ENVIRONMENT

THE NORWEGIAN PETROLEUM SECTOR

2005

Ministry of Petroleum and Energy

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Foreword

Each year, the Ministry of Petroleum and Energy (MPE) issues an environmental publication, the purpose of which is to raise awareness of the environmental aspects of Norwegian oil and gas activities.

This year's edition focuses on petroleum activity in the Barents Sea and on the stringent environmental requirements imposed on activities in the north. Our intention is to explain how petroleum activity is being undertaken in an environmentally responsible manner.

The environmental publication consists of two sections: one factual, one thematic. The factual section deals with the status of emissions and discharges, environmental impacts and measures for reducing discharges to the air and sea across the entire Norwegian Continental Shelf (NCS). The thematic section discusses petroleum activity in the Barents Sea in particular, but from a broader perspective.

The government has an aim for Norway to combine its role as a major energy producer with that of being a pioneer in environmental issues. This focus on environmental issues has placed the petroleum sector at the frontier of environmental protection. We hope that this publication will help to raise awareness of environmental issues in the oil and gas industry.

Sincerely

Thorhild Widvey

Minister of Petroleum and Energy

1 Facts

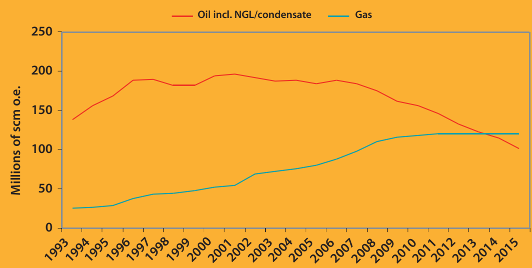


Figure 1. Production of saleable petroleum.
(Source: MPE/NPD)

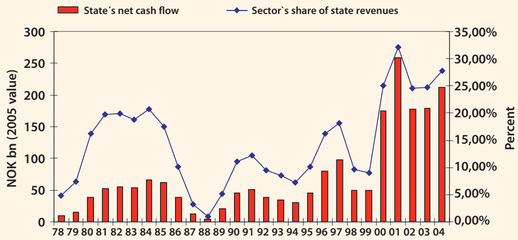
The petroleum industry in Norway

Facts about the petroleum sector

- In 2004, the petroleum sector accounted for 47 percent of Norwegian exports
- It contributed 28 percent of the state's total revenues for 2004, through:
  - income from the State's Direct Financial Interest (SDFI)
  - taxes and levies from the oil companies
  - dividends from Statoil
- Gas is becoming increasingly important relative to oil
- The estimated remaining oil and gas resources on the continental shelf are considerable. Of originally recoverable oil resources, 31 percent have been sold and supplied, 40 percent are in existing fields/discoveries and 26 percent have yet to be discovered. The remaining resources derive from potential future measures to improve recovery.

Oil production on the Norwegian continental shelf (NCS) began in the Ekofisk field in 1971. Gas exports started up in the same field in 1977. The coming on stream of Draugen in 1993 introduced the Norwegian Sea as a production area. A decision to develop the Snøhvit field was taken in 2002, marking the first development in the Barents Sea. Since the start, production on the NCS has, generally speaking, increased year on year (figure 1). In 2004, oil production (including condensate and NGL) was 3.2 mill b/d, while the figure for 2005 is forecast to be an average of 3.2 mill b/d for the year as a whole. It is anticipated that oil production will be maintained at this level for the next three years. Gas sales are expected to build up sharply from today's level of 76,1 bn scm per annum to reach 120 bn scm in 2011.

In addition to the development of the NCS, land facilities have been set up at Kårstø, Kollsnes, Sture, Mongstad and Tjeldbergodden to receive and, to one degree or another, process gas and oil from the fields. Receiving terminals for natural gas from the NCS have been established at St. Fergus (UK), Emden and Dornum (Germany), Zeebrugge (Belgium) and Dunkirk (France). There are also two processing facilities under construction, one at Melkøya outside Hammerfest and one at Nyhamna in Møre og Romsdal county. The facility at Melkøya will process gas and NGL from the Snøhvit field, while the one at Nyhamna will process gas from the Ormen Lange field.



Figur 2. The state´s net cash flow from petroleum activities.
(Source: MPE/FIN)

There is high demand for oil and gas resources in the market, and production generally yields revenues that are typically greater than in other industries. These additional earnings go largely to the state through taxes and levies and via direct ownership interests (The State's Direct Financial Interest, or SDFI). The state also receives dividends from its interests in Statoil and Norsk Hydro.

In 2001, the Storting (the norwegian parlament) resolved to restructure state participation in the industry. As a result of the part-privatisation of Statoil, two companies were set up: Petoro AS, which manages the SDFI portfolio on behalf of the state, and Gassco AS as a neutral operator for the gas transport system.

The petroleum industry has contributed large revenues to Norwegian society. The total revenues from the sector have varied over time in line with price and production fluctuations (figure 2). In addition to sold volume, oil revenues are affected by the global market price of crude, the dollar exchange rate and production costs.

Emissions and discharges from petroleum activities

The petroleum sector is responsible for a significant share of Norway's emissions to the air of carbon dioxide (CO_2), nitrogen oxides (NO_x) and non-methane volatile organic compounds (nmVOC). Added to this are smaller emissions from the sector of methane (CH_4) and marginal ones of sulphur dioxide (SO_2). Activities also lead to discharges of oil and of various kinds of chemicals into the sea.

Singly or in combination, NO_x, SO_2 and nmVOC contribute to transboundary regional environmental problems such as acid rain, eutrophication and ground-level ozone. Emissions also cause specific localised environmental problems.

CO_2

CO_2 emissions related to the installations on the NCS derive primarily from the combustion of gas in turbines, flaring of gas and diesel combustion. CO_2 is the most important of the climate gases and is closely linked to the burning of fossil fuels, of which natural gas emits the lowest volume of CO_2 per unit of energy.

The environmental impacts of CO_2 include:

- A contribution to the greenhouse effect, which in turn causes global warming.
- High concentrations of CO_2 in the atmosphere may disolve more CO_2 in water, this may cause a reduction in the sea's pH value.

NO_x

There is an strong relationship between emissions of CO_2 and NO_x. As for CO_2, key sources of emissions of NO_x are gas combustion in turbines, gas flaring and diesel consumption on installations. The volume of emissions depends both on the combustion technology employed and the quantity of fuel used. For instance, gas combustion in turbines produces lower emissions of NO_x than diesel engine combustion.

The environmental impacts of NO_x include:

- Impact on fish and other fauna through acidification of watercourses and the ground.
- Damage to buildings and stone and metal work resulting from acid rain.
- Eutrophication which may alter the species composition of ecosystems.
- Damage to health, crops and buildings due to the production of ground-level ozone.

nmVOC

nmVOC stands for non-methane volatile organic compounds, which vaporise from crude oil, among other substances. In the petroleum sector, the majority of emissions derive from offshore and onshore storage and loading of crude oil.

The environmental impacts of nmVOC include:

- The creation of ground-level ozone which is capable of damaging health, crops and buildings.
- May cause respiratory tract damage on direct exposure.
- An indirect contribution to the greenhouse effect through the production of CO_2 and ozone when nmVOCs react with air in the atmosphere.

Chemicals

Chemicals is a generic designation for all additives and auxiliary products used in drilling and well operations and in producing oil and gas. In general no environmentally hazardous substances should be released, whether chemical additives or naturally occurring chemicals.

The majority of chemicals employed are considered to have little or no environmental impact.

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

- the type of compound, i.e. release of slightly environmentally harmful or more hazardous chemicals
- The quantities used and the quantities released.
- Where and under what conditions they are released and the conditions in the recipient.

The environmental impacts of chemicals include:

- A local contamination effect, although research shows that chemical are diluted in the water column so that they do not cause a significant acute environmental impact beyond the immediate locality of the release.
- A small proportion of chemical discharges may have highly dangerous environmental consequences, including hormonal disruption and bioaccumulation.
- There is still uncertainty about any long-term effects of discharges into the sea, but considerable research is being done on this topic.

Oil discharges

The most significant source of oil released to the sea from day-to-day operations is the discharge of water coming up with oil and gas from the well (produced water). This contains residues of oil as droplets (dispersed oil), other organic compounds (including dissolved oil fractions), inorganic compounds (heavy metals, naturally occurring mildly radioactive compounds) and the residues of chemical additives.

The environmental impact of any acute oil discharge depends on more factors than just the scale of the discharge. Conditions such as the location of the discharge, the season, wind strength, currents, and the efficiency of contingency measures determine the extent of the damage. The most serious acute discharges in Norway have been from ships near the coast. There has been no major acute discharge of oil that reached land from petroleum operations on the NCS.

The environmental impacts of oil discharges include:

- Acute oil discharges can harm fish, marine mammals, seabirds and beach areas.
- No direct environmental damage from the discharge of produced water has been demonstrated; new research findings from the Institute of Marine Research and RF-Akvamiljø, the marine environmental research center, show, amongst other things, that alkylphenols in produced water do not pose any risk of damage to fish stocks in the North Sea. Nonetheless, there is uncertainty about potential long-term impacts, and much research in the area is accordingly being carried out, not least through the PROOF research programme.

Measuring and reporting of discharges and emissions

Emissions to the air are calculated in most cases on the basis of the quantity of combustion gas and diesel used on the installation. The emissions factors employed are based on measurements from suppliers or standard figures prepared by the sector itself, through the Norwegian Oil Industry Association (OLF).

For most fields, emissions are calculated using field-specific factors. Software is also available that can calculate emissions based on measured process parameters.

Discharges of produced water to the sea are measured by water meters. The oil content of this water is analysed and used to calculate total oil discharges. The discharge of chemicals is calculated from consumption relative to what is recovered and/or injected.

The Norwegian Pollution Control Authority (SFT), The Norwegian Petroleum Directorate (NPD) and OLF have set up a joint database for discharges to the sea and emissions to the air from petroleum operations. From 2004, all operators of petroleum activities on the NCS report discharge and emission data directly into the database. This facilitates both the operators' and the authorities' ability to produce analyses of historical discharges and emissions in a way that is more comprehensive and consistent than was previously the case.

Norway as a pioneer in environmental solutions – aims and means

To allow Norway to combine its role of being a major energy producer with that of being a pioneer in environmental issues, a comprehensive apparatus of instruments has been developed to manage environmental concerns in all phases of petroleum operations.

The Ministry of Petroleum and Energy has sectoral responsibility for petroleum operations and is required to liaise with other authorities to ensure that operations are followed up in an integrated fashion. Close cooperation with the industry is a prerequisite for enabling established environmental targets to be met without excessive financial costs to society.

Emissions and discharges from petroleum operations in Norway are regulated extensively by the Petroleum Act, the CO_2 Tax Act and the Pollution Control Act. Installations on land face the same types of instruments as other land-based industry. In petroleum legislation, the processes relating to the approval of new development plans (PDO/PIO) are key. Installations located on land or in the sea within the area of operations are also subject to the provisions of planning and building legislation.

The authorities use various instruments in the different phases of the petroleum industry, from the exploration phase, through the development and operation phases, to the decommissioning phase. In addition to this, and in compliance with international agreements, Norway is obliged to reduce its emissions of various compounds. This is discussed in the following.

The exploration phase

The object of opening up new areas for petroleum operations is to set in motion activities for discovering profitable petroleum resources with a view to future development and production. The most significant environmental consequence of exploration activity is the risk of acute discharge of oil. Such discharges may harm larvae, fish roe, fish, seabirds, marine mammals and beach-dwelling life. The probability of such discharges is, however, low. During nearly 40 years of exploration drilling on the NCS there have been no major acute discharges.[1]

In order to open up new areas for petroleum operations, thorough analyses are made, under the direction of the authorities, of the environmental impacts of petroleum activities. The obligation to carry out such impact assessments derives from the Petroleum Act as well as relevant regulations in the EU's SEA Directive on the assessment of the effects of certain plans and programmes on the environment (Directive 2001/42/EC). The assessments are sent out for consultation and then submitted to the Storting. Special impact assessments are carried out for the Norwegian Sea, the Skagerrak and the south Barents Sea.

In areas that are opened for petroleum operations, the Government also imposes specific requirements on exploration activity in order to limit potential conflict between environmental, oil and fishing

[1] The oil discharge from the Bravo blowout in 1977 happened during production.

interests. Examples of such impositions on exploration activity include limitations on when in the year drilling can take place, limitations on the number of concurrent installations in any one area, requirements on the discharge of drill cuttings, and specific requirements on contingency planning in order to limit damage in the event of any acute pollution.

Once an area is opened for petroleum activity, blocks in the area can be announced. Production licences are awarded based on applications from companies. On the basis of applications received, the Government makes an overall assessment and awards licences to the companies it believes can best realise the estimated value lying in the area.

Development and operations phase

Once a commercially recoverable find has been established in a production licence, the next phase will be development and operation to realise the value.

Before the participants in a production licence can begin to develop a find, the Petroleum Act requires that a plan for development and operation (PDO) be approved by the authorities. Furthermore, the licensees must, in accordance with §4-3 of the Petroleum Act, have obtained permission for installation and operation (PIO) of any associated facilities.

As part of the PDO/PIO requirements, the developer must provide an assessment that covers, among other things, the impact on nature and the environment of the realisation of the project in question. The assessment will describe any environmental impacts of anticipated discharges, and a systematic review of the costs and benefits of potential mitigation measures will be made. Both the programme for the impact assessment and the assessment itself are circulated to stakeholders in society.

Depending on the scope of the development, the question of approval of a PDO/PIO will be dealt with by the King in Council of State, or by the Storting following an overall assessment of the project. One of the criteria for this assessment involves observance of environmental considerations.

In addition to the risk of acute discharges, the operation phase involves continual releases into the air and sea.

These include primarily:

- Discharge of water with residues of oils and chemicals (produced water).
- Emission of CO_2 and NO_x from energy production and flaring.
- Emissions of nmVOC from the storage and loading of crude oil.

The CO_2 Tax Act and Greenhouse Gas Emission Trading Act are key instruments in reducing environmentally harmful emissions of climate gases. The Greenhouse Gas Emission Trading Act establishes a system of quota obligations for CO_2 emissions and freely tradable quotas for the period 2005-2007. Offshore petroleum operations are not covered by the previous quota system since these emissions are subject to the CO_2 tax. The authorities also use other instruments such as terms in PDO/PIOs, permitted discharge levels and production permits, which cover, among other things, flaring. The instruments vary for the different releases to air and sea.

Decommissioning phase

Petroleum production from several of the fields on the NCS has now ceased or is about to cease. In all, 13 fields have closed down production. The Frigg field closed down in the autumn of 2004.

The regulations in the Petroleum Act concerning the disposal of installations will be enforced in accordance with the relevant national laws and regulations as well as international obligations.

The commission for the Convention for the Protection of the Marine Environment of the North-east Atlantic (OSPAR) adopted in 1998 a general prohibition against leaving redundant offshore installations in the area covered by the convention. Exception to the prohibition may be made for concrete installations and the lower sections of large steel structures, and for other installations where exceptional or unforeseen circumstances dictate.

Before a possible decision on an exception to the OSPAR convention is made, consultations must be made with the other parties to the convention. The OSPAR resolution is discussed in Parliamentary Bill no. 8 (1998-1999). The OSPAR resolution does not cover pipelines and cables. Report to the Storting no. 47 (1999-2000) Decommissioning of redundant pipelines and cables provides general guidelines stating that permission should be granted to leaven place pipelines and cables if they do not obstruct or present a safety risk for bottom fishing, as compared to the costs of burying, covering or removal.

International agreements and obligations

In keeping with international agreements, Norway is obliged to limit its emissions of various compounds. How this affects the petroleum sector will depend on the formulation of the individual agreement and how the requirements/instruments employed are distributed by sector in Norway. Air pollution agreements normally specify an emissions threshold for each country. The formulation of the agreements determines whether the emissions limits imposed must be implemented in their entirety within each country's borders, or whether the reductions can also be made in other countries where the costs of reductions may be lower. The costs of reducing emissions from the various sources both nationally and internationally will be important for the degree to which a measure will be implemented in respect of the petroleum sector.

Global climate pollution is regulated internationally by the UN Climate Convention. Norway's obligations in respect of the **Kyoto Protocol** entail that average emissions for the years 2008-2012 must not increase by more than 1 percent compared with the emissions level in 1990. Relative to current levels, this implies a reduction of almost 6 percent. This obligation can be met through reductions nationally and in other countries through the Kyoto mechanisms (international emission trading, clean development and joint implementation). With its Greenhouse Gas Emission Trading Act, Norway has established a national quota system for climate gases in Norway from 2005, as a follow-up to the Kyoto Protocol.

Emissions with regional environmental impacts are regulated by various protocols under the Convention on Long-Range Transboundary Air Pollution **(LRTAP).** In 1999, together with the USA, Canada and other European countries, Norway signed the **Gothenburg Protocol,** which aims to tackle the environmental problems of acidification, eutrophication and ground-level ozone. Under the Protocol, Norway is to reduce NO_x emissions to 156,000 tonnes by 2010. This means a 29 percent reduction compared with 1990 emission levels. The new commitment for nmVOC is virtually unchanged from the one accepted by Norway under the existing Geneva Protocol, i.e. that annual nmVOC emissions from the entire mainland and the Norwegian economic zone south of the 62nd parallel should be reduced as quickly as possible by 30 percent from the 1989 level. Under the Gothenburg Protocol, total national emissions shall not exceed 195,000 tonnes/year by 2010.

Oil and chemical discharges can have localised impacts in the immediate vicinity of installations and are regulated nationally through permitted discharge levels determined in the Pollution Act. Discharges are also regulated internationally through the **OSPAR Convention.** For discharges into the sea, a recommended maximum level for the oil content of water is set internationally at 40 g/m3 (milligrams per litre). A recommendation has been adopted for a reduction to a maximum of 30 g/m3 from 2006, as has a recommendation that member states' total discharges of oil in produced water be reduced by 15 percent in 2006 from 2000 levels. The use and discharge of chemicals is regulated internationally in the form of requirements concerning risk assessment and categorisation according to the chemical's inherent characteristics.

Zero environmentally hazardous discharges to the sea

The target of zero environmentally hazardous discharges to the sea from petroleum operations was established in Report to the Storting no. 58 (1996–97), Environmental Policy for a Sustainable Development. The authorities and industry have since worked together to define the targets precisely and arrive at solutions for achieving them. The authorities' targets are reflected in Report to the Storting no. 25 (2002-2003), The Environmental Policy of the Government and the State of the Environment in Norway.

Zero emissions targets are contingency aims to help ensure that the discharge to the sea of oil and environmentally hazardous substances does not lead to unacceptable damage to health or the environment. The main rule here is that no environmentally hazardous substances must be released, whether chemical additives or naturally occurring chemicals. The targets apply in the first instance to new standalone developments, and from 31 December 2005 to existing installations, and cover all offshore operations - drilling and well operations, production and discharges from pipelines.

In each case, when deciding on measures, an overall assessment must be made of the environmental impacts, safety concerns, costs and technical conditions in the reservoir. Thus, it may be the case that, for an existing field, and based on such field-specific overall assessments, the practically achievable target would be the minimisation of individual discharges.

It is expected that operators on the NCS will be ambitious in their efforts to achieve the target and that they actively develop and deploy new techniques to work towards the target.

As one step in their work on zero discharges, the operating companies have reported appropriate measures and associated costs to the authorities. The NPD has carried out an analysis of the cost and environmental impacts of the measures that the companies have assessed to be appropriate, and this shows that more focus on replacing environmentally hazardous chemicals will, in general, be a cost-effective measure to adopt. Equally, the reinjection of produced water in fields that still require more water for pressure support may also be environmentally cost-effective. In addition, a series of purification measures and process optimisations will help to reduce further the risk of environmental damage.

The companies' reports indicates that a wide range of measures has been implemented and that major environmental improvements have already been achieved. If the measures that the operators have planned are implemented, they will come very close to achieving the target before year-end 2005.

Definitions of zero emissions and zero emissions targets.

Definitions

Environmentally hazardous, environmentally hazardous compounds, environmentally hazardous substances, environmentally hazardous chemicals:
Chemicals or groups of chemicals with inherent characteristics of being toxic, not breaking down readily, potentially bioaccumulative and/or causing hormonal disruption. The most hazardous of these are designated as environmental toxins.
Environmentally harmful, environmentally harmful discharges/emissions:
This term refers to the damage that emissions and discharges can cause, and depends on the quantity released, the location and the time of the release. An environmentally harmful discharge may be of an environmentally hazardous substance, but it may also be a substance that has no such inherent characteristics.

Zero emissions targets

Environmentally hazardous substances:

- Zero discharges, or minimisation of discharges, of naturally occurring environmental toxins encompassed by end objective no. 1 for chemicals hazardous to health and the environment. See priority list in Report to the Storting no. 25 (2002-2003).
- Zero discharges of chemical additives in the black SFT category (by default use and discharge prohibited) and the red SFT category (high priority for phasing out via substitution).

Other chemical substances:
Zero discharges or minimisation of discharges that can lead to damage to the environment by:

- Oil (components that are not environmentally hazardous)
- Substances in the yellow and green SFT categories
- Drill cuttings
- Other substances that can lead to environmental damage 1) See regulations relating to activities in the petroleum industry (activity regulations) of 3 September 2001

Source: Report to the Storting no. 25 (2002-2003),
The Environmental Policy of the Government and the State of the Environment in Norway.

Instruments employed to protect the environment

CO_2

The use of gas, oil and diesel in association with petroleum operations on the NCS is subject to the carbon tax under the CO_2 Tax Act with effect from 1 January 1991. The tax is imposed on the combustion of fossil fuels that produce CO_2 emissions – primarily natural gas and diesel. As of 1 January 2005, the CO_2 tax on the NCS is NOK 0.78 per litre of oil/scm of gas (equating to approx. NOK 330/tonne). Under the Petroleum Act, the burning of gas through flaring, beyond what is necessary for safety reasons in normal operation, is not permitted without authorisation from the Ministry of Petroleum and Energy. The Greenhouse Gas Emission Trading Act established a system of quota obligations and freely tradable quotas for the period 2005-2007. For the time being, in the petroleum sector, only some land-based installations are subject to quota obligations and offshore activities are exempted, since emissions are subject to the CO_2 tax. The Greenhouse Gas Emission Trading Act will however be reviewed at the end of 2007.

NOx

In the operations phase, NO_x is regulated on the NCS, any terms being set in the context of PDO/PIO processing. Shortly NO_x emissions will also be regulated through permitted discharge levels under the authority of the pollution act.

nmVOC

Discharges of nmVOCs in association with the storage and loading of crude oil offshore have been regulated since 2001 through permitted discharge levels under the authority of the Pollution Act.

Oil, organic compounds and chemicals

The companies have to apply for a discharge permit from SFT in order to discharge oil and chemicals to the sea. SFT grants permission in accordance with the provisions of the Pollution Act. Under the Pollution Act, the operating companies themselves have a responsibility and obligation for establishing the necessary contingency planning measures to counter acute pollution. There are also municipal and national emergency planning measures in place.

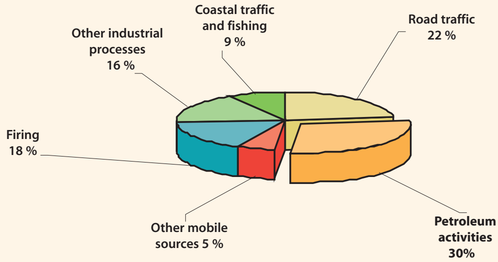


Figure 3. Sources of Norwegian emissions of CO_2, 2003
(Source: Statistics Norway)

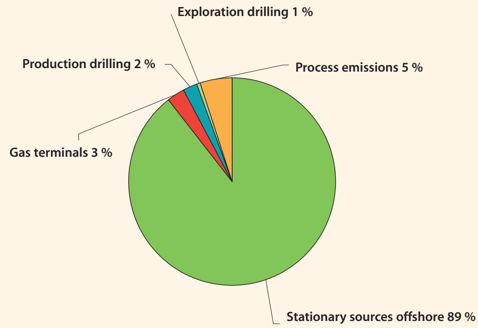


Figure 4: Taxable CO_2 emissions from petroleum activities 2003, by source.
(Source: MPE/NPD)

Emissions status of carbon dioxide (CO_2)

Nationally, petroleum operations account for 30 percent of CO_2 emissions (figure 3). This share is expected to remain at 30 percent in 2005/2006 and then fall off. The other major sources of emissions in Norway are road traffic and other mobile sources, firing and emissions from various industrial processes.

As shown in figure 4, the majority of CO_2 emissions from the petroleum sector relate to offshore installations. Other CO_2 emissions come from land-based gas terminals and indirectly from VOC emissions (process emissions).

Total CO_2 emissions from the sector have grown year on year, primarily as a result of increased activity levels. The trend in recent years and forecasts for the years to come are shown in figure 6. Increased total emissions do not imply that improvements on the environmental side are lacking. Improvements in the utilisation of energy and reductions in flaring have, however, not been significant enough to counterbalance the increase in energy consumption from higher levels of activity. One indication that activity has become more efficient is that CO_2 per produced oil equivalent fell by 22 percent from 1990 to 2003 (figure 7).

The reductions are due, amongst other things, to general improvements in technology and emission-reducing measures, for instance, as a result of the introduction of the CO_2 tax in 1991. Other factors, including an increasing number of producing fields and the fact that key fields have reached a mature phase, may however lead to increased emissions. In general, emissions linked to the production of a unit of oil/gas will vary both between fields and over a single field's lifetime. Reservoir conditions and transport distances to the gas markets are factors that cause the energy requirements, and hence emissions, to vary from field to field. The variation in emissions over a field's lifetime is due in part to the fact that the proportion of water in the well stream increases as the field ages. Since it is essentially the total liquid and gas volumes (water, oil and gas) that determine the energy requirements on the processing installation, a field will have higher emissions per produced unit the older it gets. This is one of the reasons we have seen a slight increase in emissions per unit over recent years. The trend on the NCS towards more mature fields and the movement of activities northwards is leading towards increased emissions per produced unit. Processing and transport of produced gas is more energy-intensive than production of liquids. The proportion of produced gas is still on the increase on the NCS. This is an important contributory factor in the increase in the indicator showing CO_2 emissions per produced unit. Total emissions of CO_2 from activities increased by less than 1% from 2002 to 2003.

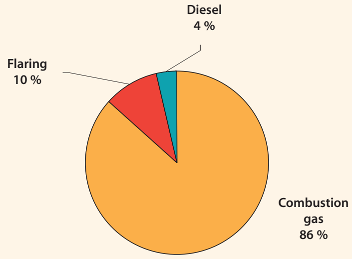


Figure 5. Taxable CO_2 emissions from oil and gas production, by source, 2003 *(Source: NPD)*

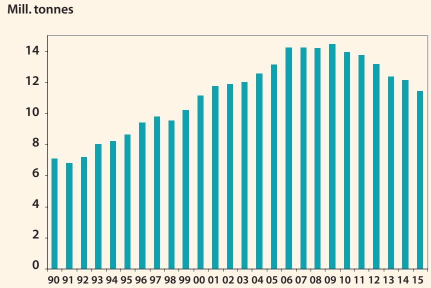


Figure 6. Total emissions of CO_2 from the Norwegian petroleum sector *(Source: MPE, NPD)*

Measures for reducing CO_2 emissions

The development of combined solutions for energy production offshore (combined cycle power plants), recirculation of flare gas and injection of CO_2 from produced gas at Sleipner West, are examples of the NCS's leading-edge position in terms of implementing environmentally efficient solutions.

Combined power solutions

Combined cycle power plants which are currently in operation on the Oseberg, Snorre and Eldfisk fields represent a solution whereby heat from turbine exhaust gas is used to produce steam, which in turn is used to generate electric power. These plants are totally unique in an offshore context.

Storage of CO_2

Since 1996, 1 million tonnes of CO_2 has been stored annually in the Utsira formation in connection with the processing of gas from the Sleipner field. When the Snøhvit field comes on stream in 2006, CO_2 in the gas will have to be separated out before the gas is cooled into LNG. Pure CO_2 will be transported in a pipeline from the LNG plant at Melkøya back to the field for injection into a water-filled reservoir.

In future, Norway will have excellent opportunities for storing CO_2 due to its access to large water-filled reservoirs and fully produced oil/gas reservoirs off the Norwegian coast. Storing of CO_2 in fully produced reservoirs is, geologically speaking, a good solution, since the structure is highly likely to be impermeable inasmuch as it will have retained gas and oil for millions of years.

The Norwegian authorities are working actively to ensure that such CO_2 storage can be achieved in a safe and secure manner. Work is therefore being undertaken under the auspices of the OSPAR and London Conventions to ensure that sound international regulations for CO_2 storage are established. In autumn 2004 the authorities organised a scientific OSPAR workshop on the potential environmental impacts of long-term storage of CO_2; a number of international experts took part. It is important to understand the potential impacts of CO_2 on the marine environment in order to facilitate large-scale long-term storage of CO_2. In time, this may become a very significant aid to solving climate problems.

Use of CO_2 for enhanced oil recovery

The NPD has estimated a considerable technical potential for increased oil production through the use of CO_2 in mature oil fields on the NCS. Use of CO_2 for increased production from a field will completely change a field's production strategy, in addition to the technological and cost challenges linked to factors such as modifications to processing installations and CO_2 transport to the field. It is unlikely to find to sufficient quantities of pure CO_2 from principal sources in Norway to cover the need for possible CO_2 injection for increased production on the NCS. In addition to CO_2 sources in Norway, therefore, other sources around the North Sea are being assessed.

Currently, it is not profitable for individual fields to use CO_2 for increased production. The Ministry of Petroleum and Energy has commissioned the NPD to produce a study of the prospects of implementing projects to inject CO_2 for enhanced oil recovery.

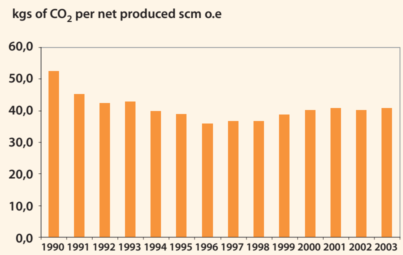


Figure 7. Emissions of taxable CO_2 per produced unit *(Source: NPD)*

Power plants and energy efficiency

CO_2 emissions from power production on the NCS account for just under 80 percent of all emissions from offshore operations. In 2004, the petroleum and energy authorities, in conjunction with the industry, carried out a survey of the potential for more efficient power supply on the NCS. It concluded that a realistic, if ambitious, estimate of potential emissions reduction is approximately 5-10 percent over the course of 10 years, an improvement that has already been taken into account in projections of the sector's CO_2 emissions. This is achievable if the industry systematically implements energy management in all aspects of operations. OLF has advised that this will be a focus area in 2005.

To achieve further contributions to increased energy efficiency in the longer term, a change in technology and concepts of power provision will be required. This calls for a long-term commitment to the development, testing and implementation of new technology.

Flaring

CO_2 emissions from flaring account for about 10 percent of total emissions from petroleum operations. Studies carried out by the NPD show that technical measures for reducing flaring have largely been implemented. To achieve further reductions in flaring, more focus will need to be placed on the companies' operating routines and regularity.

Adopted and implemented technologies for reducing CO_2 emissions

- Removal of CO_2 from well streams with subsequent deposition at Sleipner West and Snøhvit.
- Utilisation of exhaust heat in processing.
- More efficient power production, e.g. combined power plants at Oseberg, Snorre and Eldfisk.
- Optimal sizing of pipelines.
- Replacement of old installations, e.g. Ekofisk.
- Increased use of gas engines instead of gas turbines.
- Optimisation of new fields in respect of energy consumption and energy efficiency.
- Power from onshore to Troll A.
- Flare gas Recovery.
- Transfer of power between Snorre A and B.

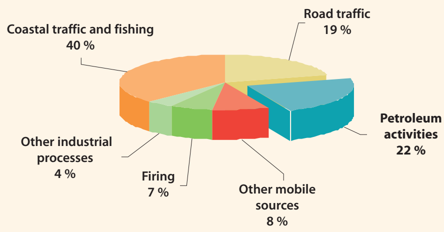


Figure 8. Sources of NO_x emissions in Norway, 2003
(Source: Statistics Norway)

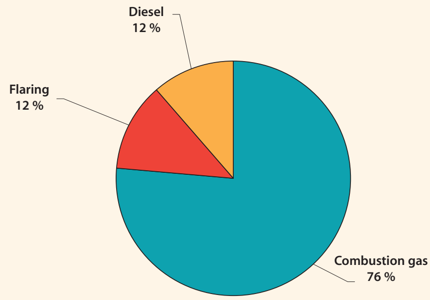


Figure 9. NO_x emissions from oil and gas production, by source, 2003
(Source: NPD)

Emissions status of nitrogen oxides

Mobile sources account for the majority of Norwegian NO_x emissions (figure 8). The petroleum sector, for its part, contributes 22 percent. Figure 9 shows the breakdown of emissions from offshore sources. There will also be emissions connected with exploration activities and gas terminals onshore.

Emissions of NO_x from the sector have grown gradually since 1991 (figure 10). They are expected to increase until 2005 and then fall off. The prime cause of this is increased activity contributing to higher energy demand, which in turn has contributed to higher emissions. The change in emissions per produced unit give us an indication of the trend in efficiency of activities on the NCS. Emissions per produced unit are shown in figure 11.

Measures for reducing NO_x emissions

Most of the measures that reduce CO_2 emissions also help to reduce NO_x emissions from the petroleum sector. Other measures which may assist in reducing NO_x emissions are:

- Low NO_x burners as standard on gas turbines on new installations; NO_x emissions can be reduced by up to 90 percent in this way. In some cases, however, CO_2 emissions may increase through the use of this technology.
- Retro-fit of low NO_x burners on existing turbines. Studies indicate that the general level of costs of retro-fitting low NO_x burners on existing installations is considerably higher than previously assumed. In general, low NO_x technology installed on machines that are run at high capacity provide considerable environmental benefits. On machines run at low capacity, CO_2 emissions increase, while NO_x reductions are lower as compared to high rates of utilisation.
- Steam injection/water injection into the combustion chamber. Steam or water is used to reduce the combustion temperature and hence the production of NO_x. These technologies require access to large volumes of clean water, which presents a challenge offshore.
- In addition, in some locations, there is now the option of using third-party measures in order to meet stringent emissions requirements, e.g. on the power plant at Snøhvit.

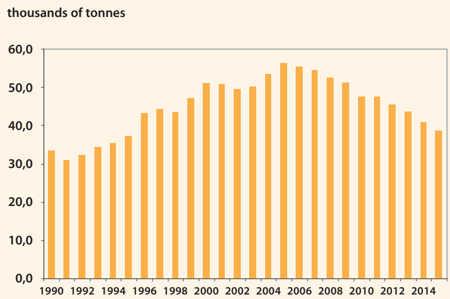


Figure 10. Total emissions of NO_x from the Norwegian petroleum sector *(Source: MPE, NPD)*

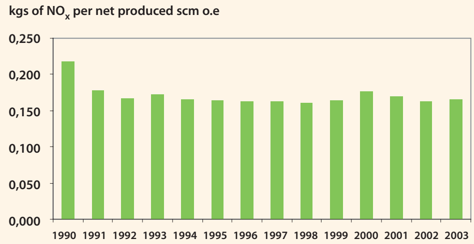


Figure 11. Emissions of NO_x per produced unit *(Source: MPE, NPD)*

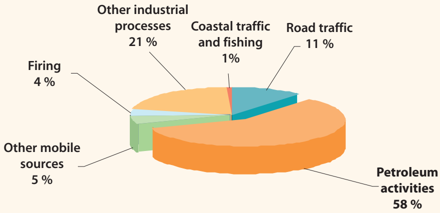


Figure 12. Sources of Norwegian emissions of nmVOCs, 2003 *(Source: Statistics Norway)*

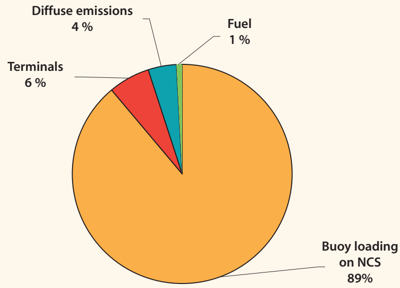


Figure 13. Sources of nmVOC emissions from the petroleum sector, 2003 *(Source: Environment Web)*

Emissions status of non-methane volatile organic compounds (nmVOCs)

The petroleum sector is the primary source of emissions of nmVOCs in Norway. In 2003, some 58 percent of Norway's emissions of nmVOCs derived from the storage and loading of crude oil offshore. Other industrial processes and road traffic are other significant sources of emissions (figure 12). The petroleum sector's share is waning as a result of the phasing in of emission-reducing technology. Minor emissions also occur at gas terminals and through minor leakages (figure 13).

There are large differences in emissions from the loading of a unit of oil in the various fields. A prime cause of this is that the content of light gases in oil varies from field to field.

Several of the newer fields on the NCS employ floating storage installations. This type of installation may produce higher emissions of nmVOCs than is the case on fields where the oil is stored in the base of the platforms (Statfjord, Draugen and Gullfaks). This is due to the fact that, with floating storage installations, emissions will also occur between production and storage.

The forecast for nmVOC emissions from the sector shows a strong downward trend in years to come (figure 14), both because emission-reducing technology will be installed and because oil production is expected to peak within a few years.

Measures for reducing nmVOC-emissions

For a number of years, the oil companies have worked to make technology for recovering nmVOCs available to storage vessels and shuttle tankers. There currently exists proven recovery technology that reduces emissions from loading by around 70 percent. Several vessels have now installed emission-reducing technology. The operators of fields with buoy loading on the NCS have formed a joint venture to install recycling equipment for nmVOC on these ships (see text box).

A recovery installation for nmVOCs was deployed at the crude oil terminal at Sture in 1996. This is the first of its kind at a crude oil terminal. Use of the installation requires loading tankers to be fitted with coupling equipment. From 1 January 2003, a requirement was issued that all vessels must be fitted with equipment for recovering nmVOCs, and the ships are not normally granted access to the installation without the necessary equipment.

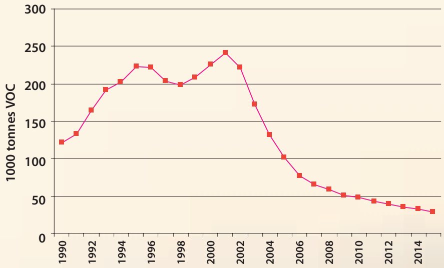


Figure 14. Total emissions of nmVOCs from the Norwegian petroleum sector *(Source: MPE, NPD)*

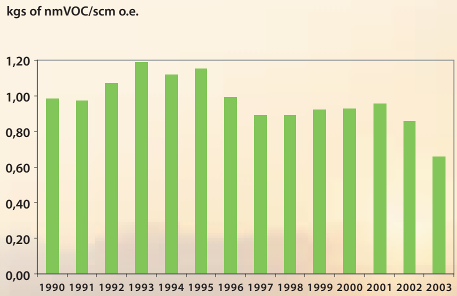


Figure 15. nmVOC emissions per produced unit *(Source: MPE, NPD)*

Joint venture

Discharge permissions impose a requirement that oil must be stored and loaded using the best available technology (BAT) for reducing emissions. Technologies designed to meet this requirement will be phased in to a specified timetable up to the end of 2008.

The operators of fields on the NCS with buoy loading have established a joint venture to coordinate the phasing in of the technology and meet the requirement in an effective and cost-efficient manner. The joint venture paves the way for exchange of experience in respect of operation of the installation.

The joint venture agreement was signed in 2002 and 26 companies participate in it. It covers buoy loading from Varg, Glitne, Jotun, Balder, Gullfaks, Statfjord, Draugen, Njord, Åsgard and Norne.

By year-end 2004, nmVOC reduction technology had been installed on 10 shuttle tankers. In 2003, an estimated nmVOC reduction of 31,340 tonnes had been achieved.

In future, there will be a focus on achieving high operational regularity at existing installations, while two new recovery installations will be installed in 2005.

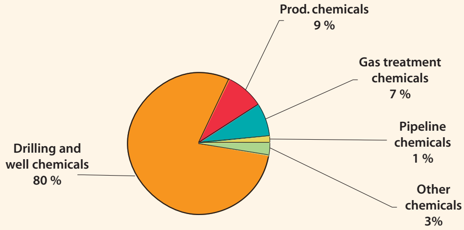


Figure 16. Discharges of chemicals on the NCS, by activity, 2003
(Source: EnvironmentWeb)

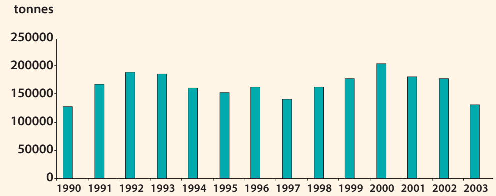


Figure 17. Total chemicals discharged from Norwegian petroleum operations
(Source:EnvironmentWeb)

Discharge status of chemicals, oil and other organic compounds

Discharge of chemicals

A full 95 percent of chemical consumption in Norwegian petroleum activities consists of chemicals considered to have little or no environmental impact (green and yellow chemicals in SFT's categorisation). These substances are largely ones that occur naturally in seawater. The remainder include chemicals that are environmentally hazardous or where any impacts are insufficiently documented.

In 2002, 30.4 percent of quantities employed were discharged, including the water the chemicals were dissolved in. The corresponding figure for 1989 was 64 percent excluding water. The chemicals not discharged are either dissolved in the oil, deposited underground or treated as hazardous waste.

Discharges of oil and other naturally occurring chemical substances

Total discharges of oil from Norwegian petroleum operations account for a small proportion of total releases into the North Sea. The main release of oil into the North Sea is considered to come from shipping and riverine input.

Oil discharges from the petroleum sector derive essentially from normal operations, but acute discharges or spills also occur. Produced water consists of previously injected seawater, where employed, and formation water that has come into contact with oil in the reservoir and hence contains a number of organic compounds. The most important of these compounds as regards the environment are PAH and alkylphenols. Produced water may also contain residues of chemicals used in processing.

Acute discharges

The total volume of oil that escapes as a result of acute oil discharges is very limited in relation to what other sources release. All acute discharges from installations on the NCS are reported to The Norwegian Coastal Administration and the causes are investigated. Discharges of more than one tonne are shown in figure 23.

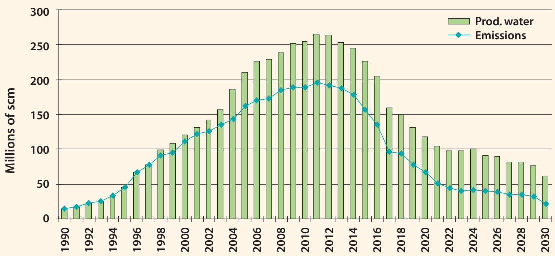


Figure 18. Quantity of produced water and discharges of produced water, historically and forecast. *(Source: NPD)*

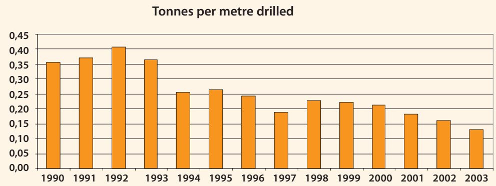


Figure 19. Discharges of tonnes of drilling chemicals per metre drilled *(Source: EnvironmentWeb/NPD)*

In May 2003, there was a very acute discharge at Draugen, which caused the discharge figure to increase dramatically in that year. This discharge was of some 750 scm of oil, and is the third largest oil discharge to have occurred on the NCS. It was due to a crack in and leakage from an end-coupling after the installations had been shut down for a period. The coast in the area in question in Mid-Norway was monitored and no oil reached land. The investigation report does not indicate any harm to bird life or fish, even though only about 180 cubic metres of oil were retrieved.

Drilling and well operations

Drilling and well operations are plainly the largest sources of chemical discharges on the NCS (figure 16). Changes from year to year in overall chemical discharges are therefore due largely to a variation in the number of wells being drilled. Discharge of oil-bearing drill cuttings has been prohibited on the NCS since 1991. This prohibition has contributed to reducing oil discharges from operations significantly from what they would be with continued discharge of oil-bearing drill waste.

New drilling methods and technology have, together with the reinjection of drill cuttings, helped to reduce discharges per metre drilled in recent years. An increased requirement for well maintenance as the fields age may however contribute to a slight increase in discharges (figure 19).

Recovery, injection under ground and disposal on land are alternative means of avoiding discharges from drilling.

Water which comes up the well with the oil and gas – produced water

Some of the largest fields have now reached such a phase of maturity that more water is produced per unit of oil and gas from the wells than previously. This is contributing to an increased volume of produced water and hence an increased discharge of oil. Discharge of oil in produced water is the main source of oil discharges from day-to-day operations (figure 20).

The majority of water is released to the sea after cleaning and some is reinjected into the reservoirs. In addition to reinjection, measures such as reduced use of chemicals and better cleaning can reduce discharges of chemicals and organic compounds. Replacing unwanted chemicals with more environmentally friendly alternatives also provides a considerable environmental benefit.

Although discharges of produced water increased by 11 percent in 2003 over the preceding year, discharges of oil in produced water fell by around 290 tonnes over the same period. This reduction is due primarily to better cleaning technology on the installations, but the change to a new analytical method may also have had a certain effect on the results.

Most operators have made extensive progress in the task of replacing environmentally hazardous chemicals with more environmentally friendly alternatives, and the consumption, discharge and injection of chemicals was significantly reduced from 2002 to 2003. The total discharge of chemicals in 2003 was 26 percent lower than in the year before, and the majority of these were chemicals considered to have no significant environmental impact on discharge into the sea. Of the remainder, approximately 2 percent were

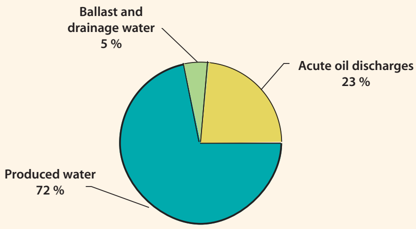


Figure 20. Oil discharges on the NCS, by activity, 2003
(Source: EnvironmentWeb)

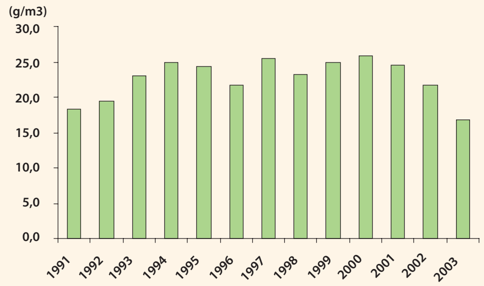


Figure 21. Discharges of oil per cubic metre of produced water
(Source: EnvironmentWeb)

chemicals considered to be environmentally hazardous or potentially environmentally harmful, and whose use/discharge is permitted only when overriding technical or safety reasons make this necessary. A further reduction in the discharges can be expected in future.

The average oil concentration in produced water on the NCS has been falling slightly. The annual average for 2003 for Norwegian installations was 16.9 g/m^3, the lowest recorded since 1990 (figure 21).

Development of new technology

The development of new technology is important in reducing discharges of environmentally hazardous substances. Technology to separate or block the water before it reaches the installations will be key. Separation can be done either down in the well or on the sea-bed.

Because such solutions avoid water being pumped back to the platform, energy consumption and hence emissions to the air can be reduced. At the same time, reinjection of water for pressure support contributes to increased oil production. For fields where water injection is not the ideal solution, various kinds of cleaning technologies may be viable.

Technology for removing or reducing discharges of environmentally harmful compounds in produced water

- Full or partial return of produced water underground following separation on the installation.
- Isolation of water-bearing strata in wells, either mechanically or chemically.
- Separation of produced water in the well or on the sea-bed with subsequent reinjection.
- Cleaning of produced water at the field before discharge into the sea.

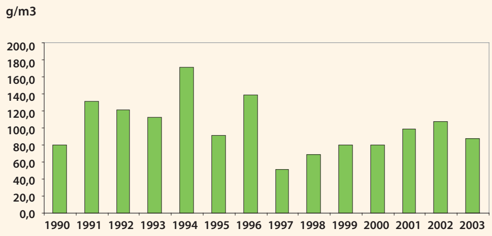
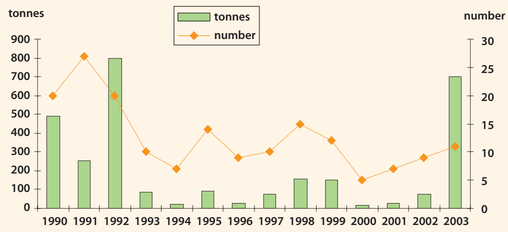


Figure 22. Content of production, injection and pipeline chemicals in produced water *(Source: EnvironmentWeb)*



Figur 23. Acute oil discharges of more than one tonne *(Source: EnvironmentWeb)*

Technologies for avoiding discharges of drilling fluids

- Recovery.
- Collection and injection under ground.
- Collection and disposal onshore.

Many of the technologies mentioned have already been implemented, are due to be implemented, or are being tested or evaluated in a number of fields.

Whole or partial reinjection is employed or planned in more than 20 fields and is also being evaluated on other installations. Various forms of isolation of water-bearing strata have been carried out in many wells on the NCS, and this method will see more widespread use as new and improved technologies become available. Sea-bed separation has so far been implemented only at Troll C, where a pilot plant separates out produced water from the rest of the well stream on one of the production lines and is then reinjected. Downhole separation is being tested onshore, but will need to be tried out in a well offshore before the technology can be used on a permanent basis.

There are many different types of cleaning technologies for produced water. The most widely used of these mainly separate out only dispersed oil. A number of newly developed cleaning technologies that also remove dissolved compounds such as PAH and alkylphenols are now available and under trial offshore, or are under development. For a more thorough discussion of cleaning technologies for produced water, please see the special topics section in Environment 2004.

2 Special topic

High environmental standards for petroleum activities in the Barents Sea

Introduction

The Barents Sea's environment and natural resources

The Barents Sea is the northernmost sea of the Norwegian Continental Shelf, and is regarded as being one of the cleanest and richest marine areas in the world. It covers a large area, some 1.4 million square kilometres, and there are huge seasonal climate changes in the various parts of the sea.

The area is marked by the influx of warm and nutritious Atlantic water. This means that the Norwegian coast and great parts of the sea are free of ice throughout the year, allowing considerable biological production. A transitional area, the Barents Sea Polar Front, is created where the warm Atlantic water meets cold water from the Arctic Ocean. Such areas provide a rich source for the production of plankton algae, which are grazed upon by animal plankton. The animal plankton, in their turn, provide food for fish, seabirds and such mammals as seals and whales. This forms the basis for the wealth of the fisheries, which include the largest remaining cod stocks in the northern Atlantic.

Norway and Russia both bound the Barents Sea, and share responsibility for the fish stocks and the other marine biological resources. The central Barents Sea is an area of overlapping claims. Russia and Norway have not yet agreed on the position of the Border in this area.

The petroleum industry in the Barents Sea

In addition to the importance of the area for fishing, both the Norwegian and Russian sectors of the Barents Sea also contain oil and gas resources. Estimates indicate that a third of the undiscovered petroleum resources on the NCS are under the Barents Sea.

The petroleum industry is not new to the Barents Sea. Parts of the Tromsø Bank opened in 1979, and the first production licences were awarded in the fifth licensing round in 1980. Approval for extension of the area around the Tromsø Bank was given in 1985, while the entire southern area of the Barents Sea was opened to the industry in 1989. The first wildcat well was drilled in the southern Barents Sea in 1980, and a total of 41 exploration licences have been awarded and 61 wildcat wells drilled.

When the government came to power in 2001, it saw a need for an assessment of the impact of year-round petroleum activity in the northern areas, before activity continued. In all, a total of 26 specialist basic surveys of different aspects were carried out. These were collated in the summary report entitled *Report on the impact of all year petroleum activities in the Lofoten – Barents Sea area (ULB)*, which was published in July 2003. Both the summary report and the basic surveys were presented in broad-ranging public consultancy processes, in addition to separate hearings with pressure groups with special interests and local authorities

On 15 December 2003, the government handed down its decision in this matter. In the case of the Barents Sea, the government decided to permit further year-round petroleum activity in those parts of the southern region of the Barents Sea that were already open, with certain exceptions. These exceptions were the areas near the coast of Troms and Finnmark counties, and the especially valuable areas of the polar front, the edge of the ice cap, Bear Island and the Tromsø Bank.

Results from drilling for oil and gas in the Barents Sea have been mixed in both the Norwegian and Russian sectors. The Snøhvit gas field is the only project in the Norwegian sector for which the government has approved development and operation. Gas will come on stream in 2006 with production from a land facility outside Hammerfest. The small oil discovery Goliath is also being considered for development.

More than 30 wildcat offshore wells have been drilled in the Russian sector, and both oil and gas have been proven. The first offshore oil field, Prirazlomnoye in the Pechora Sea, is expected to come on stream in 2005. An enormous gas discovery, Shtokmanovskoye, has been made in the eastern sector of the Barents Sea. The sea freezes in this region in the winter, and any potential development of the discovery will face a number of technological and environmental challenges.

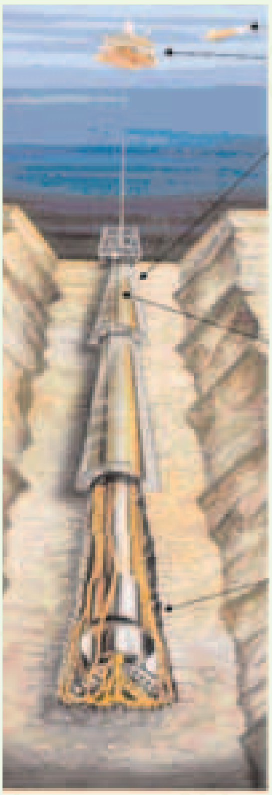
Oil has been produced on the island of Kolguyev, in the west Pechora Sea, since the mid-1990s. An offshore installation came on stream on 2003 for oil export in the eastern Pechora Sea. Large ice-strengthened tankers load oil from land-based fields all year round, and the oil is transported to Murmansk for reloading. This oil is transported onward along the Norwegian coast to, among other places, the USA.

Awarded areas
Blocks intended to be announced in 2003-2006
Discoveries
Svalbard
Kvitøya
Novaja Semlja
Kara Sea
Eastern Barents Sea
North-eastern Barents Sea
Ostrov Vaiga
Shtokmanovskoye
Bjørnøya
Southern Barents Sea
Area of overlapping claims
Prirazlomnoye
Pechora Sea
Kolguyev Isl.
Snøhvit
Vadsø
Hammerfest
NORWAY
Murmansk
RUSSIA
Tromsø
FINLAND
Kandalaksja
Harstad
White Sea

Stringent environmental regulations

Environmental regulations for this area have been further tightened relative to those applying to the rest of the NCS, as one of the conditions for further petroleum activity in the Barents Sea. The environmental regulations are described in the opposite box.

These intensified environmental regulations also apply to exploration, which will be the core activity in the area in the short term. Exploration drilling in the Barents Sea during 2005 will therefore be among the most environmentally sound that has ever been carried out on the NCS. The stringency of the environmental regulations is forcing the industry to develop new environmental technologies and new solutions. The figure below illustrates the solutions that have been chosen for drilling during 2005.



Support vessel

Mobile drilling rig. Emissions from diesel engines. Rig wash and rainwater from the rig is collected and cleaned. The pollution risk is reduced by equipping all systems capable of producing environmentally harmful emissions with two barriers.

The well's **top hole** is drilled 100-500 m into the ground. A drilling fluid is used, which consists of seawater, clay, starch and weighting materials designed to stabilise the drilling and transport the drill cuttings away from the drill bit. For safety reasons, the top hole is drilled without a return system to the rig itself. This means that there is a discharge of drill cuttings, cement residues and chemicals onto the seabed. The chemicals come both from the cement and from grease used to thread pipes together on the drill deck, to prevent hazards arising.

Once the top hole has been drilled, the drill string is withdrawn and a steel pipe **(casing)** is cemented down into the hole to avoid it collapsing and the drilling fluid leaking out.

Then a large **blow-out preventer (BOP)** is placed on the seabed over the casing. This safety valve prevents danger to personnel and equipment on the rig if there is high pressure in the formations being drilled into. Operation and testing of the BOP entails discharges of hydraulic fluid, but the installation of a return line can reduce these discharges considerably. Once the BOP is in place, a riser can then safely be installed between the seabed and the rig, including a return system for the drilled rock cuttings from the well.

The drill bit and drill string are then fed down into the well again and drilled a section at a time. For each section, new and narrower casings are installed. There is no discharge to the sea from drilling these sections, since all drill cuttings are led back to the rig through a closed system. From the rig, the waste is transported onshore to be recycled or disposed of.

If any oil or gas is discovered, **well testing** is planned down in the hole, without any discharges or emissions.

Environmental regulations governing petroleum activities in the Barents Sea

It is a general requirement for all petroleum activity on the NCS that there shall be no environmentally hazardous discharge to the sea. The authorities have set even more stringent environmental requirements for petroleum activity in the Barents Sea:

- Injection, or other technology which prevents discharges, must be employed in order to avoid discharge of produced water, which is water that emerges from reservoirs with the oil and gas. A maximum of 5% of the produced water can be discharged outside of normal operations under the condition that it is cleaned before discharge. Precise treatment requirements will be set by the authorities.

- Drill cuttings and drill mud must be reinjected or taken ashore for landfill.

- It will normally be possible to discharge drill cuttings and drill mud from the tophole section, on condition that the discharge does not contain compounds with unacceptable environmental properties, i.e. environmentally hazardous substances or other substances that can harm the environment. This only applies in areas where the potential damage to vulnerable environmental components is considered to be low. Such consideration must be based on thorough surveys of vulnerable environmental components (spawning grounds, coral reefs and other vulnerable bottom fauna). Such discharges will be conditional upon application to, and licences from, the authorities.

- Petroleum activity must not lead to harm to vulnerable flora and fauna. It is, therefore, a requirement that areas that could be affected must be surveyed before activity begins.

- If exploration proves oil and gas deposits, there must be no discharges to the sea in connection with well testing.

A further requirement states that petroleum activities are carried out in such a way as to obstruct fishing as little as possible. Important conditions include design of trawl-safe seabed installations, including pipelines, and minimising the use of surface installations.

Activities may also be seasonalised, in order to reduce the potential consequences to fishing, and any impact on fishery resources, and this will include, for example, seismic testing.

Discharges to the sea from exploration in the Barents Sea

Three wildcat wells will be drilled during 2005 in the Barents Sea. The wells will be drilled from the semi-submersible platform Eirik Raude, which is a large modern installation designed for operation under extreme weather conditions.

Discharge to the sea is permitted during drilling of the upper section of the well, the tophole. This means discharge of drilled rock, and residual added substances (chemicals). Chemicals used vary from substances that have little or no negative environmental impact (green and yellow categories in the NPCA classification) to substances that, based on inherent characteristics, are defined as environmentally hazardous and which should, therefore, be replaced (red category).

The total chemical discharges consist of 99.8 % (776 tonnes) of green substances. These are mainly a mixture of water, clay, salt and excess cement. In addition to this, 1.6 tonnes of yellow substances (0.2 %), mainly from detergents from the rig. Less than 5 kilogrammes of red substances have been discharged. These are remains of thread grease, which is used to screw pipes together satisfactorily. Environmentally sound thread grease is being developed, but its use is not yet justifiable.

Risk of, and contingency measures for, accidental discharges

The environmental regulations governing drilling and production in the Barents Sea ensure low discharge levels to the sea under normal operations, and the main challenge is therefore to avoid accidental discharges. Much of the experience gained in the North Sea will also be relevant in the southern Barents Sea, as wind and wave conditions and sea depths are fairly similar in both seas. The air temperature in the Barents Sea is, however, lower than in the North Sea, and special measures to avoid icing of equipment are necessary.

In the summer months, there are more hours of daylight in the Barents Sea than in the North Sea, but the lack of daylight in the winter will present a challenge to oil spill contingency measures. Despite this, the industry's contingency measures will greatly reduce the amount of oil from a discharge that could reach the coastal zone. Sample studies, based on statistical models, show that current contingency levels can reduce the amount of discharged oil that reaches the coast by 85%, compared to no measures, with the option of achieving a 93% reduction if oil spill protection is extended. Further development of the technology is taking place to improve the effectiveness of the protection in the face of such challenging conditions.

Fish, seabirds and beach areas are vulnerable to an acute discharge of oil. If oil is spilled, tests have shown that adult fish are largely able to avoid the oil, while fry and stationary bottom dwellers are more vulnerable. One preventive measure is, therefore, to establish so-called drilling restrictions on the NCS. This means that exploration may not take place at those times of year when fry are especially vulnerable. In certain situations, the authorities will place restrictions on how many wildcat wells can be drilled in one area at the same time, so that the oil spill protection can tackle any spill in the best way possible.

The risk of accidental spill is linked to uncontrolled blowouts during drilling, discharges from production and storage vessels, or a tanker foundering. There has only been one major blowout during the 40 years of petroleum activity on the NCS, the Bravo blowout of 1977 (12,700 m^3 of oil). Other major discharges to have occurred on the NCS are those from Statfjord in 1992 (900 m^3) and Draugen in 2003 (750 mm^3). Given that there are around 400 installations and around 11,000 kilometres of pipeline on the NCS, it can be assumed that a major accidental discharge of oil from Norwegian petroleum activity is a very unlikely event.

It is also worth noting that the greatest risk of oil spill in the Barents Sea comes from shipping and oil transport from Russia. Oil spill contingency from Norwegian petroleum activity in the Barents Sea will be strengthened, using the private NOFO spill contingency. As a result, calculations carried out by DNV show that the total risk for environmental damage will be reduced at moderate levels of activity, as compared with no activity.

Integrated management plan for the Barents Sea

The most important users of the sea are the fishing, trapping, transport and petroleum industries. Our goal is for these industries to be able to carry out their business without harming the environment, natural resources or each others' business interests.

Since the start of petroleum activity on the NCS, coexistence with other industries, especially the fishing industry, has been key. As the petroleum industry has moved northwards, where fishing is more intensive, the need to find even better solutions for coexistence has increased.

In order to be able to see the various human activities in context, the government intends to establish integrated management plans for the marine areas. The Barents Sea management plan will prepare for value creation, based on the sustainable exploitation of the resources of the seas from Lofoten and northwards, at the same time as the natural environment will be protected for future generations.

The management plan will provide guidelines for how the environment and resource stocks in the area shall be monitored. Areas where the administration lacks significant knowledge will be highlighted, and follow-up initiatives will be recommended.

The management plan will prepare for a process which involves both various government departments and other interested parties. As developments on the Russian side of the borderline will have major consequences for the Barents Sea, the Norwegian technical authorities have cooperated with Russia in the acquisition of data for the reports on which the management plan will be based.

The planned completion date for the Barents Sea management plan is 2006. A more detailed assessment of opening up Nordland VI for petroleum activities will be taken once the management plan is in place.

Especially sensitive areas

It is especially important to protect biological production and diversity in certain parts of the Barents Sea. In their work on the integrated management plan for the Barents Sea, the Norwegian Institute of Marine Research and the Norwegian Polar Institute carried out an assessment of the environmental value of this sea, which named four areas of special value. These are:

- Lofoten - Røstbanken – Vesterålen
- the Tromsø Bank
- the Polar front
- the ice edge

Certain areas have also been identified as being especially important for fishing. This applies to:

- The area along the edge of the continental shelf (Troms I, Troms III and Bear Island West).
- The eastern sections of Nordland VI, VII and Troms II.
- A coastal belt along Troms III, Finnmark West and Finnmark East.

Both the especially valuable areas and the especially important areas for fishing were accorded particular attention in the work on the ULB, and these areas are not currently open for petroleum activities.

Other countries' environmental regulation of petroleum activity in environmentally sensitive areas

Globally, petroleum activity takes place in a number of environmentally vulnerable areas. In general, the conditions and environmental challenges that are faced vary widely from area to area.

Norway has discovered oil and gas far offshore, on deep waters and with demanding weather conditions. Cooperation between the authorities and the industry has uncovered solutions that allow wealth to be recovered without an unacceptable burden on the natural environment. The demand for sustainable management in the Barents Sea means that there must be more stringent regulation of petroleum activities there than in the North Sea.

Activity under equivalent conditions to those on the NCS is taking place off the eastern coast of Canada. The authorities in this area have also imposed stringent regulations on petroleum activities, which resulted in a choice of solutions that only place a slight burden on the natural environment.

The more stringent environmental regulation of petroleum activities in Lofoten – the Barents Sea is, however, unique, in that the petroleum activities in the Canadian area do not have the equivalent of the Norwegian regulation concerning no discharges under normal operations.

Canada has developed one offshore gas field and two offshore oil fields, and one new oil field is under development. The regulations concerning discharge of produced water and drilling residues are equivalent to those generally applicable to the NCS. In the case of chemical discharges and emissions to the air, the regulations are generally less stringent than the Norwegian. This means that flaring is employed far more than on the NCS, which has led to greater emissions of the climate gas, CO_2.

The Russians, for their part, have limited experience of offshore petroleum activities, as their gas and oil recovery has mainly taken place onshore, although Russian focus on developing offshore petroleum resources has increased in recent years. They have recognised that this is technologically demanding, and wish to cooperate with the international oil and gas industry in order to increase profitability and make it more environmentally sound. A number of companies, including Hydro and Statoil, may participate in such projects.

Russian oil and gas companies have a financial interest in more environmentally sound operations, and a good environmental profile can increase the value of these companies. For this reason, several Russian companies want to share ownership with international companies. It is important to factor this in when the Norwegian authorities want to make a contribution to Russian exploration for, and production of, oil and gas being as environmentally sound as possible.

If a closer commercial partnership develops between Norwegian and Russian oil companies, use of advanced Norwegian offshore technology will reduce the risk of acute discharges, and reduce discharges from normal operations in the Russian sector. Increased cooperation between Norwegian and Russian oil companies is also an extremely important factor in increasing environmental awareness in the Russian petroleum industry. In 2003, a

partnership was initiated between the Russian and Norwegian authorities, Norwegian and Russian oil companies and Norwegian and Russian geological, environmental and petroleum resource communities. These partnerships can contribute positively to environmentally sound operation of petroleum activities.

Norway employs leading edge technological solutions, compared with those employed by other countries. Norwegian oil companies and authorities have provided the impetus for the development of environmental technology as a competitive edge in a potential future and extended partnership with e.g. Russian and Canadian oil and energy companies. These efforts have been important for several reasons, and we can see that strict adherence to the precautionary principle and protection of commercial and strategic interests can go hand in hand in these waters.

Terms and abbreviations

BAT	Best available technology
CH_4	Methane
CO_2	Carbon dioxide
EIF	Environmental Impact Factor, a tool developed to calculate the risk of environmental damage from the discharge of produced water from an individual field
Gothenburg-Protocol	Protocol which aims to tackle acidification, eutrophication, and ground-level ozone.
Kyoto Protocol	Protocol adopted in Kyoto, Japan in 1997, under the auspices of the UN Climate Convention
LRTAP Convention	Convention on Long-Range Transboundary Air Pollution
NCS	Norwegian Continental Shelf
nmVOC	Non-methane volatile organic compounds
NO_x	Nitrogen oxides
NPD	Norwegian Petroleum Directorate
OED	Ministry of Petroleum and Energy
OIC	Offshore Industry Committee, a committee under the OSPAR Convention
OLF	The Norwegian Oil Industry Association
OSPAR Convention	Oslo-Paris Convention. Convention for the Protection of the Marine Environment of the North-East Atlantic
PIO	Plan for installation and operation
PAH	Polyaromatic hydrocarbons, produced by all incomplete combustion of organic materials
PLONOR	Pose Little or No Risk. Substances on the PLONOR list occur naturally in seawater and/or are not harmful to the environment
Produced water	Water which comes up the well with the oil and gas
PDO	Plan for development and operation
SDFI	State’s Direct Financial Interest
SFT	Norwegian Pollution Control Authority
scm	standard cubic metres
SO_2	Sulphur dioxide