from petroleum activities and their potential effects on living marine resources also play an important role in relations between this industry and fishing. The principal components in such discharges are oil, other organic compounds and chemicals. They largely derive from regular activities, but acute spills and discharges from drilling can also occur. Norway's oil and gas business accounts for about two per cent of the oil discharged to the North Sea, with shipping and run-off from land via rivers as the main sources.

About 85 per cent of the oil discharged by the petroleum sector is contained in produced water, which primarily comes up from the formation in the wellstream. The environmental impact of such water relates primarily to organic components such as PAH and alkyl phenols, heavy metals and some chemicals.

However, the dispersion and effects of produced water are difficult to track in the water column because concentrations of substances are small, dilution is high and no plants or animals remain long within the direct area of influence of the discharges. Just under 13 per cent of produced water on the

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NCS is injected back below ground, and forecasts indicate that this will rise to about a third when water production from offshore wells peaks around 2010.

Various chemicals are necessary as additives and utilities in petroleum activities, with drilling and well activities accounting for most of the consumption and discharges. Discharging substances which might cause environmental harm is normally banned today, with the environmental impact of discharges from ordinary drilling activities both minor and confined to the area immediately around a well.

The operators are working to reduce the impact of such discharges even further. However, a number of chemicals used in petroleum activities have some toxic effect locally, while a small proportion of the substances discharged could have disruptive effects on hormones and be bioaccumulative. About 99 per cent of the chemicals used are thought to have little or no environmental impact, but knowledge about possible long-term effects remains inadequate.

At present, the probability of acute spills from petroleum activities is very low. No large acute spills have occurred since the Bravo incident in 1977. Potential sources of accidental discharges from the petroleum sector will be blowouts, pipelines and shuttle tankers.

Petroleum activities close to the coast and in northern areas

Challenges relating to the marine environment will differ between the North, Norwegian and Barents Seas. And new challenges have arisen now that the petroleum sector in the North Sea has entered a mature phase, and activities are moving steadily further north and closer to the shore.

Food chains in the environmentally-sensitive northern waters are fewer and shorter. Long periods of darkness and low temperatures mean that degradability and other environmental effects of oil and chemical discharges differ from those found further south. Warmblooded marine animals contain significantly more fat, which makes them more likely to accumulate many of the most problematic environmental toxins.

An important challenge for the future will be to learn more about activities close to the shore and in the far north, including year-round activity off the Lofoten Islands.

It is important to develop a system which allows available knowledge to be applied in an optimal manner when carrying out impact assessments and risk analyses.

Better tools are needed for evaluating the biological impact of environmental toxins and for impact assessments and risk analyses.

Petroleum activities in these waters also pose a substantial challenge for developing technology to minimise their discharges to the sea.

Instruments and measures

Building on established instruments will be important for becoming better equipped to meet future challenges in the relations between the petroleum and fishing industries. Impact assessments and discharge permits are key measures. Activities in more environmentally-sensitive waters also require an increased commitment to research and technology development.

Impact assessments

To ensure that petroleum activities are harmonised with other important social interests, weight has been given from the start to preparing detailed studies and analyses on the impact this industry could have on such aspects as the marine environment and fishing. The oil and gas sector was one of the first in Norway to develop a system for such assessments.

The Petroleum Act requires that impact assessments are carried out before an area is opened, developing a specific field and the cessation of activities. In addition, regional impact assessments are carried out to provide an overall picture of the effects on the environment and other industries in a region.

Consultation with affected industries and environmental organisations forms an important part of the impact assessment process, and their comments provide a natural input to decision-making. The impact assessment system has helped to lay the basis for pursuing oil and gas activities in the same waters as industries such as fishing without generating major conflicts of interest.

Impact assessments when opening an area

Before production licences can be awarded, an area must be opened for petroleum activities. In that context, the authorities carry out an impact assessment, which includes an evaluation of the possible environmental, economic and social effects of activities on adjoining industries such as fishing.

Local authorities and key interest organisations considered to have an interest must be consulted on the question of opening new areas before it is put to the Storting.

Impact assessments for developments and cessation of activities

The Petroleum Act also requires the operator, on behalf of the licensees, to submit an assessment as part of its plan for development and operation (PDO) and plan for installation and operation (PIO) which covers the impact of producing the relevant discovery on nature, the environment and the fisheries.

This assessment must outline possible environmental effects of anticipated discharges and the impact on other industries, including fishing. A systematic cost/benefit analysis of possible mitigatory measures is also required.

The impact assessment is used as a tool throughout the development period to ensure that environmental considerations are taken into account. Both the programme for the assessment and the completed work are subject to public consultation.

According to the Petroleum Act, a similar assessment must also be carried out as part of a cessation plan.

Regional impact assessments

In order to obtain the best possible overview of environmental impacts, petroleum activities also need to be assessed across wider areas. This is done through a regional impact assessment prepared by the companies, which will also provide important background information for impact assessments relating to specific developments.

Such assessments have been done for the North Sea in 1999. A regional impact assessment

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was also carried out for the Norwegian Sea in 1998, but activities on this part of the NCS have changed substantially since then. As a result, the Norwegian Sea regional impact assessment is due to be updated. Once that has been done, such assessments will cover the whole NCS from 56°N to 69°N.

The ecosystem in northern sea areas is thought to be particularly vulnerable to both operational and accidental discharges, and more knowledge about activities in these regions is required.

The Barents Sea has some of the world's richest stocks of fish, seabirds and marine mammals, and the authorities want to take a cautious approach to ensure that environmental conditions there are taken sufficiently into account. As a result, the MPE wants to initiate an impact assessment covering the area from northwards from the Lofoten Islands.

A number of impact assessments have been done for petroleum activities in the Barents Sea, which will form an important basis for work on the regional impact assessment. Together with the impact assessments for fishing and marine transport, this will form part of a unified management plan for the Barents Sea.

Requirements for seismic surveys and exploration drilling

Once an area has been opened to petroleum activities, regional seismic surveys are conducted on behalf of the authorities. These form part of the input available to companies when submitting applications in offshore licensing rounds. After a production licence has been awarded, the licensees carry out more detailed seismic surveys ahead of exploration drilling.

Since the 15th licensing round in 1996, the authorities have requested applicants in the accompanying documentation to take special account of fishing activities and stocks of living marine resources when planning drilling activities.

A number of block-specific conditions relating to the environment and fishing have also been set in the 17th round in 2001. Tight restrictions have been imposed on seismic surveying out of concern for seabirds and fish stocks. Very strict curbs are also set on discharges of produced water in both exploration and production phases, and limits have been put on the number of exploration wells which can be drilled simultaneously.

Work on preparing and implementing seismic surveys is pursued in close cooperation with the fisheries authorities. To ensure that licensees are aware of fishing-related conditions and take these into account, the Directorate of Fisheries and the Institute of Marine Research have prepared materials which show where and when the various fish stocks normally breed.

Each licensee is required by the Petroleum Act to submit information on a planned survey to the authorities, which consider whether the survey can be carried out as planned. In some areas, surveying is banned for specified periods to protect the marine environment.

A ship conducting seismic surveys must carry a fisheries specialist, and maintain an acceptable distance from fishing vessels.

More information is needed about whether seismic shooting frightens sand eels, and a research programme will be established to investigate this issue.

Measures to reduce conflicts over sea areas

Various measures have been implemented to reduce potential conflicts from overlapping use of sea areas by the two industries in various phases of petroleum activities.

Licensees are committed during the exploration phase to a work programme which normally includes seismic surveying and drilling commitments. An average seismic survey lasts 20-25 days, while a well averages just under 50 days. The drilling commitment usually covers one-three wells. Other than these activities, no acreage is occupied during the exploration phase.

During production, offshore installations and the safety zone around them mean some loss of area for fishing. The aim is to minimise this deprivation. All subsea installations must accordingly cope with being over-trawled. However, a 500-metre safety zone is required around structures which extend above the sea surface. How much of a loss these zones are for fishing varies from place to place. The potential for a conflict of interest between the two industries depends on such factors as depth, currents and fishing gear as well as the significance of the area for fisheries.

In the closing phase, the Ospar convention's requirements for removing installations means that the area occupied during production again becomes accessible for fishing and other users of the sea. An overall assessment of the consequences for the environment and fishing as well as the costs involved will be applied by the authorities to determine the fate of installations not covered by Ospar.

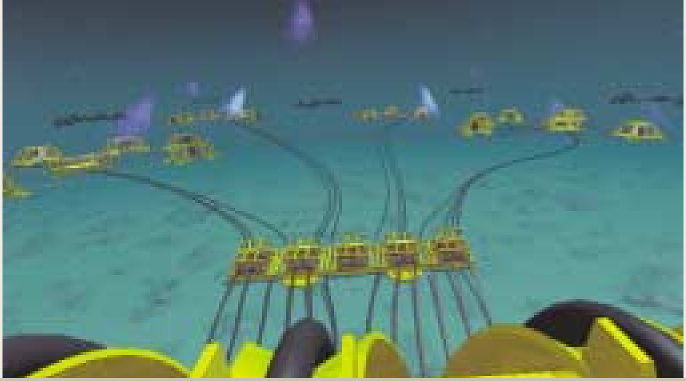
Discharge permits and environmental monitoring

Strict regulations have been introduced under the authority of the Pollution Act to minimise discharges to the sea from petroleum activities. In order to discharge oil or chemicals, operators must apply to the SFT for a permit.

Regular monitoring of the marine environment is one of the requirements imposed in such permits, and provides an important supplement to the surveillance carried out by the authorities. Such monitoring has been pursued off Norway over 30 years on every field, from pre-drilling surveys to follow-up after production ceases. Together with experimental studies, it helps to identify which discharges call for countermeasures.

The studies have shown a significant reduction in environmental impact around offshore platforms since discharging oil-based drilling mud was banned in 1993. Discharges are now estimated to have caused pollutions across 0.04 per cent of the seabed in those parts of the NCS where oil and gas are produced.

In cooperation with the Norwegian Oil Industry Association (OLF) and others, the UK Offshore



Operators Association (Ukooa) has conducted a study which aims to establish acceptable and practical solutions for disposing of drill cuttings which have been deposited on the seabed. At present, there are no mitigatory measures which offer a more appropriate alternative to leaving such cuttings in place.

To meet the challenges presented by petroleum activities in areas close to the shore, the authorities plan a general expansion in existing biological monitoring of living marine resources in the Norwegian Sea. This will be introduced in connection with the 17th licensing round in order to identify the possible impact of the petroleum sector.

Environmental management

The zero discharge philosophy represents an important measure for minimising discharges to the sea from petroleum activities. It provides an example of the way Norway's authorities and industry have jointly succeeded in integrating environmental concerns in these operations.

This philosophy was introduced in Report no 58 (1996-97) to the Storting on environmental policies for sustainable development. Zero discharges can be achieved by continuously reducing the release of environmentally-harmful chemicals towards a level which equals zero for all practical purposes. At this level, environmental harm will depend on the content of potentially harmful chemicals as well as the time and place of the discharge.

Assessments relating to zero discharges will also take account of emissions to the air. The special feature of working to achieve zero discharges is its focus on all harmful components released to the sea, rather than the generally one-sided concentration on oil which has prevailed internationally.

The offshore operators have developed a strategy for zero environmentally harmful discharges for their fields, and will be assessing measures for achieving zero emissions from drilling/well activities, production and pipelines. Measures in these categories will cover all discharges to the sea from offshore activities. They are directed both at various chemical additives and at handling the water flow as such. Measures for produced water will be implemented on every field. The zero discharge philosophy is due to be fully implemented by 2005.

One development by the oil industry in this context is the environmental impact factor (EIF), a tool for calculating the total effect of a discharge stream. This makes it possible to assess which components in produced water are most harmful to the environment, and to compare the environmental impact of various discharge streams. That in turn allows countermeasures to be prioritised. This method is based on knowledge about discharge volumes, diffusion and toxicity.

Similarly, the dose-related risk and assessment model (Dream) has been developed to calculated the environmental risk posed by produced water and other discharges to the sea. The emphasis is again on alkyl phenols as well as PAH as the substances with the greatest potential for causing environmental harm. Action against them should therefore be prioritised. At the same time, the modelling work shows that the environmental risk posed by discharges on the NCS is low.

The chemical hazard and risk model (Charm) provides another tool which makes it possible to achieve environmental improvements in the most effective possible way. With its aid, the industry can compare the various chemicals in order to select those which represent the lowest environmental risk. The authorities have also required the players to make environmental risk assessments with the aid of Charm when adopting new chemicals.

Research and development

Technology development

Considerable technological progress has been made since oil production from the Ekofisk field commenced in 1971. With each new offshore development, the industry has demonstrated advances in its technical solutions.

The trend outlined above, with petroleum activities expanding in the far north and areas closer to the shore combined with a shift towards activities in deeper water and smaller, more marginal fields, indicate that a substantial technological challenge lies ahead. Technology and possible development solutions already being devised can help to reduce the potential for conflicts between petroleum activities on the one hand and fishing and environmental interests on the other.

Technology development will generally be positive for the environment, and many solutions have been specially devised to reduce the negative environmental impact of oil and gas activities. The technologies relevant for each offshore project will depend on a number of field-specific conditions. Technical solutions available for use in future developments will be very different from those utilised on the NCS so far.

Wellstream separation subsea or downhole is one example of new technology now under development, and could cut energy consumption and produced water discharges to the sea in the longer term. Much energy is needed to transport water from reservoir to surface process plant for treatment and possible injection back below ground. Subsea or downhole separation would significantly reduce this energy requirement, while early removal of water from the wellstream could also cut the need for process chemicals.

The Troll Pilot project on the Troll field is currently testing subsea separation. Testing of the downhole approach, which will be important for further development and application of this technology, should be initiated on the NCS during 2002-03.

Technology development also contributes to simpler and less extensive production solutions. In addition to reduced energy consumption and emissions to the sea, these advances will help to cut the size of traditional installations or to eliminate them. New technical solutions also enhance safety and diminish the risk of acute spills to the sea.

Long-term effects of discharges to the sea

Large-scale studies are currently being pursued by

the industry itself into the possible impact of its activities on the living marine environment. Bodies such as the Norwegian Institute of Marine Research, the Sintef research foundation and the Norwegian Institute for Water Research are also helping to enhance knowledge about this issue.

But there is wide agreement that information on the long-term effects of discharges to the sea has been inadequate, and that the commitment being made in this area should be strengthened and organised in a more appropriate way.

A broad-based working group drawn from the research community, the authorities concerned and the industry has considered where the need is greatest, and how the various parties involved can be coordinated and cooperate in a more rational way than before.

The group has recommended that research into long-term effects in the water column should be given priority in this area. In its view, long-term effects of acute spills and drilling fluids should be given top priority, followed by the link between research and monitoring, special research tasks in Arctic areas, discharges from drill cuttings and acute spills in the coastal and shore zone.

Over the coming decade, most of the discharges to the sea from petroleum activities will derive from fields which are already in production. These will eventually move into a mature phase with a rising water cut. At the same time, possible future extension of petroleum activities into deeper waters, Arctic areas and waters close to vulnerable coasts will create special requirements for more information on long-term effects of discharges to the sea.

The authorities accordingly want to establish a research programme as soon as possible and in cooperation with the industry to look at such long-term effects.

Disseminating information

Another key task is the dissemination of existing knowledge and establishing a shared understanding of the challenges faced. Since Miljøsok was established in 1995, it has provided a meeting place for key players from oil companies, the supplies industry, the authorities, the research community, environmental groups and fishing organisations.

This partnership reflected a desire to develop more effective cooperation between the Norwegian authorities and the country's oil and gas industry in order to resolve the most important environmental challenges.

Miljøsok ended in 2000, but is being followed up by the Environment Forum as a new arena for collaboration. Relations between the fishing and petroleum industries was a central issue at the forum's inaugural meeting in the autumn of 2001.