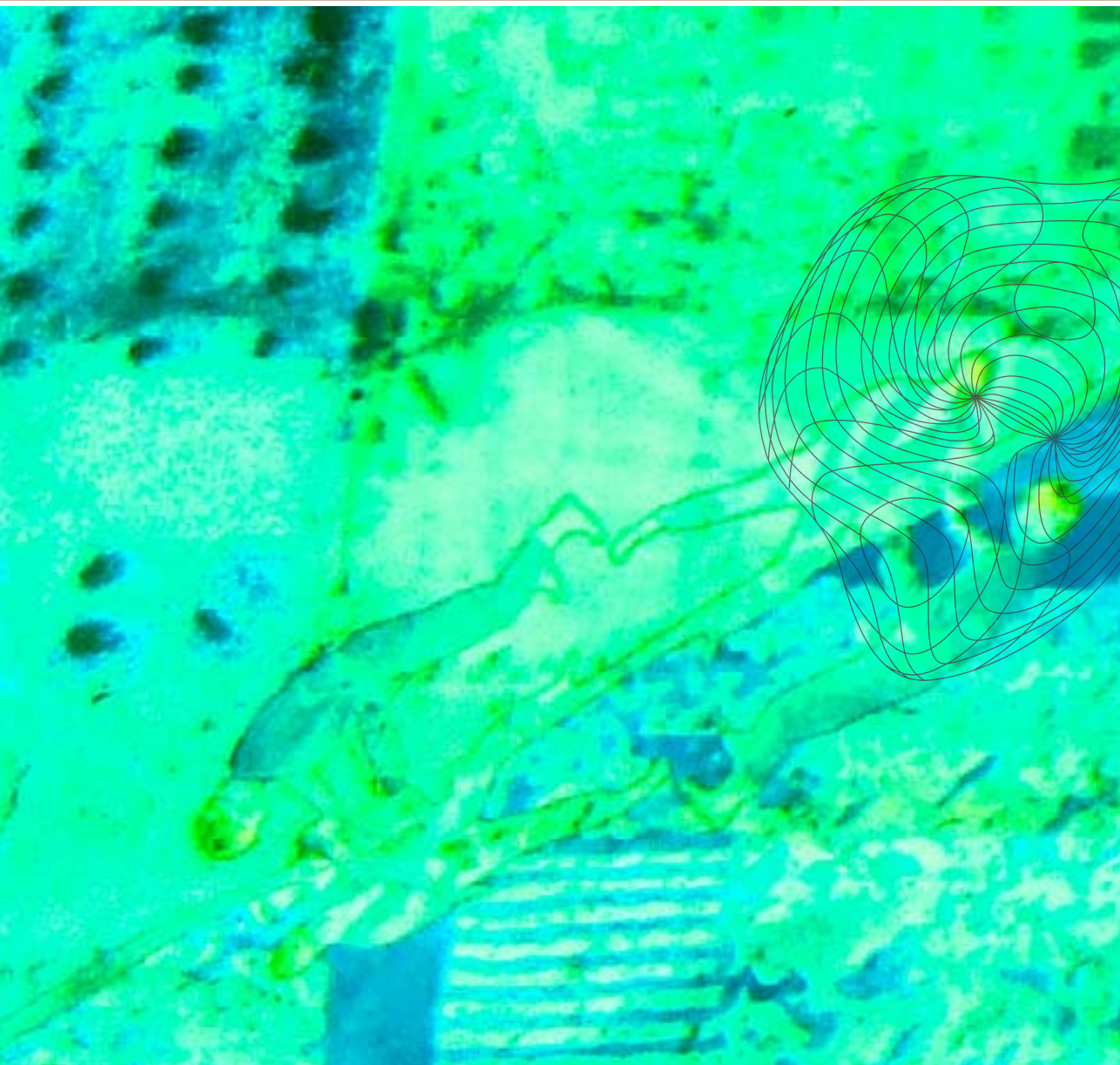


9 Environmental considerations in the Norwegian petroleum sector



Introduction

Consideration for the environment has always been an integrated part of the Norwegian petroleum activities. In order to ensure that Norway can combine its role as a major energy producer with being a pioneer in environmental issues, a comprehensive set of policy instruments has been developed to safeguard consideration for the natural environment in all phases of the activities, from licensing rounds to exploration, development, operations and decommissioning.

Norway was quick to take the climate issue seriously, and in 1991 it was one of the first countries to introduce a substantial CO₂ tax. This tax has led to development of technology and triggered initiatives that led to considerable emission reductions. The strict regulation of flaring through the Petroleum Act contributes to a low general level of flaring on the Norwegian continental shelf, compared with other countries. The authorities and the petroleum industry have worked together closely to reach the objective of zero environmentally hazardous discharges to sea from the petroleum activities (zero discharge target). As a result, the zero discharge targets are considered to be achieved as regards discharges of chemical additives. As a result of the continuous strong emphasis on the environment, the Norwegian petroleum sector maintains very high environmental standards compared with petroleum sectors in other countries.

This chapter provides an overview of emissions and discharges from the petroleum activities, as well as policy instruments and measures designed to ensure consideration for the environment.

Acts and legislation that regulate emissions and discharges from the petroleum sector

Emissions and discharges from petroleum activities in Norway are largely regulated by the Petroleum Act, the CO₂ Tax Act, the Special Tax Act,

Various types of emissions and discharges from the petroleum activities

The different phases of the petroleum activities lead to different types of discharges and emissions. With exploration activity come discharges of drill cuttings and emission from generating energy. The operations phase brings discharges to sea, primarily in the form of water containing residues of oil and chemicals (produced water); and emissions to air in the form of carbon dioxide (CO₂) and nitrogen oxides (NO_x) from generating energy and flaring, as well as non-methane volatile organic compounds (nmVOC) from storage and loading of crude oil. Both exploration activity and production entail the risk of acute spills.

the Greenhouse Gas Emission Trading Act and the Pollution Control Act. Petroleum facilities on land are subject to the same types of policy instruments as other land-based industry. The processes involved in evaluating consequences and approving new development plans (PDOs/PIOs) are key elements of the petroleum legislation. Facilities located on land or at sea within the baseline are also subject to the scope and extent of the Planning and Building Act (see Chapter 6).

In addition to the aforementioned statutes, the petroleum sector has committed to reducing emissions and discharges under various agreements. In accordance with international agreements, Norway has pledged to limit its discharges of various components. How this affects the petroleum sector depends on the wording of the respective agreements, and how the requirements and policy instruments are allocated to the various sectors in Norway.

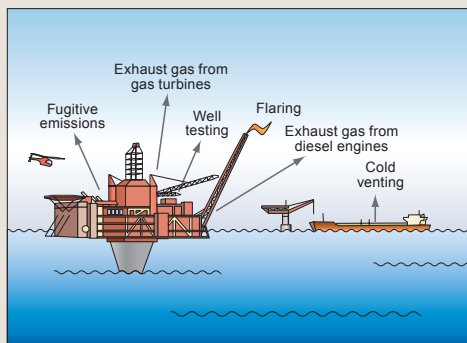
Emissions to air

The agreements regarding emissions to air usually specify emission limits for each country. The wording of the agreement determines whether the imposed limits must be implemented completely within the borders of each country, or whether reductions can also be implemented in other countries where the costs of such reductions may be lower. The costs associated with reducing emissions from the various sources, both national and international, have an impact on the types of measures implemented vis-à-vis the petroleum sector.

After the Kyoto Protocol, Norway has an emissions target which entails that the country's average greenhouse gas emissions for the years 2008–2012 shall not increase more than one per cent compared with the emission level in 1990. Compared with today's level, this would mean a reduction of greenhouse gas emissions by about 7 per cent. The requirement will be met by reducing emissions both nationally and in other countries using the Kyoto mechanisms "Clean Development Mechanism (CDM)" and "Joint Implementation (JI)".

The Climate White Paper presented in June 2007, entails that Norway should exceed the Kyoto target by 10 percentage points. The climate compromise of January 2008 suggested that Norway would become carbon-neutral in 2030. In addition, a reduction of Norwegian greenhouse gas emissions of 15–17 million tonnes of CO₂-equivalents by 2020 has been assumed, including forestry. This means that about 2/3 of our total emission reductions must come from national sources.

With the Greenhouse Gas Emission Trading Act, Norway established a national quota system for greenhouse gases starting in 2005 as a follow-up of the Kyoto Protocol. The Greenhouse Gas Emission Trading Act was revised in 2007 and in February 2009. Norway implemented the EU's



Overview of emission/discharge sources

directive on emission trading in the fall of 2007, and the Norwegian quota system is linked to the EU's quota system for the period 2008–2012. In December 2008, the EU agreed on an emissions trading directive for the period 2013–2020. This directive is now being considered by the EEA//EFTA countries.

Emissions that have regional environmental consequences are regulated in the protocols under the Convention on Long-Range Transboundary Air Pollution (the LRTAP Convention). Together with the USA, Canada and other European countries, Norway signed the Gothenburg Protocol in 1999. This protocol seeks to solve the environmental issues of acidification, over-fertilization and ground-level ozone. The Gothenburg Protocol took effect on 17 May 2005. Under this Protocol, Norway is to reduce NO_x emissions to 156,000 tonnes by 2010. This means a 27 per cent reduction compared with the 1990 emission levels. As regards nmVOC, the new commitment is approximately the same as Norway assumed under the prevailing Geneva Protocol, which requires annual nmVOC emissions from the entire mainland and the Norwegian economic zone south of the 62nd parallel to be reduced as soon as possible by 30 per cent compared with the 1989 level. Under the Gothenburg Protocol,

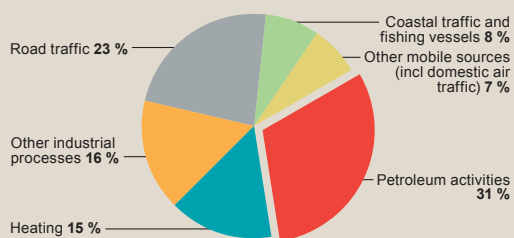


Figure 9.1 Sources of Norwegian CO₂ emissions, 2007
(Source: Statistics Norway)

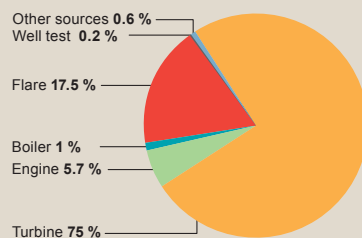


Figure 9.2 CO₂ emissions from the petroleum activities, 2007, by source
(Source: Norwegian Petroleum Directorate)

total national emissions shall not exceed 195,000 tonnes per year by 2010.

Discharges to sea

Discharges to sea mainly include produced water, drill cuttings and residues of chemicals and cement from drilling operations.

Discharges of oil and chemicals can have local effects in the area near the facilities, and such discharges are regulated at the national level through discharge permits based on the Pollution Act. These discharges are also subject to international regulation through the Oslo-Paris Convention on discharges to sea (the OSPAR Convention). For discharges to sea, the stipulated international maximum level for oil content in water was reduced to 30 mg per litre starting from 2007. Use and discharge of chemicals are regulated at the international level in the form of risk assessment requirements and categorisation according to the properties of the chemicals.

The objective of zero hazardous discharges to sea from the petroleum activities was confirmed in Storting White Paper No. 58 (1996–1997) *Environmental protection policy for sustainable development*. This objective has also been raised in several subsequent white papers, including in Storting White Paper No. 12 (2001–2002) *Clean and rich seas*, Storting White Paper No. 25 (2002–2003) *The Government's environmental protection policy and the state of the environment in Norway* and Storting White Paper No. 26 (2006–2007) *The Government's environmental protection policy and the state of the environment in Norway*.

The zero discharge target is a precautionary target intended to contribute to ensuring that discharges to sea of oil and environmentally hazardous substances do not lead to unacceptable damage to human health or the external environ-

ment. The main rule is that no environmentally hazardous substances may be discharged, neither chemical additives nor chemical substances that naturally occur in the environment. After the objective of zero discharges to sea was confirmed, the authorities and the industry have worked together to find solutions aimed at achieving this goal.

The oil industry has invested billions in reducing discharges to sea, and the implemented measures have significantly reduced these discharges. Discharges of environmentally hazardous substances on the priority list from produced water and drill cuttings account for less than 3 per cent of the national discharges of the specific substances. Discharges of environmentally hazardous chemical additives (red and black categories) have been reduced by more than 99 per cent during the period 1997 to 2007, and the zero discharge target is considered to be achieved as regards chemical additives. The Norwegian Pollution Control Authority (SFT) has provided an account of the progress in the zero discharge work in reports to the Ministry of the Environment in 2002, 2003, 2005 and 2006.

The target for environmentally hazardous natural substances in produced water has not been achieved to the same extent as for chemical additives. Produced water contains residues of oil and chemical substances, both chemicals added in the process and naturally occurring chemical substances. For oil and naturally occurring substances in produced water, the greatest contributions towards reducing the risk of environmental damage within an acceptable cost framework are provided by process optimisations, reinjection of produced water and cleaning measures.

Many fields have implemented measures to reduce discharges, with a view towards the zero discharge target. However, several of the planned measures have proven to be more time-consuming

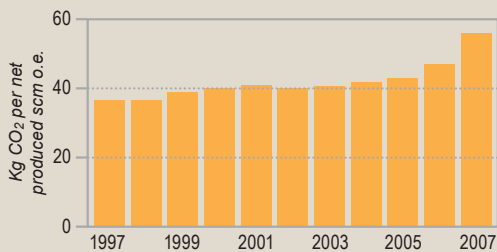


Figure 9.3 Emissions of taxable CO₂ per produced unit
(Source: Norwegian Petroleum Directorate)



Figure 9.4 CO₂ emissions from the petroleum sector in Norway
(Source: Norwegian Petroleum Directorate)

than expected. Thus, the final achieved objective for existing fields cannot be evaluated until 2009, at the earliest. In 2009, the government will assess the progress made, and determine whether additional measures are needed to ensure that the zero discharge target is achieved.

Emissions from the petroleum activities

Emissions to air from the petroleum sector largely consist of exhaust gases from combustion of gas in turbines, flaring of gas and combustion of diesel. These exhaust gases contain components such as CO₂ and NO_x. Other environmentally hazardous substances released include nmVOC, methane (CH₄) and sulphur dioxide (SO₂). Discharges from the petroleum sector to sea contain residues of oil and chemicals used in the production processes, as well as naturally occurring chemical substances.

Measuring and reporting discharges and emissions

In most cases, emissions to air are calculated on the basis of the volume of fuel gas and diesel consumed on the facility. The emission factors are based on measurements from suppliers or standard figures developed by the industry itself, through the Norwegian Oil Industry Association, or using field-specific measurements and calculations.

When calculating total oil discharges, the volume of produced water discharged to sea is measured, followed by an analysis of the oil content in the water. Discharge of chemicals is calculated based on consumption, relative to how much is recovered and/or injected.

The Norwegian Pollution Control Authority, the Norwegian Petroleum Directorate and the Norwegian Oil Industry Association have established a joint database to report discharges to sea and emissions to air from the petroleum activities. Since 2004, all operators on the Norwegian

continental shelf report emission/discharge data directly in this database. This allows both the operating companies themselves and the authorities to more easily analyse historical emissions to air and discharges to sea in a more complete and consistent manner.

Emission status for CO₂

In a national context, the petroleum activities account for 31 per cent of the CO₂ emissions (see Figure 9.1). The other major sources of CO₂ emissions in Norway are road traffic, heating and emission from industrial processes. CO₂ emissions from the facilities largely come from combustion of gas and diesel in turbines and flaring of gas (see Figure 9.2).

The environmental effects of CO₂ emissions include the following:

- CO₂ contributes to the greenhouse effect, which in turn causes global warming.
- High concentrations of CO₂ in the atmosphere may result in more CO₂ dissolved in water, which can in turn lead to a reduction of the pH value in lakes and the sea.

The development on the Norwegian continental shelf towards more mature fields, movement of activities towards the north and longer distances for gas transport all reinforce the trend of higher emissions per produced unit (see Figure 9.3). Treatment and transport of produced gas requires more energy than production of liquid. Gas accounts for an increasing share of production on the Norwegian continental shelf. At the same time, reservoir pressure in the production wells is declining, thus increasing the need for gas compression and, in turn, the need for energy.

Reservoir conditions are another factor which causes an increase in the need for power. As field

CO₂ emissions from production in Norway compared with the international average

Emissions on the Norwegian shelf are low compared with most other countries in the world. The figure below shows Norway's emissions compared with the international average.

The figure shows CO₂ emissions per produced unit of petroleum. The figure shows developments for Norway and for the world. In 2006, Norway's emissions per produced unit were about 47 kg per scm o.e., while the international average in 2006 was about 120 kg per scm.¹

There has been a slight increase in emissions per produced unit on the Norwegian continental

shelf in recent years, largely due to more energy-intensive production from mature fields.

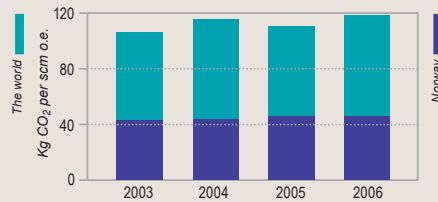


Figure 9.5 CO₂ emissions per produced unit in Norway and international average (2003-2006)
(Source: Norwegian Petroleum Directorate)

¹ Source: International Association of Oil and Gas Producers, www.ogp.org.uk.

lifetime progresses, more water is produced in the well stream. Since the total volume of liquid and gas (water, oil and gas) largely determines the energy need in the process facilities, a field will have higher emissions per produced unit as it matures.

In the next few years, CO₂ emissions from the petroleum activities will be about 14 million tonnes of CO₂ per year, most likely peaking in 2019.

Measures aimed at reducing CO₂-emissions

Norway is well in the forefront when it comes to using efficient environmental solutions, and the country utilises both policy instruments and technical measures in the work to reduce CO₂ emissions. The CO₂ tax and the Greenhouse Gas Emission Trading Act are central policy instruments in the efforts to reduce these emissions. The authorities can also use other measures, such as the conditions in PDOs/PIOs, emission permits and production permits, which cover factors such as flaring.

CO₂ Tax

Under the CO₂ Tax Act which took effect on 1 January 1991, all use of gas, oil and diesel in connection with petroleum activity on the continental shelf is subject to CO₂ tax. As of 1 January 2008, the CO₂ tax is 45 øre per litre of oil and per standard cubic metre (scm) of gas (equivalent to approximately NOK 184 per tonne of CO₂).

Greenhouse Gas Emission Trading Act

The Greenhouse Gas Emission Trading Act was revised in 2007 and in February 2009. Offshore petroleum facilities were included in the Norwegian quota system starting from 2008, together with the companies that had quota obligations in the first period of the quota system, 2005–2007.

Petroleum facilities must purchase all necessary quotas. At present, several fields receive all or part of their power supply from land. The facilities on Troll A and Ormen Lange use electricity from the power grid, and decisions have been made to use

power from land for the Valhall Redevelopment project and development of the Gjøa field.

Conditions and permits

Under the Petroleum Act, companies may not flare any more gas than is necessary to ensure normal operations, without the approval of the Ministry of Petroleum and Energy. Although flaring accounts for about 7 per cent of the CO₂ emissions from the petroleum sector, the level of flaring in Norway is low compared with other countries (see Figure 9.5). The CO₂ tax and direct regulation of flaring have triggered a number of emission-reducing measures, which have put Norway in the forefront in this area.

All plans for development and operation of oil and gas fields (PDOs/PIOs) must contain an analysis of potential power supply from land. This applies both to new field developments and major modifications to existing installations.

Examples of measures aimed at reducing CO₂ emissions

In addition to the overarching policy instruments, there are also concrete, practical measures on the shelf. The authorities and the oil companies have a strong commitment to research and development of technology to find good technical solutions that can contribute to reducing emissions which can harm the environment. Much is being done to develop environmental competence and environmental technology, and the Norwegian oil industry leads the way when it comes to applying environmentally friendly solutions. This has yielded results, and many of the solutions first applied in Norway have become export commodities.

Combined power

Combined power is a solution which utilises heat from the exhaust gas in the turbines to produce steam, which is in turn used to generate electricity.

Combined power boosts energy efficiency, and it is currently in use on the Oseberg, Snorre and Eldfisk fields. These facilities are unique in a global offshore context.

Storage of CO₂

CO₂ can be injected and stored in depleted oil and gas reservoirs, or in geological formations under water or on land. Since 1996, one million tonnes of CO₂ have been stored annually in the Utsira formation in connection with processing of gas from the Sleipner field. Storing CO₂ in the Utsira formation is unique. This is the only facility in the world where large quantities of CO₂ are stored in a geological formation under the seabed. On the Snøhvit field, starting in April 2008, CO₂ from the gas production was separated out and stored before the natural gas is cooled to liquid natural gas (LNG). The CO₂ gas is transported via pipeline from the LNG plant on Melkøya and back to the field for reinjection and storage in the Tubåen formation, 2600 metres below the seabed. When the Snøhvit field is operating at full capacity, approximately 700,000 tonnes of CO₂ will be stored each year.

In the future, Norway will have excellent opportunities for storing CO₂ due to its access to large, water-filled reservoirs and depleted oil or gas reservoirs off the Norwegian coast. Storing CO₂ in depleted reservoirs is a good solution in terms of geology, because the structure is likely to be impermeable inasmuch as it has contained oil and gas for millions of years.

The Norwegian authorities work actively to ensure that such storage of CO₂ can be achieved in a safe and environmentally secure manner. Work is therefore being undertaken under the auspices of the OSPAR and London Conventions to ensure that sound international regulations for CO₂ storage are established. In the autumn of 2006, it was agreed under the London Convention that injection and

storage of CO₂ in geological formations under the seabed would be allowed. This change entered into force on 10 February 2007. Similar changes were made to the OSPAR Convention in the summer of 2007. The changes will enter into force when at least seven of the parties to the convention have ratified the change resolution. Norway ratified the changes on 9 November 2007.

The Ministry of Petroleum and Energy has given Gassco, Gassnova, the Norwegian Petroleum Directorate and the Norwegian Water Resources and Energy Directorate the task of evaluating different solutions for transport and storage of CO₂ from the CO₂ capture plants, including Kårstø and Mongstad. The first reports were made in the summer of 2007 and the group is to make a recommendation on the best transport and storage solution for CO₂, taking into consideration costs, reservoir conditions and technological risk. According to the plan, an investment decision will be made in 2009.

A new state-owned enterprise, Gassnova SF, was established in June 2007. The enterprise is responsible for the state's interests in the technology centre at Mongstad, the work on CO₂ capture at Kårstø, as well as the projects to study transport and storage of CO₂.

Use of CO₂ to enhance oil recovery

The Norwegian Petroleum Directorate has estimated that there is a significant technical potential for improved oil recovery through the use of CO₂ injection in oil fields on the Norwegian continental shelf. New studies have shown negative profitability with current assumptions regarding development costs and oil prices (for example use of CO₂ to improve oil recovery from the Draugen field). The great potential, as well as focus on emissions, implies that the Norwegian Petroleum Directorate still will have a special focus on use of CO₂ to enhance oil recovery.

Energy management and energy efficiency

Emissions of CO₂ from power production on the continental shelf account for about 90 per cent of the total emissions from the offshore activities. In 2004, the authorities cooperated with the industry to produce a report on the possibilities of achieving more efficient energy supply on the Norwegian continental shelf. The study concluded that a realistic, but ambitious estimate of potential emission reductions is about 5–10 per cent over a period of 10 years. This improvement has already been incorporated in the projected CO₂ emissions from the sector. This can be achieved if the industry systematically implements energy management in all aspects of the activities. The industry followed up the authorities' study, and in the spring of 2006, the Norwegian Oil Industry Association (OLF) published guidelines to assist the companies in achieving a formalised, systematic approach to the work on energy management, based on the same principles as in approved standards for environmental management, such as ISO 1400 and EMAS. Under the Pollution Act, emission permits issued by the SFT stipulate requirements for energy management (an energy management system), and companies are to be audited on this requirement.

Many energy efficiency measures were implemented when the CO₂ tax was introduced in 1991. A fundamental shift in technology and energy supply concepts is needed to ensure even better energy efficiency over the long term. This demands a long-term commitment to development, testing and implementation of new technology.

Electrification by means of power from land

On 4 January 2008, the Norwegian Petroleum Directorate (NPD), the Norwegian Water Resources and Energy Directorate (NVE), the Norwegian Pollution Control Authority (SFT) and the Petroleum Safety Authority Norway (PSA)

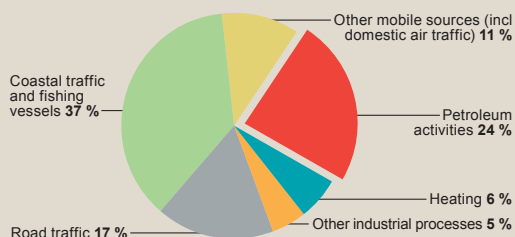


Figure 9.6 Sources of Norwegian emissions of NO_x 2007
(Source: Statistics Norway)

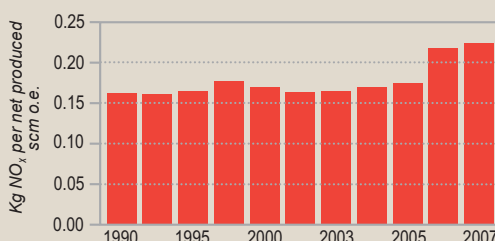


Figure 9.7 NO_x emissions per produced unit
(Source: Norwegian Petroleum Directorate)

submitted a report to the government. The report was a new review of the costs associated with supplying the petroleum activities on the shelf with power from land; a report that was presaged in Storting White Paper No. 34 (2006–2007) Norwegian climate policy. The new calculations show that the costs of measures needed to electrify an area with existing facilities was in the range of NOK 1600 to 5000 per tonne of CO₂. These costs are mainly related to significantly higher construction costs offshore, greater complexity in the modification processes and shorter field lifetime than previously assumed. At the same time, the report showed that nearly 45 per cent of the emissions from the sector cannot be replaced by electricity from land (such as emissions from floating facilities and emissions linked to gas flaring as a safety measure). In the agreement on the Climate White Paper (the climate compromise), the parties agreed that the work on emission-free power in the petroleum sector must be intensified. Based on technical, financial and supply-related factors, power from land and emission-free power shall be considered in connection with new developments and major modification projects. Electrification must be viewed in light of the fact that there are considerable variations between the facilities as regards technical properties, costs and, not least, the effect on other power consumers through connection to the general power supply. The economics of solutions involving power from land depend particularly on the need for heat and power, distance to land and facility design.

As of today, several fields already receive all or parts of their power supply from land. For example, the Troll A and Ormen Lange facilities use power from the grid, while Valhall Redevelopment and the Gjøa field will be developed using power from land.

Emission status for NO_x

Emissions of CO₂ and NO_x are closely connected. As for CO₂, gas combustion in turbines, flaring of gas and diesel consumption on the facilities are key emission sources also for NO_x. The volume of emissions depends both on the combustion technology and the quantity of fuel used. For example, combustion in gas turbines yields lower emissions of NO_x than combustion in diesel motors.

NO_x is a nitrogen compound which contributes to acidification. The environmental effects of NO_x emissions include the following:

- impact on fish and other fauna through acidification of watercourses and the ground
- damage to buildings, stone and metalwork resulting from acid rain
- damage to health, crops and buildings due to production of ground-level ozone

Mobile sources account for the majority of the Norwegian NO_x emissions (see Figure 9.6). The petroleum sector contributes 24 per cent. Emissions of NO_x per produced oil equivalent have risen slightly since 1997 (see Figure 9.7). Total emissions of NO_x from the sector have also increased from 1991 (see Figure 9.8). The main cause of the growth to date is increased activity, which has entailed a need for more energy, and in turn, more emissions.

Measures for reducing NO_x emissions

PDOs/PIOs

In the operations phase, emissions of scm on the continental shelf are regulated by conditions that may be set in connection with consideration of the PDO/PIO. Emission permits may also be issued pursuant to the Pollution Act, which includes NO_x.

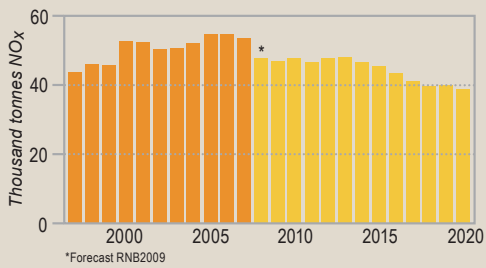


Figure 9.8 NO_x emissions from the petroleum activities
(Source: Norwegian Petroleum Directorate)

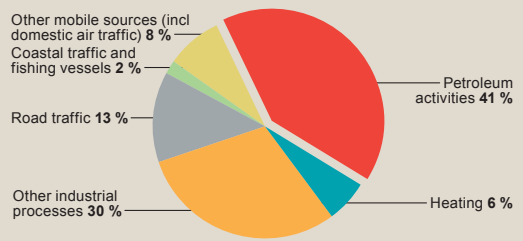


Figure 9.9 Sources of Norwegian emissions of nmVOC, 2007
(Source: Statistics Norway)

The SFT is currently working on updating the emission permits.

NO_x tax and the Gothenburg Protocol

On 28 November 2006, the Storting adopted a tax on emissions of NO_x. The legal basis for this is found in the amendment (1 January 2007) of the Regulations relating to special tax. The tax applies to all emissions from the petroleum activities from turbines with a gross added energy greater than 10 MW and machinery larger than 750 hp, as well as emissions from flaring. The tax is currently set at NOK 15 per kg of NO_x.

The purpose of the tax is to reduce annual emissions of NO_x in Norway to 156,000 tonnes by 2010, in accordance with our commitment under the Gothenburg Protocol from 1999 (ratified by Norway on 30 January 2002). The tax largely targets emissions from domestic activities, and includes emissions from major within the maritime and aviation sectors, land-based activities, as well as on the continental shelf. Shipping companies and owners of vessels, owners of land-based activities and operators of activities on the continental shelf are all subject to the tax.

In connection with the Storting's consideration of the NO_x tax, a decision was made to grant an exemption for emission sources which were

part of environmental agreements with the State on introduction of measures to reduce NO_x in accordance with stipulated environmental targets. The Norwegian State (represented by the Ministry of the Environment) and the industry organisations have now entered into an environmental agreement on reduction of NO_x emissions. Emissions from these industry organisations shall not exceed 98,000 tonnes in the geographical area covered by Norway's commitments under the Gothenburg Protocol.

The industry organisations have established a dedicated NO_x fund that will be used to fulfill the commitments under this agreement. On behalf of the industry organisations, the fund collects payments per kilogram of NO_x emissions from enterprises that have endorsed the agreement. The fund also provides subsidies for cost-effective measures aimed at reducing NO_x emissions.

Examples of measures for reducing NO_x emissions

Low-NO_x burners

In addition to the regulations mentioned above, practical measures are also being implemented to reduce emissions of NO_x. Low-NO_x burners are one such measure. These burners can be

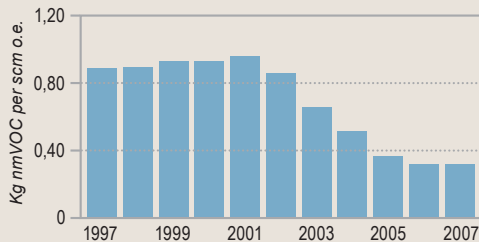


Figure 9.10 nmVOC emissions per produced unit
(Source: Norwegian Petroleum Directorate)

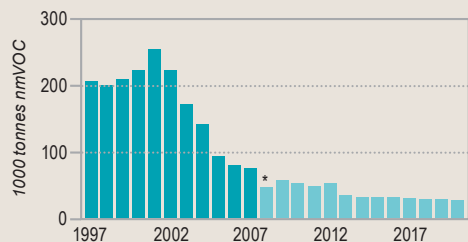


Figure 9.11 Emissions of nmVOC from the petroleum activities
(Source: Norwegian Petroleum Directorate)

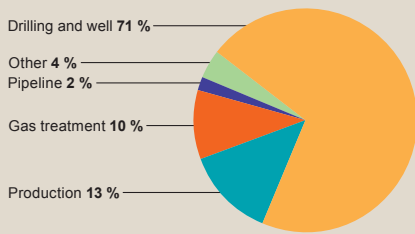


Figure 9.12. Discharges of chemicals from the Norwegian petroleum activities, by source, 2007
(Source: Norwegian Petroleum Directorate)

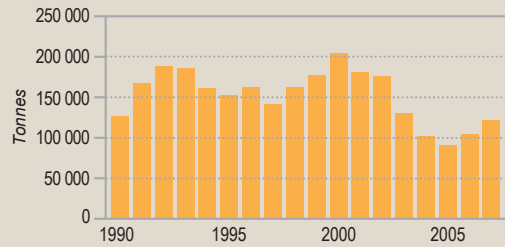


Figure 9.13 Total discharges of chemicals from the Norwegian petroleum activities
(Source: Norwegian Petroleum Directorate)

retrofitted on existing turbines. Studies show that the general cost level associated with retrofitting such burners on existing facilities is considerably higher than previously assumed. Generally speaking, low-NO_x technology installed on machinery running at high efficiency will result in significant environmental benefits. On machinery running at low capacity, CO₂ emissions increase, while NO_x reductions are less when the utilization of capacity is high.

Injection of steam or water is a technology that can reduce NO_x emissions by reducing the combustion temperature in the combustion chamber. This technology is not in use today because steam and water injection is not qualified to be used offshore. Among other things, there are great challenges related to the fact that the technology requires great amounts of clean water. However, in the future, this technology could contribute to reducing NO_x emissions from the petroleum sector even more.

Emission status for nmVOC

nmVOC stands for non-methane volatile organic compounds, which are vapours from substances such as crude oil. In the petroleum sector, most of these emissions come from storage and loading of crude oil offshore and from the land terminals.

The environmental effects of nmVOC include:

- Formation of ground-level ozone, which can damage health, crops and buildings
- Direct exposure to nmVOC can cause respiratory tract damage
- nmVOC contributes indirectly to the greenhouse effect in that CO₂ and ozone are formed when nmVOC reacts with air in the atmosphere.

The petroleum sector is the main source of nmVOC emissions in Norway (see Figure 9.9), accounting for approximately 41 per cent of total emissions. Emissions of nmVOC largely originate from storage and loading of crude oil offshore.

Industry collaboration

Emission permits entail a requirement whereby oil must be stored and loaded using the best available emission-reducing technology (BAT). Technologies designed to meet this requirement will be implemented according to a specified timetable extending to the end of 2008.

Operators of Norwegian continental shelf fields with buoy loading have established a joint venture to coordinate phase-in of technology and to fulfil the requirement in an expedient and cost-effective manner. The joint venture paves the way for exchange of experience with regard to operation of the facilities.

The joint venture agreement was signed in 2002, and 29 companies take part in this collaboration which covers buoy loading of oil from Varg, Glitne, Jotun, Balder, Gullfaks, Statfjord, Draugen, Njord, Åsgard, Norne, Volve and Alvheim.

At the end of 2008, nmVOC-reducing technology had been installed on 16 buoy loaders, as well as on three ships transporting oil from Heidrun. The estimated nmVOC reduction from 2007 to 2008 was approximately 25,778 tonnes. In 2009, the focus will be on measures to achieve continued good, safe operations of the facilities and high operational regularity.

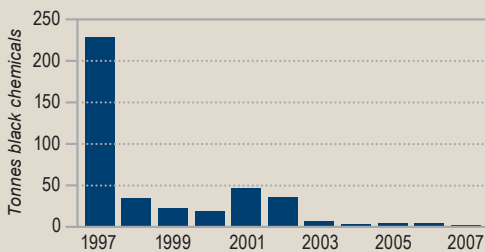


Figure 9.14 Discharges of black chemicals from the petroleum activities

(Source: Norwegian Petroleum Directorate)

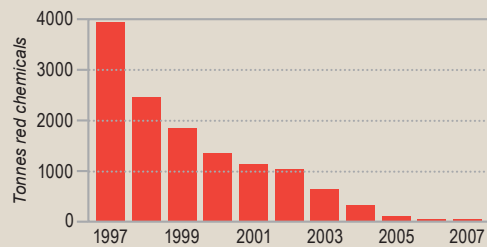


Figure 9.15 Discharge of red chemicals from the petroleum activities

(Source: Norwegian Petroleum Directorate)

Minor emissions also occur at the gas terminals and in connection with small leaks. Other industrial processes and road traffic are also important sources of nmVOC emissions in Norway. The petroleum sector's share of this is shrinking due to the phase-in of emission-reducing technology. Emissions of nmVOC per produced unit of oil have also declined in recent years (see Figure 9.10).

There are large differences in emissions depending on where the oil is loaded. The main reason for this is that the content of volatile gases in the oil varies from field to field. Several of the newer fields on the Norwegian continental shelf use floating storage facilities. This type of development can result in higher emissions of nmVOC than on fields where oil storage takes place in the base of the platforms (Statfjord, Draugen and Gullfaks). This is because the use of floating storage facilities also entails emissions between production and storage.

The forecast for emissions of nmVOC from the sector shows a distinct declining trend in the years to come (see Figure 9.11). Implementation of emission-reducing technology is the main reason for this.

Measures and instruments for reducing nmVOC emissions

Starting from 2001, emissions of nmVOC linked to offshore loading and storage of crude oil have been governed under the emission permit system, pursuant to the Pollution Act.

For a number of years, the oil companies have worked to make technology for recovering nmVOC available to storage vessels and shuttle tankers. Today, tested technology exists that can reduce emissions from loading by approximately 70 per cent. Several vessels have now installed technology to reduce emissions. The operators of fields with

buoy loading on the Norwegian continental shelf have formed a joint venture (see text box).

A recovery facility for nmVOC was deployed at the crude oil terminal at Sture in 1996. This facility is the first of its kind in a crude oil terminal. In order for loading tankers to use the facility, they must be fitted with coupling equipment. From 1 January 2003, it became a requirement that all vessels must be fitted with equipment for recovering nmVOC. Ships without the necessary equipment are not normally granted access to the facility.

Discharge status for chemicals

Chemicals are a generic designation for all additives and auxiliary products used in drilling and well operations and in the production of oil and gas. The main rule is that no environmentally hazardous substances may be discharged, regardless of whether the substance is an additive or occurs naturally.

The contribution from the petroleum sector to national discharges to sea is less than 3 per cent of the environmental toxins on SFT's list.

More than 99 per cent of the chemicals used in the Norwegian petroleum activities consist of chemicals which are believed to have little or no impact on the environment (green and yellow chemicals, ref. the Norwegian Pollution Control Authority's (SFT's) classification). Many of these chemicals are substances that occur naturally in seawater. The remainder are environmentally hazardous chemicals or chemicals whose potential effects have not been adequately documented.

Some of the environmental effects caused by chemicals:

- They have a certain local toxic effect, but are diluted in the water column so that the acute impact on the environment is not very significant other than in the immediate vicinity of the discharge.

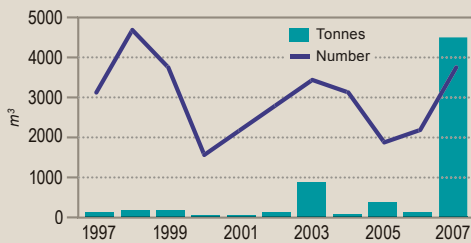


Figure 9.16. Acute oil spills larger than one cubic metre
(Source: Norwegian Petroleum Directorate)

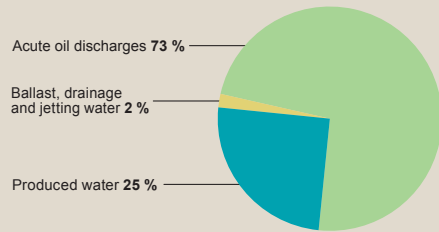


Figure 9.17 Discharges of oil from the petroleum activities distributed by activities, 2007 (Source: Norwegian Petroleum Directorate)

- A small percentage of chemical discharges may have very serious environmental consequences, including hormone disruption or bioaccumulation.

Potential long-term effects remain uncertain, but considerable research is being done in this area.

Most chemical discharges are associated with drilling activity (see Figure 9.12), and discharge volumes vary according to the level of activity taking place. Figure 9.13 shows the development in total discharges of chemicals from the petroleum activities. Discharges of added environmentally hazardous production chemicals (black and red chemicals, ref. Norwegian Pollution Control Authority's classification) have been reduced by 94 per cent for black chemicals and 98 per cent for red chemicals since 2000. Figures 9.14 and 9.15 illustrate the development in discharges of environmentally hazardous chemicals.

The chemicals that are not discharged are dissolved in the oil, deposited in the subsurface or are handled as hazardous waste.

Measures for reducing discharge of chemicals

Companies must apply for discharge permits from the SFT in order to discharge chemicals to the

sea. The SFT issues discharge permits pursuant to the rules of the Pollution Act. Under the Pollution Act, the operating companies themselves are responsible for and obliged to establish the necessary emergency preparedness to deal with acute pollution, in addition to municipal and national emergency preparedness.

Discharges of oil

Total discharges of oil from the Norwegian petroleum activities account for a small portion of the total discharges into the North Sea. The majority of oil discharged into the North Sea comes from shipping and from the mainland via rivers. Figure 9.16 provides an overview of acute oil discharges greater than one cubic meter (m³). All acute discharges from the facilities on the Norwegian continental shelf are reported to the National Coastal Administration, and the causes of the discharges are investigated.

During 40 years of oil and gas activities the operations have not caused major acute oil spills that have led to damage to the environment. In 2006, the total volume of acute discharges to sea was 122 m³ (see Figure 9.16). Unfortunately, in December 2007, there was an incident on the Statford field in the North Sea involving discharge

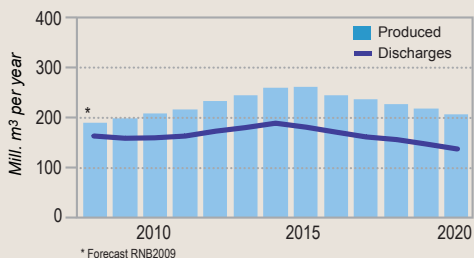


Figure 9.18 Forecasts for produced water and for discharge of produced water (Source: Norwegian Petroleum Directorate)

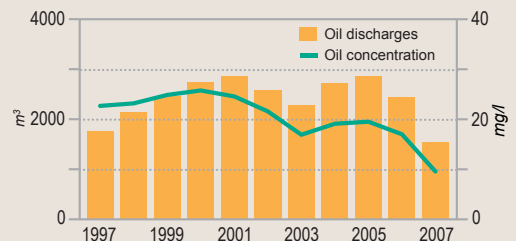


Figure 9.19 Discharges of oil in produced water and appurtenant oil concentration (Source: Norwegian Petroleum Directorate)

of approximately 4408 m³ of oil – the second largest acute oil discharge from production on the Norwegian continental shelf. This meant that the total acute discharges to sea in 2007 were 4408 m³. The objective for the industry and the authorities is to continue to reduce the risk of oil spills from future operations on the Norwegian continental shelf.

The environmental effects of potential acute oil spills depend on several factors, and not only the size of the spill. The location of the spill, season, wind strength, currents and the effectiveness of the response measures are all crucial for the extent of damage. Acute oil spills can harm fish, marine mammals, seabirds and beach zones. Most serious acute oil spills in Norway have originated from ship traffic near the coast.

Oil discharges from the petroleum sector largely occur in connection with ordinary operations. Water that is produced with oil and gas contains remnants of oil in the form of droplets (dispersed oil), other organic components (including dissolved oil fractions), inorganic components (heavy metals, natural low-radioactive compounds, etc.) and residues of chemical additives. The produced water is reinjected into the subsurface or cleaned to the extent possible before it is discharged to sea. Oily cuttings and drilling fluid that previously accounted for a large share of the oil discharged from the petroleum activity, are now reinjected into suitable reservoirs or taken to land for further treatment. Figure 9.17 shows oil discharges distributed by activities, while Figure 9.18 illustrates the predicted development in the

Oil spill preparedness

In Norway, the preparedness for acute pollution consists of private sector preparedness, municipal preparedness and state preparedness. The Ministry of Fisheries and Coastal Affairs and the Norwegian Coastal Administration are responsible for coordinating the total national oil spill preparedness, as well as the government's preparedness for acute pollution. The Ministry of the Environment is responsible for setting preparedness requirements for acute pollution in municipalities and for private enterprises. The Norwegian Pollution Control Authority approves the emergency preparedness plans and ensures that the demands are complied with.

On behalf of the oil companies, the operators are responsible for handling acute incidents that are a result of their own activities, using preparedness resources that are designed for this purpose. The Norwegian Clean Seas Association for Operating Companies (NOFO), which consists of a number of companies that are licensees on the Norwegian continental shelf, has also established regional plans which take into consideration reinforcement of ocean-going preparedness, coastal preparedness and beach zone preparedness. NOFO manages and maintains preparedness which includes personnel, equipment and vessels. NOFO has five bases along the coast – Stavanger, Mongstad, Kristiansund, Træna and Hammerfest, in addition to some fields where NOFO equipment is permanently located. NOFO has a total of 16 oil spill preparedness systems and carries out at least two joint training exercises each year.

volume of produced water and discharges of produced water. Implemented measures have led to considerable reductions in the discharge of oil per unit of produced water. However, the measures implemented so far do not exceed the increase in discharges as a result of the fact that water production increases as the fields mature, although the discharges have been stabilized at the current level. Figure 9.19 shows the total oil discharges and the average concentration of dispersed oil in water (mg/litre).

New research results indicate that alkyl phenol in produced water does not entail a risk to the fish populations in the North Sea. However, potential long-term effects are uncertain. To increase this knowledge, the Ministry of Petroleum and Energy, the Ministry of the Environment and the petroleum industry have cooperated to finance the research program "Long-term effects of discharges to sea from the petroleum activity (PROOF)", which was initiated in the autumn of 2002 under the Research Council of Norway. The program has now been continued as a subsidiary program (PROOFNy) under the research program "Sea and Coast". The main areas included in PROOFNy are effects in the water column,

special research assignments in the Arctic region, the link between research and monitoring, long-term effects of acute spills and the discharge of cuttings. The program also hopes to focus on projects in the area of synergetic effects on the ecosystem.

Measures for reducing discharges of oil

The companies must apply for discharge permits from the Norwegian Pollution Control Authority (SFT) in order to discharge oil to the sea, following the same procedure as for chemicals. The SFT grants discharge permits pursuant to the rules in the Pollution Act. Under the Pollution Act, the operating companies themselves are responsible for and obliged to establish the necessary emergency preparedness to deal with acute pollution, in addition to municipal and national emergency preparedness.

Some of the environmental statistics in the figures have not been updated since last year as they were not ready when Facts 2009 went to print. The Norwegian Petroleum Directorate and Statistics Norway have updated figures for some of the environmental indicators.

Definitions

Environmentally hazardous compounds, environmentally hazardous chemical substances, environmentally hazardous components:

Substances or groups of substances with properties including toxicity, low biodegradation, potential bioaccumulation and/or hormone disruption. The most dangerous of these substances are classified as environmental toxins.

Environmentally harmful discharges:

This term refers to the damage that emissions and discharges can cause, and depends on the quantity released, the location and 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 discharge targets for environmentally hazardous substances:

Zero discharges, or minimisation of discharges of naturally occurring environmental toxins encompassed by the end objective for chemicals hazardous to health and the environment, ref. the priorities list in Storting White Paper No. 25 (2002–2003).

Zero discharges of chemical additives in the Norwegian Pollution Control Authority's black category (general prohibition on use and discharge) and the red category (high priority for phasing out via substitution).

Other chemical substances:

Zero discharges or minimisation of discharges that can lead to harm to the environment, including oil (components that are not hazardous to the environment), substances in the Norwegian Pollution Control Authority's yellow and green categories, cuttings and other substances that can lead to harm to the environment *

Source: Storting White Paper No. 25 (2002–2003) The Environmental Policy of the Government and the State of the Environment in Norway.

Storting White Paper No. 38 (2003–2004) On the petroleum activities, stipulated specific conditions for petroleum activities in the Lofoten–Barents Sea area. The Lofoten–Barents Sea area is defined as a particularly vulnerable area, which is subject to more stringent discharge requirements than those in place for the rest of the Norwegian continental shelf.

No discharge of produced water. Injection of produced water is the assumed basis, or use of other technology that prevents discharge of produced water. In case of operational deviation, maximum 5 per cent of the produced water can be released to sea if it is cleaned (before discharge to sea).

No discharge of drill cuttings or drilling fluids. Drill cuttings and drilling fluids will be reinjected or taken to land for disposal. Drill cuttings from the top hole section may normally be discharged under the condition that the discharge does not contain substances with unacceptable environmental effects, and only in areas where the potential for damage to vulnerable environmental components is considered to be low.

No discharge to sea from well testing.

** Ref. Regulations relating to conduct of activities in the petroleum activities (the Activities Regulations) of 3 September 2001.*