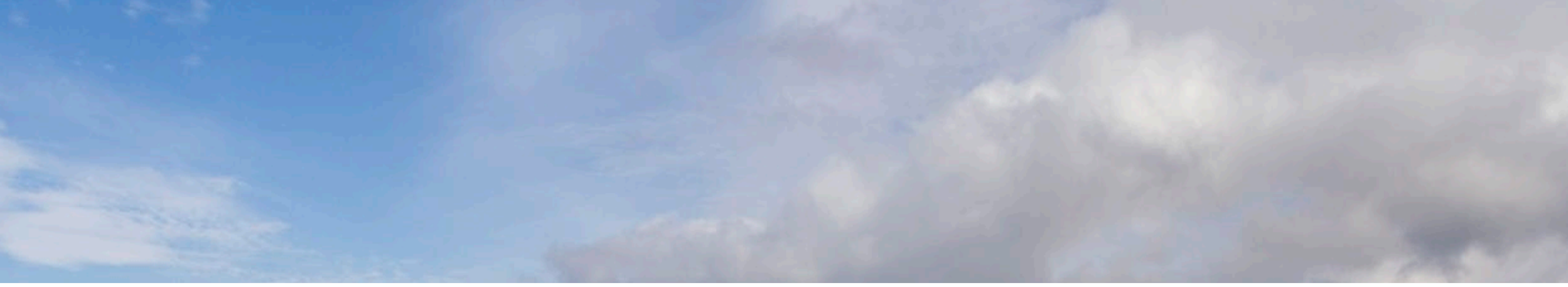

2017 ENVIRONMENTAL REPORT

ENVIRONMENTAL WORK BY THE OIL AND GAS INDUSTRY

FACTS AND DEVELOPMENT TRENDS

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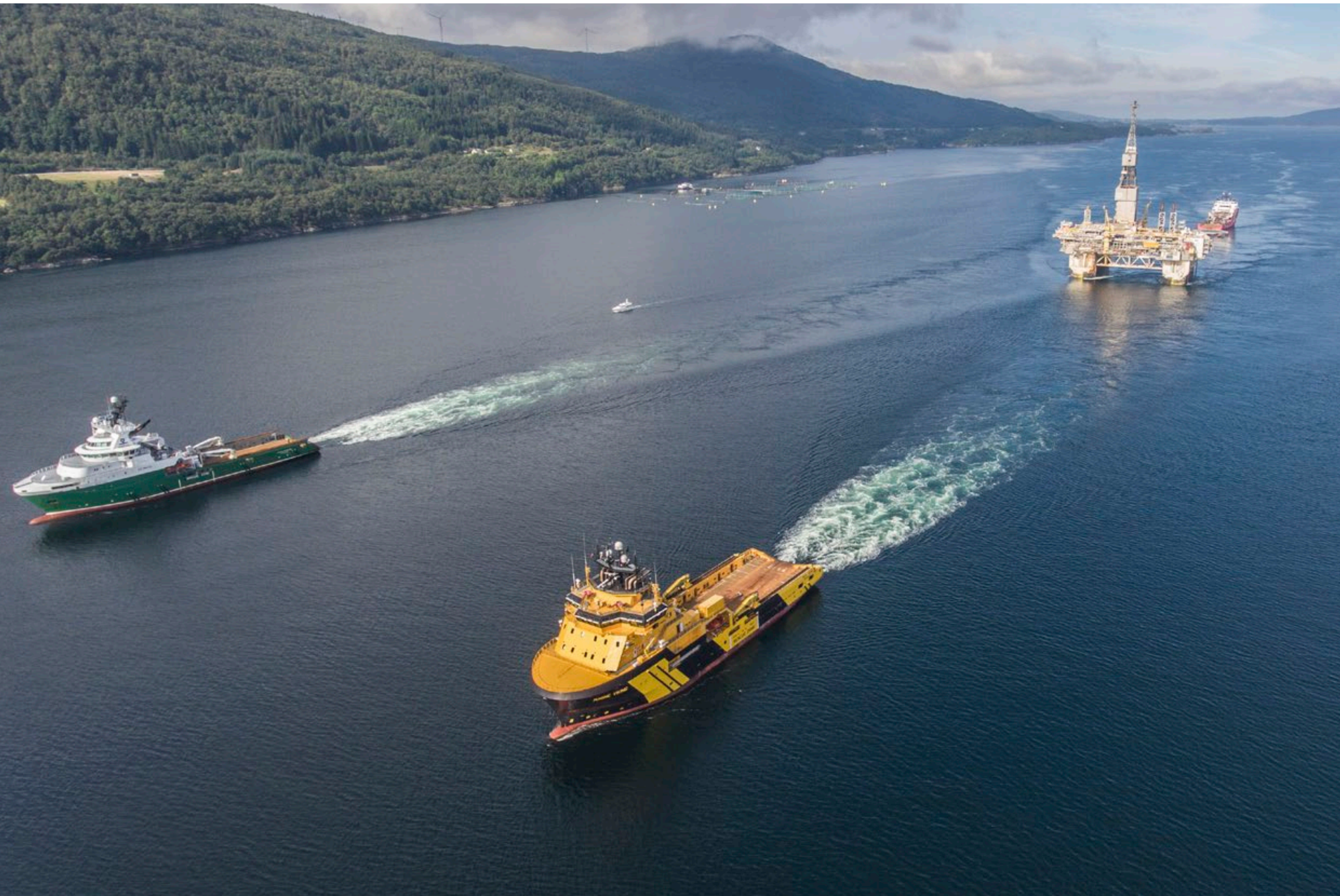


The Norwegian Oil and Gas Association (formerly the Norwegian Oil Industry Association) is an interest organisation and employer's association for oil and supplier companies related to exploration for and production of oil and gas on the Norwegian continental shelf (NCS). It represents just over 100 member companies, and is a national association in the Confederation of Norwegian Enterprise (NHO).

2017 ENVIRONMENTAL REPORT

ENVIRONMENTAL WORK BY THE OIL AND GAS INDUSTRY

FACTS AND DEVELOPMENT TRENDS

1 FOREWORD

THE NORWEGIAN OIL AND GAS ASSOCIATION PUBLISHES AN ANNUAL ENVIRONMENTAL REPORT CONTAINING A DETAILED OVERVIEW OF ALL EMISSIONS/DISCHARGES FROM THE PETROLEUM INDUSTRY IN THE PREVIOUS YEAR. ITS PURPOSE INCLUDES IMPARTING EMISSION/DISCHARGE DATA AS WELL AS INFORMATION ON THE INDUSTRY'S WORK AND RESULTS IN THE ENVIRONMENTAL AREA.

The Norwegian petroleum industry has a clear ambition: it will be a world leader in the environmental sphere. That calls for constant improvement. Detailed reporting of emissions and discharges is essential for measuring progress and how far goals are met.

This report derives its information from the Epim Environment Hub (EEH), a joint database for Norwegian Oil and Gas, the Norwegian Environment Agency (NEA), the Norwegian Radiation Protection Authority and the Norwegian Petroleum Directorate (NPD). Pursuant to the Environment Act, all operators on the Norwegian continental shelf (NCS) must submit annual emission/discharge reports in accordance with the requirements specified in the management regulations and set out in detail in the NEA guidelines for reporting from offshore petroleum activities (M-107). Where the operator companies are concerned, these requirements mean that all emissions/discharges and all waste generated from operations on the Norwegian continental shelf (NCS) must be reported in detail on an annual basis. In addition to sending the emission/discharge report for each field to the NEA, all the data are posted to the EEH. That applies both to planned and officially approved operational emissions/discharges and to those which occur accidentally. Common parameters ensure consistent emission/discharge reporting from all production licences.

This environmental report contains a synthesis of all emissions/discharges, as well as a summary of results from research projects related to the marine environment and emissions to the air.

The definition of the petroleum industry accords with the one provided in the Norwegian Petroleum Tax Act. Emissions/discharges from the construction and installation phase, onshore plants outside the scope of the Petroleum Tax Act, maritime support services and helicopter traffic are therefore excluded from this report.

This English version is a translation of the Norwegian report. Electronic versions in both English and Norwegian are published on the Norwegian Oil and Gas website at www.norskoljeoggass.no. The field-specific emission/discharge reports submitted to the NEA can also be downloaded from the site.

2 SUMMARY

OVERALL DIRECT CO_2 EMISSIONS FROM OPERATIONS ON THE NCS IN 2016 WERE DOWN SLIGHTLY FROM THE YEAR BEFORE. THIS DECLINE PRIMARILY REFLECTED A LOWER LEVEL OF ACTIVITY AND REDUCED QUANTITIES EMITTED FROM A NUMBER OF EXISTING FIELDS ON THE NCS.

The Norwegian petroleum sector had another demanding year in 2016. Oil prices appear to have bottomed out at the beginning of 2017, followed by a moderate upturn. Production is up somewhat because new fields have come on stream. At the same time, greenhouse gas (GHG) emissions have fallen a little and CO_2 intensity is down. Produced water discharges were reduced and a larger proportion of produced water was being injected in 2016, so that the quantity of oil released to the sea also fell.

Overall direct CO_2 emissions from operations on the NCS and land-based plants subject to the Petroleum Tax Act amounted to 13.34 million tonnes in 2016 – a slight reduction from the year before. This decline primarily reflected a lower level of activity related to mobile rigs, reduced emissions from existing NCS fields and a fall in the quantity of CH_4 released because the emission factors previously utilised had been too conservative. That meant the actual emissions were lower than earlier assumed. At the same time, total NCS production grew because new fields such as Goliat and Edvard Grieg came on stream. Emissions from such developments are relatively lower than on older fields. Specific CO_2 emissions per unit produced (CO_2 intensity) on the NCS therefore declined.

Over the past two years, Norwegian Oil and Gas has also implemented a joint industry project on energy management and enhancing energy efficiency. This work has focused greater attention on finding and implementing measures for more efficient energy use which reduces GHG emissions.

Rystad Energy has been commissioned by Norwegian Oil and Gas to obtain a more detailed comparison of petroleum output and associated CO_2 emissions by the world's leading oil producers. This consultancy has developed a method for assessing emissions from every field which embraces not only production but also refining and combustion of oil and gas.

The results show that the most significant factor for CO_2 emissions is the types of hydrocarbons in the reservoir. Technology development and regulatory management also play a part, along with the extent of flaring and power from shore as well as the maturity of the continental shelf. Rystad's calculations confirm that CO_2 intensity on the NCS is half the world average.

A roadmap for the NCS was drawn up by the petroleum industry in 2016 which sets specific goals and ambitions for further cuts in GHG emissions from oil and gas production. It has been compiled by Norwegian Oil and Gas and the Federation of Norwegian Industries through KonKraft, a collaboration arena for these two organisations as well as the Norwegian Shipowners Association and the Norwegian Confederation of Trade Unions (LO).

Emissions of short-lived climate forcers from production on the NCS, with CH_4 and nmVOC as the most important sources, are already low in international terms. A joint project with the Norwegian Environment Agency (NEA) revealed that the emission factors previously applied on the NCS have been conservative, and that the actual figures are lower than earlier assumed. According to a recent study, the overall proportion of CH_4 emitted on the NCS from the whole gas value chain – including the transmission and distribution network – comes to about 0.3 per cent. This is lower than earlier estimates.

Further reductions from earlier years also occurred with emissions of NO_x and SO_x in 2016. This decline reflects lower use of diesel engines owing to reduced employment of mobile units. The present environment agreement under the Business Fund for Nitrogen Oxides expires at the end of 2017. Both industry and the government want the agreement to continue from 2018. The 15 industry associations affiliated to the fund signed a new agreement in May 2017 for 2018-25.

Discharges to the sea derive primarily from drilling wells and from the produced water which comes up with the oil. On new fields, produced water consists exclusively of the amount already present in the reservoirs. However, its quantity increases as the field ages because water is injected to maintain reservoir pressure and improve the oil recovery factor. Treated seawater is primarily used. Annual produced water discharges peaked in 2007 at around 162 million standard cubic metres (scm). They have subsequently varied between 130-150 million scm and amounted to 138 million scm in 2016.

On certain fields where conditions are appropriate, all or part of the produced water is injected back into the sub-surface. Such injection increased substantially in 2002 and has been around 20 per cent of the total quantity in recent years. Just over 24 per cent was injected in 2016. Produced water represents the most important source of oil discharges on the NCS. The water is treated before release with the aid of technologies which differ between the various fields.

The oil content in produced water averaged 12.3 milligrams per litre across the NCS in 2016 – unchanged from the year before. The regulatory threshold is 30 mg/l.

Drilling discharges primarily comprise rock particles (drill cuttings) from the borehole and drilling fluid. Discharges are only permitted from wells drilled with water-based fluid, or when contamination from oil-based fluid is less than 10 grams of oil per kilogram of cuttings. Drilling activity in 2016 declined somewhat from the year before, particularly for exploration wells (36 compared with 56 in 2015). Despite this decline, the number of production wells remained historically high, at 177 compared with an average of 153 over the past 10 years.

The use and discharge of chemicals is strictly regulated in Norway. Chemicals are assessed on the basis of their environmental properties and criteria laid down in the HSE regulations with associated guidelines. Chemical additives are divided into four categories (green, yellow, red and black), where green substances have no or very limited environmental impact while black can only be discharged in special circumstances – where this is crucial for safety, for instance. The operators are required to make regular assessments of which chemicals can be replaced with less environmentally harmful alternatives – known as the substitution duty.

Extensive substitution of chemicals has reduced the release of the most environmentally harmful substances to a fraction of what it was only 10 years ago. However, a marked increase in reported discharges of black chemicals occurred in 2011-14. This primarily reflects changed reporting requirements and work on substitution. Discharges of fire-extinguishing foam were not reported earlier because this was a safety chemical with no alternative products able to offer satisfactory extinguishing properties. Alternatives with less environmentally harmful properties are now available. These are currently being phased in, but it will be several years before all fields on the NCS have replaced the old types with new versions. As a result, mandatory fire drills and system tests will mean continued foam discharges for several years to come. Discharges of black chemicals in 2016 were less than a third of the 2014 figure.

New fire-extinguishing foams still contain components which fall into the red category. This contributed significantly to a marked increase in red chemical discharges in 2013-16, which amounted to 103 tonnes in the latter year. A further contribution was made by reclassification of certain chemicals from yellow to red.

Extensive preventive work by the operators to avoid unintentional discharges has led to a continued decline in the number of spills. Totalling 39 instances, acute oil discharges in 2016 were at a record low. Only two crude oil discharges larger than one cubic metre occurred during the year, compared with three in 2015.

Production from the NCS increased somewhat because of new fields. Total emissions nevertheless declined and the amount of CO_2 released per unit produced was reduced.

3 LEVEL OF ACTIVITY ON THE NCS

NORWAY'S PETROLEUM SECTOR HAS BEEN THROUGH ANOTHER DEMANDING YEAR. COSTS ARE BEING CUT TO ADAPT TO LOWER OIL PRICES, AND SOME 50 000 EMPLOYEES HAVE HAD TO LEAVE THE INDUSTRY SO FAR.

At the beginning of 2017, the signs are that the slump in oil prices is over and has been followed by a moderate upturn. Continued attention will nevertheless need to be paid to cost developments in the industry.

The oil and gas industry on the NCS has experienced another demanding year. Substantial cost cuts have been required to restore profitability in the sector after the sharp drop in oil prices which began in the summer of 2014. The result so far is that 50 000 people have had to leave the industry, while the level of capital spending has been substantially reduced. At the same time, decisions on cutting petroleum output by Opec and other producer countries have helped to halt the price decline and produce a moderate rise since 2016.

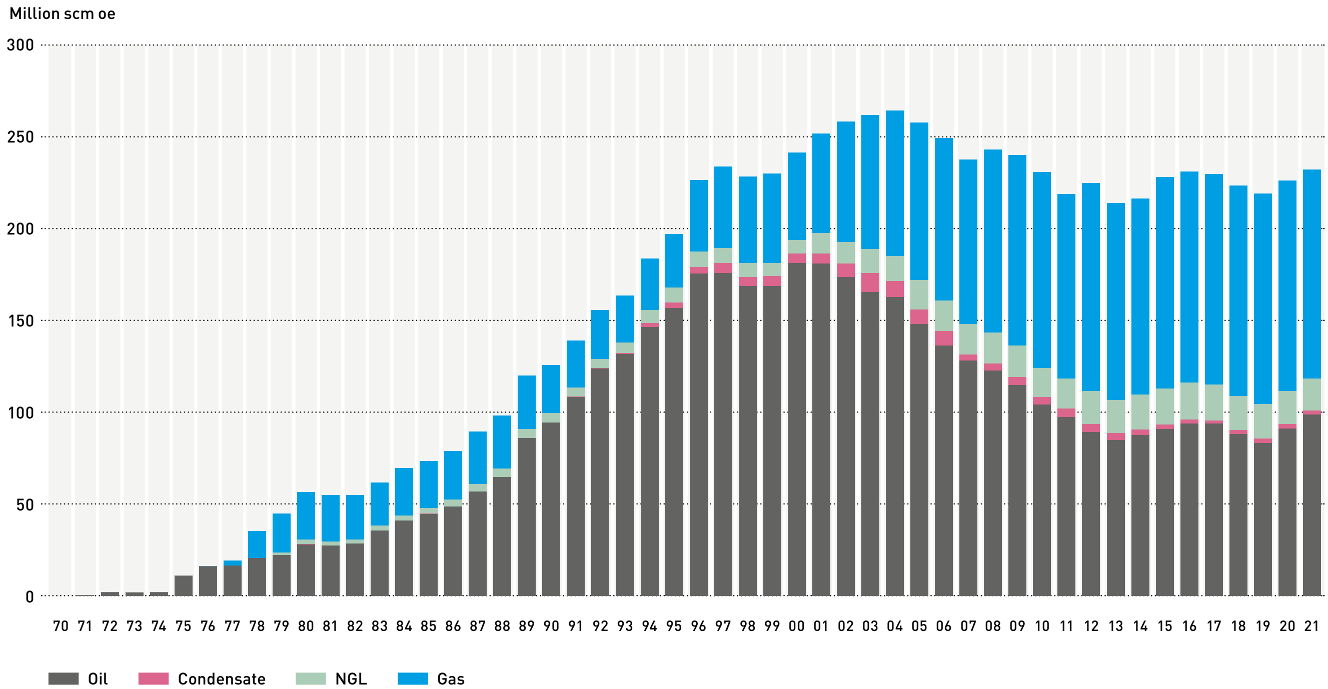
With continued attention devoted to cost trends, the role of the petroleum sector in the Norwegian economy will be expanding again. The industry is well equipped for the future.

PRODUCTION TREND POSITIVE DESPITE LOWER OIL PRICES

Despite low oil prices and declining investment, crude output has been rising over the past three years. At the same time, gas sales have remained at the same high level as in 2015. Final figures show that 232.7 million standard cubic metres of oil equivalent (scm oe) were sold in 2016. That was up 2.5 million scm oe or 1.1 per cent from the year before, which reflects several new fields coming on stream in recent years. Total petroleum output in 2017 is expected to be 229.5 million scm oe. This moderate decline must be viewed in relation to good regularity on the fields and to the various efficiency improvement measures which have also significantly reduced operational and exploration costs. Overall production from the NCS in 2016 was nevertheless down by 11.9 per cent from the 2004 peak. The NPD expects total output to rise somewhat again over the coming five-year period.

FIGURE 01 **ACTUAL AND FORECAST SALES OF PETROLEUM 1971-2021 (MILL SCM OE)**

Source: NPD



Oil production could fall a little over the next couple of years, and is then expected to increase again. Natural gas liquids (NGL) and condensate are expected to show a moderate decline over the next five years, while gas output could rise weakly. Uncertainty over production forecasts relates to further energy price trends as well as to the number of exploration wells drilled on the NCS. Thirty-six of the latter were spudded in 2016 at a total cost of NOK 22 billion. That was 20 wells down from the year before, while exploration costs were about 35 per cent lower. The NPD estimates that these costs will fall by a further 15 per cent from 2016 to 2017, and then gradually rise.

OIL – MODERATE DECLINE UNTIL JOHAN SVERDRUP COMES ON STREAM

Oil production in 2016 came to 94 million scm or 1.62 million barrels per day (b/d), compared with 91 million scm (1.56 million b/d) the year before – an increase of 3.3 per cent. New fields coming on stream contributed more than five million scm of oil in 2016. At the same time, the decline in output from fields long on stream was smaller than expected. The most important reasons were high regularity and the substantial number of new production wells drilled. The NPD assumes that oil output in 2017 will remain on a par with the 2016 figure. It is expected to decline somewhat (by 2.8 per cent) until 2020 (see figure 1), with the contribution from Johan Sverdrup again expected to boost production. Uncertainty relates particularly to the drilling of new wells, bringing new fields on stream, reservoir deliverability and the regularity of producing fields.

FLAT TREND LIKELY FOR GAS SALES

Sales of gas from the NCS totalled 116.6 billion scm in 2016, down slightly by 0.5 billion scm or 0.4 per cent from the year before. Gas output has exceeded oil production since 2010. The level of gas sales is difficult to predict, even in the short term. It proved about nine per cent higher in 2016 than the NPD forecast the year before. That partly reflects a continued high level of demand from Europe. The NPD's prediction for gas sales over the next five years shows a relatively stable level, with only small changes from year to year.

NGL/CONDENSATE SET TO DECLINE

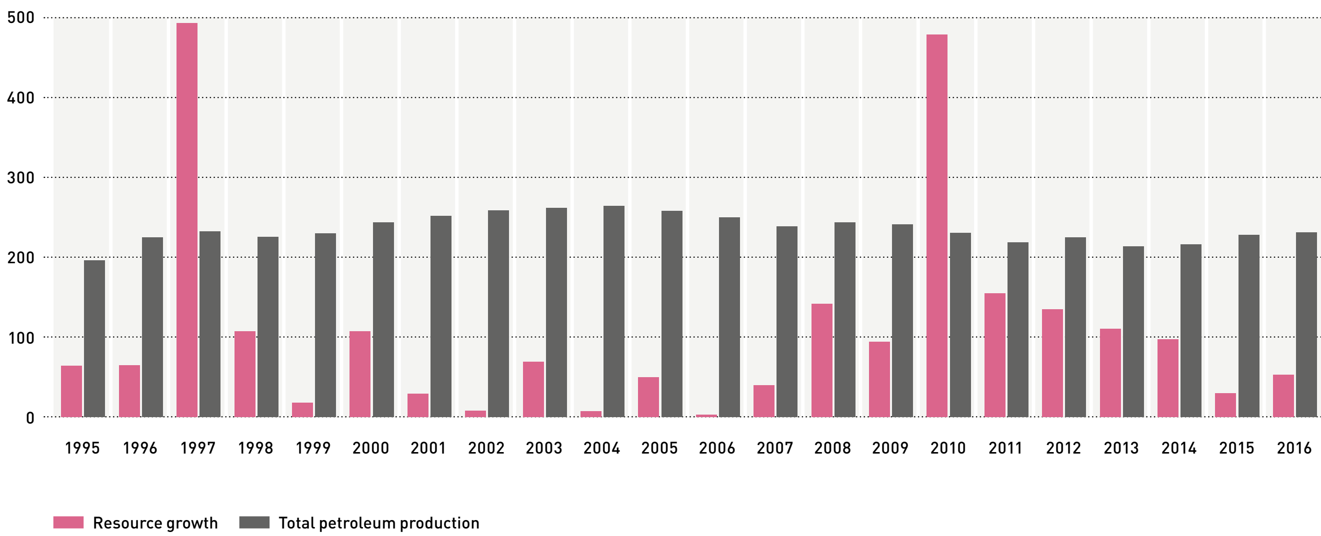
NGL output totalled 20.2 million scm oe in 2016, up by 0.6 million scm oe or 2.9 per cent from the year before. The NPD estimates that this figure will decline by 14.3 per cent up to 2021, which means a reversal of the weakly rising trend seen in recent years. Condensate production has been declining over the past few years. It amounted in 2016 to 1.9 million scm oe, down by 23.9 per cent from the year before. The NPD expects a further 15.8 per cent fall in condensate output up to 2021. Overall, this means NGL and condensate production could decline by roughly 14.5 per cent from 2016 to 2021.

LIMITED BOOST TO FLUIDS OUTPUT

Fluids production (oil, NGL and condensate) amounted to 116 million scm oe in 2016, and may decline even further in the next few years. According to the NPD,

FIGURE 02 RESOURCE GROWTH AND PRODUCTION ON THE NCS (MILL SCM OE)

Source: NPD



this could be reversed in 2020-21 because of prospects for higher oil output. Estimates therefore indicate a possible increase of 1.6 per cent in fluids production from 2016 to 2021.

Forecasts for overall NCS production show a relatively flat trend up to the mid-2020s. Compared with the NPD's previous prediction, output is now expected to remain higher until 2027. That partly reflects expectations of greater drilling activity, improved regularity for fields on stream, and a lower level of costs which contributes to a faster phasing-in of new projects than was previously assumed.

48 PER CENT OF RESOURCES SOLD AND DELIVERED

The main goal of Norwegian petroleum policy is to facilitate profitable production of oil and gas in a long-term perspective. At 31 December 2016, the NPD's resource accounts had risen by 0.1 billion scm oe from a year earlier to 14.3 billion. Of this, 6.9 billion or 48 per cent had been sold and delivered, while 7.4 billion remained to be produced. Proven resources accounted for 4.6 billion scm oe of the latter figure, while estimated undiscovered resources came to 2.9 billion or roughly 39 per cent of total remaining resources.

24TH LICENSING ROUND

The government invited the oil companies on 29 August 2016 to nominate blocks for possible inclusion in the 24th licensing round. Numbered licensing rounds cover the opened frontier areas of the NCS, where the potential for making big discoveries is at its greatest.

With each licensing round, the Ministry of Petroleum and Energy decides which areas should be incorporated when plans for inviting applications are drawn up. As with the work on the 23rd round and the annual awards in predefined areas (APA), the government's commitments to its supporting parties and the limitations imposed by the management plans will form the basis for announcing the 24th round. The ministry proposes to offer a total of 102 blocks in this round, broken down into nine in the Norwegian Sea and 93 in the Barents Sea. Plans call for applications to be invited in the second quarter of 2017, with a deadline in the last quarter. While the North and Norwegian Seas have so far been the most important areas for the petroleum sector, the Barents Sea's role will become increasingly significant in coming years.

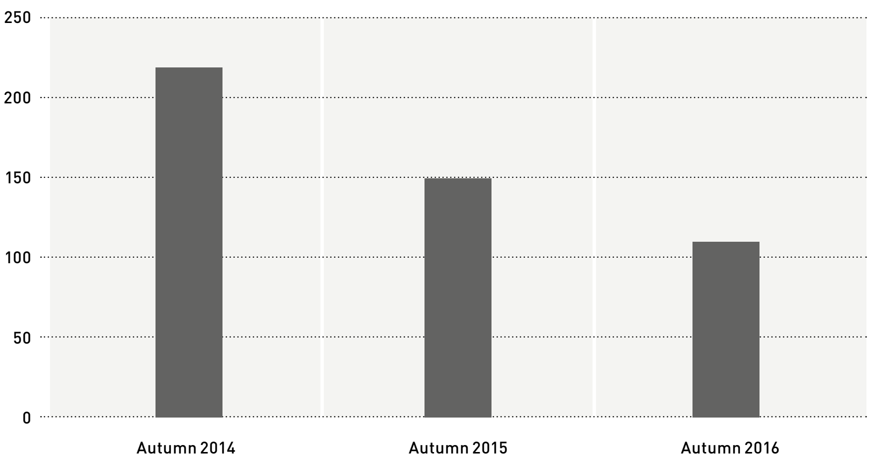
INVESTMENT DECLINE CONTINUING

Capital spending on oil and gas operations, including pipeline transport, totalled NOK 163.3 billion in 2016 and was down by NOK 37.9 billion or 18.8 per cent from the year before. While cutbacks occurred in all investment categories, the biggest were from fields on stream, exploration and field development. Ongoing investment rose by no less than 70 per cent from 2010 to 2014, but fell by more than 27 per cent from 2014 to 2016 measured in current value. An important role was played in this development by a substantial fall in investment-related costs, as illustrated in figure 3.

In the investment survey for the first quarter of 2017, licensees on the NCS estimate that capital spending on oil and gas production – including pipeline transport – will come to NOK 149.4 billion for the full year. This figure is marginally higher than in the previous quarter, and reflects somewhat higher estimates for field development, fields on stream, and cessation and removal. The improvement from the previous quarter has been moderated by a further reduction in estimated exploration spending, which is expected to decline by 13 per cent from 2016.

FIGURE 03 COST PROGRESS FOR SELECTED FIELD DEVELOPMENTS (NOK BN, 2016 VALUE)

Source: NPD



(Johan Sverdrup phase II, Johan Castberg, Utgard, Oda, Trestakk, Dvalin and Snilehorn).

4 DISCHARGES TO THE SEA

DISCHARGES TO THE SEA DERIVE PRIMARILY FROM DRILLING WELLS AND FROM THE PRODUCED WATER WHICH COMES UP FROM THE RESERVOIR WITH THE OIL. PRODUCED WATER DISCHARGES PEAKED AT JUST OVER 160 MILLION SCM IN 2007. THE OVERALL AMOUNT DISCHARGED IN 2016 CAME TO 138 MILLION SCM.

4.1 DISCHARGES FROM DRILLING

Drilling discharges primarily comprise rock particles (drill cuttings) from the borehole and drilling fluid. Discharges are only permitted from wells drilled with water-based fluid, or with permission from the NEA where contamination from oil-based fluid is less than 10 grams of base oil per kilogram of cuttings. Even with a somewhat lower level of both exploration and production drilling, discharges were roughly on a par with 2015.

Despite lower oil prices, drilling activity in 2016 was relatively high (see figure 4). A total of 177 new production wells were drilled during the year, the second largest number since 2000 but a slight decline from 2015. However, exploration drilling showed a marked decline to just 36 wells in 2016 compared with 56 and 57 wells in the two preceding years.

The fluid used when drilling wells has many functions. These include bringing up drill cuttings, lubricating and cooling the drill bit, preventing the borehole from collapsing and, not least, keeping pressure in the well under control to prevent an uncontrolled blowout of oil and gas.

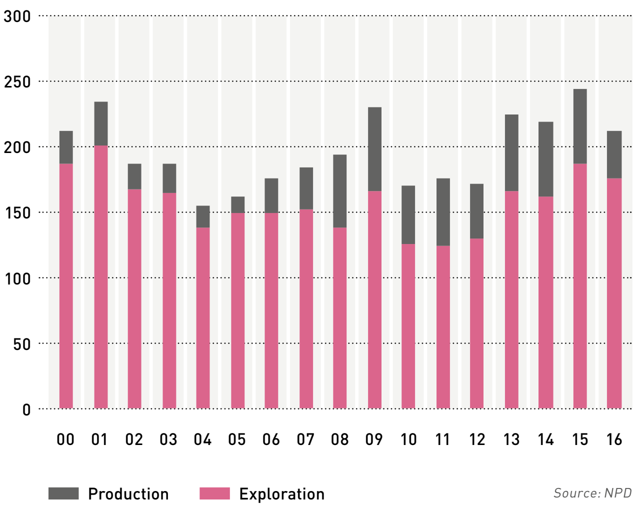
The industry primarily utilises two types of drilling fluids today: oil- and water-based. Ether-, ester- or olefin-based "synthetic" fluids were also utilised earlier, but have been little used in recent years.

Discharging oil-based or synthetic drilling fluids, or cuttings contaminated with these, is prohibited if the oil concentration exceeds one per cent by weight – in other words, 10 grams of oil per kilogram of cuttings. Cuttings contaminated with less than one per cent of oil-based or synthetic drilling fluids may only be discharged with permission from the NEA. Spent oil-based drilling fluids and contaminated cuttings are either shipped ashore as hazardous waste for acceptable treatment or injected in dedicated wells beneath the seabed.

Consumption of oil-based drilling fluid in 2016 was on a par with the year before.

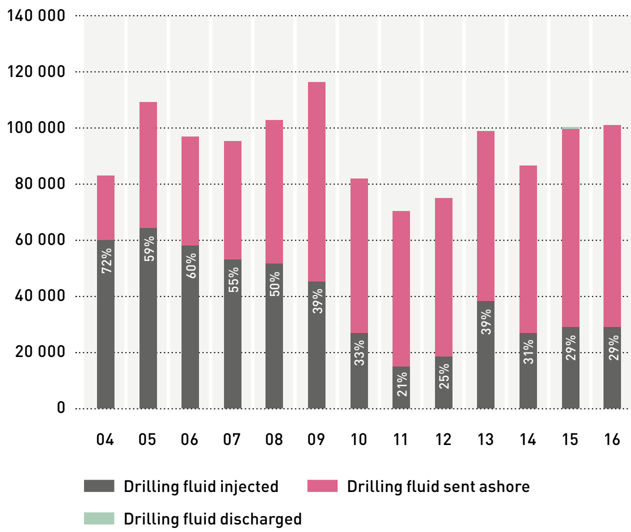
The proportion of drilling fluid injected was also stable, at about 29 per cent. Injection wells have been established on a number of new fields, while injection wells on certain older fields found in 2007-09 to contain fractures and leaks have not been replaced.

FIGURE 04 WELLS DRILLED ON THE NCS AFTER 2000



Source: NPD

FIGURE 05 DISPOSAL OF OIL-BASED DRILLING FLUID (TONNES)



A thermomechanical cuttings cleaner (TCC) technology for dealing with oil-contaminated cuttings was adopted on one offshore platform in 2015. In that context, 9.4 tonnes of oil-based fluid was discharged as contamination on 2 460 tonnes of cuttings. No such discharges occurred in 2016, but a number of them are likely in the future under permits from the NEA. Statoil, for example, has wished to utilise this technology on Johan Sverdrup.

The quantities of cuttings presented above are based on calculations of the rock drilled out. However, the amount recorded as being delivered to land in the form of hazardous waste is substantially larger. This is because cuttings from many fields are slurrified by adding water so that they can be handled more easily to and from the vessels shipping them to land. Oil-contaminated cuttings delivered as waste totalled just over 50 000 tonnes in 2013, rising to 77 000 in 2014 and almost 106 000 in 2015. Deliveries in 2016 totalled 118 000 tonnes. Water and cuttings are separated on land, with the former treated and discharged to sea while the latter are subject to further treatment in accordance with the applicable regulations.

Discharges of cuttings drilled out with water-based fluids in 2016 were roughly on a par with the year before at 105 000 tonnes. Water-based fluids consist primarily of natural components such as clay or salts, which are classed as green chemicals in the NEA's classification system. In line with Ospar, they pose little or no risk to the marine environment when discharged. The possible impact of these discharges is followed up by extensive environmental monitoring (see section 5.1).

FIGURE 06 DISPOSAL OF DRILL CUTTINGS CONTAMINATED WITH OIL-BASED DRILLING FLUID (TONNES)

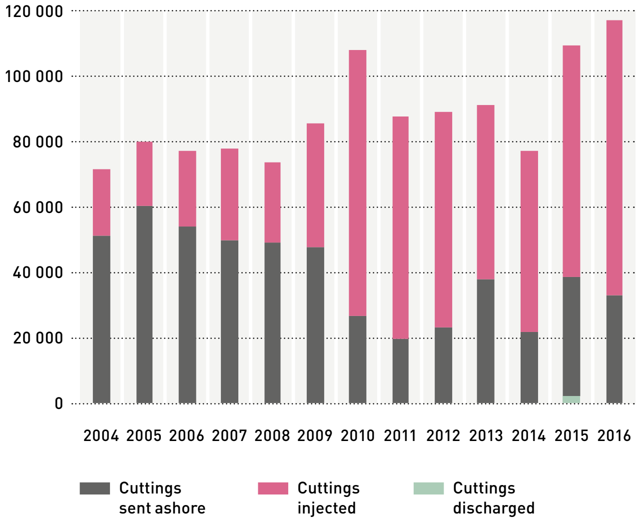
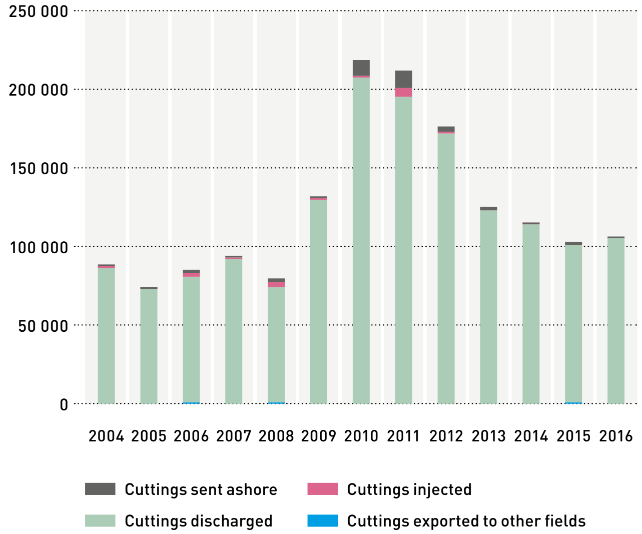


FIGURE 07 DISCHARGE OF DRILL CUTTINGS FROM WELLS DRILLED WITH WATER-BASED FLUID (TONNES)



4.2 DISCHARGES OF OILY WATER

Discharges of oily water from petroleum operations on the NCS derive from three main sources, with produced water accounting for the biggest contribution. Smaller contributors are displacement and drainage water as well as jetting.

Produced water: This has been in contact with geological formations as well as with any oil in these, and accompanies the crude up to the platform where it is treated before being discharged to the sea. The water contains dispersed oil, various inorganic salts, heavy metals and organic compounds as well as naturally occurring radioactive substances. Various treatment technologies help to get its oil content as low as possible. The regulatory threshold for the oil concentration in produced water discharged to the sea is 30 milligrams per litre (mg/l).

Displacement water: Seawater is used as ballast in the storage cells on some platforms. When oil is to be stored in the cells, this water must be treated before discharge. The seawater has a limited contact area with the crude, so the quantity of dispersed oil is usually small. The volume discharged depends on the level of oil production.

Drain water: Water falling as rain or used to wash down decks may contain chemical residues and oil. Drain water forms only a small proportion of the total quantity discharged.

Jetting may also form an additional category. Particles and oily sand which accumulate in the separators must be flushed out by water jetting from time to time. Some oil contamination remains on the particles after the water has been treated in accordance with the regulations. The quantity of oily water discharged is marginal.

Oily water can also derive from cleaning process equipment, from accidents, or from the deposition of oil droplets released by flaring in connection with well testing and workovers.

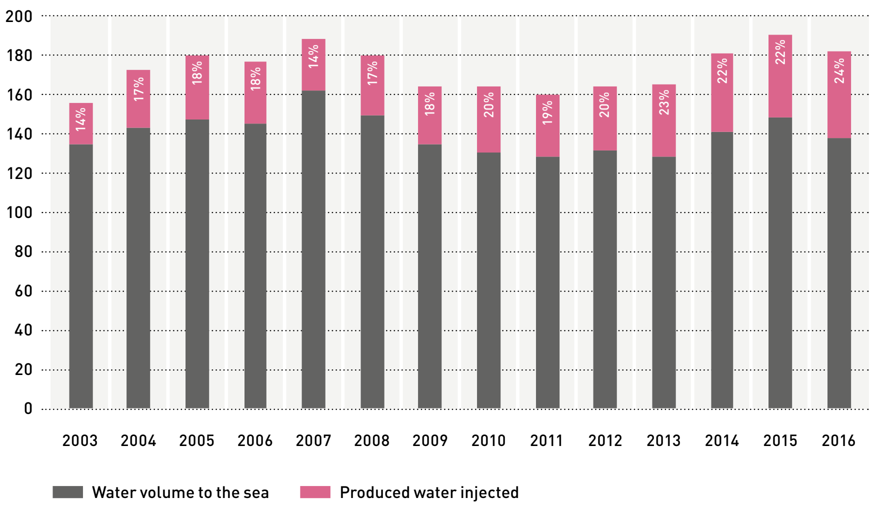
PRODUCED WATER DISCHARGES

A continuous rise in discharges of produced water on the NCS was forecast for many years, with the volume expected to exceed 200 million scm in 2012-14. However, it peaked at 160 million scm in 2007 and has declined substantially since. Annual discharges rose to almost 150 million scm in 2012-15, but declined again in 2016 to just over 138 million scm.

On certain fields where conditions are appropriate, all or part of the produced water is injected back into the sub-surface. Such injection rose substantially from 2002, and has been about 20 per cent of the total quantity in recent years. Twenty-four per cent, or a little over 43 million scm, was injected in 2016.

Produced water in new fields consists exclusively of the amount already present in the reservoirs. However, its quantity increases as the field ages because water is injected to maintain reservoir pressure and improve the oil recovery factor. Treated seawater is normally used. Oil recovery factors for fields on the NCS are generally well above the global average.

FIGURE 08 PRODUCED WATER DISCHARGED TO THE SEA OR INJECTED BELOW GROUND (MILL SCM)



Despite this, discharges on the NCS are comparable with international figures.

The growing proportion of older fields means that produced water as a share of the total output of oil and water has shown a rising tendency. However, it declined somewhat in 2016 – probably because a number of new fields came on stream.

Monitoring has not identified any environmental effects from releasing produced water (see section 5.1).

DISCHARGES OF OTHER WATER TYPES
Displacement water dominates discharges of other water types. The volume discharged declined steadily up to 2009-11 and thereafter rose slightly. However, it declined somewhat in 2016, when sources other than produced water accounted for just over 32 million scm of discharges.

DISCHARGES OF OILY WATER
Water is treated before discharge with the aid of different technologies on the various fields. The average oil content of produced water for the whole NCS was 12.3 mg/l in 2016, compared with the official requirement of 30 mg/l. That was on a par with the year before and a slight decline from 2014.

The quantity of oil in produced water discharged to the sea fell from just over 1 800 tonnes in 2015 to 1 697 (see figure 12). A total of 1 805 tonnes of oil was released in water on the whole NCS in 2016.

DISCHARGES OF OTHER SUBSTANCES WITH PRODUCED WATER
Produced water has been in contact with the sub-surface for a long time, and therefore contains a number of naturally occurring substances. In addition to oil, these typically include monocyclic and polycyclic aromatic hydrocarbons (PAH), alkylphenols, heavy metals, natural radioactive materials, organic substances, organic acids, inorganic salts, mineral particles, sulphur and sulphides. Their composition will vary from field to field, depending on sub-surface properties. The content of environmentally hazardous substances is generally low, close to the natural background level in seawater.

FIGURE 09 RATIO BETWEEN PRODUCED WATER AND OIL PRODUCTION ON THE NCS (CU.M)

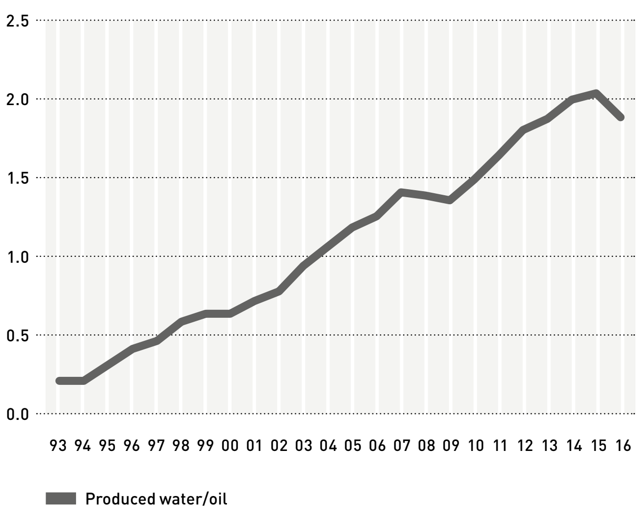


FIGURE 10 DISCHARGES TO THE SEA OF OTHER OILY WATER TYPES (MILL CU.M)

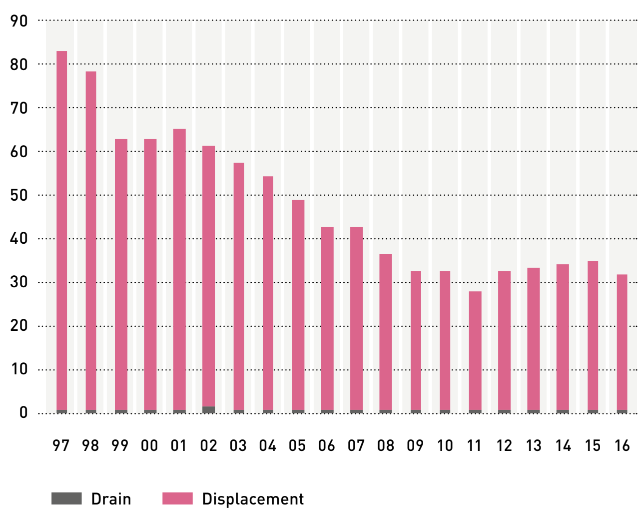


FIGURE **11** OIL CONCENTRATION IN PRODUCED WATER DISCHARGED TO THE SEA (MG/L)

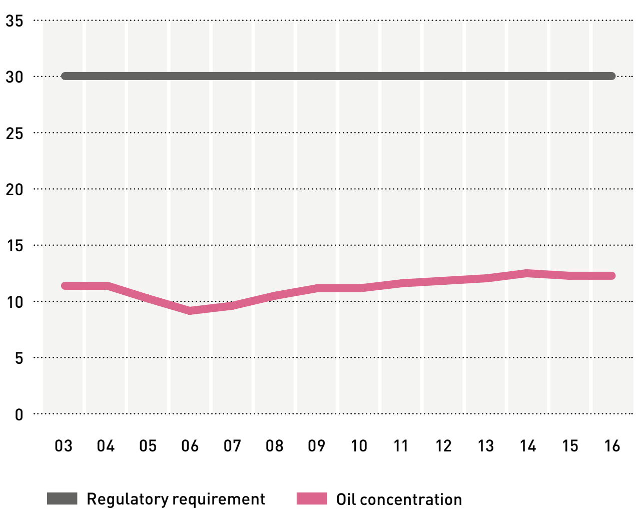
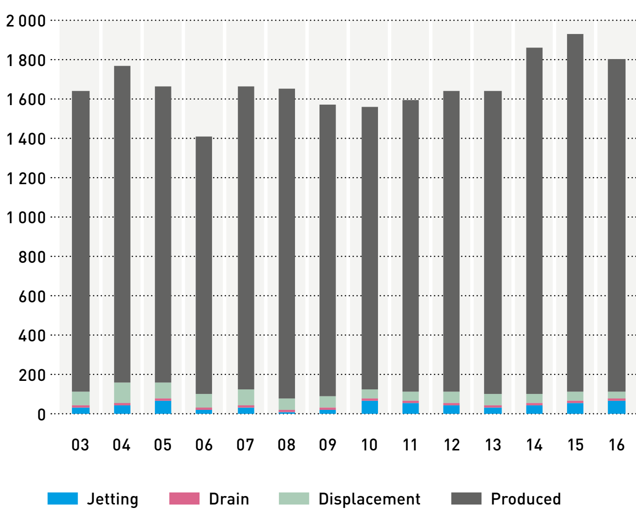


FIGURE **12** OIL CONTENT IN WATER DISCHARGED ON THE NCS (TONNES)



4.3 TREATMENT OF OILY WATER

The strategy of zero harmful discharges on the NCS is pursued using a risk-based approach, where risk assessments ensure that measures are applied where they have the biggest environmental effect while also providing a sensible cost/benefit balance. These efforts have led to a substantial reduction in oil released to the sea by injecting produced water below ground or treating it before discharge.

Research as well as environmental impact factor (EIF) calculations show that certain chemical additives and natural components from the sub-surface discharged together with produced water can have harmful effects on aquatic organisms. However, this relates to concentrations only found close to the discharge point – within a distance of a few hundred metres. Chemical additives which contribute to the environmental risk are subject to substitution (see section 4.4). Water-column monitoring on the NCS confirms that no negative effects can be demonstrated from the discharges beyond the immediate vicinity (see chapter 5). Effects relate primarily to outcomes in biomarkers.

Substantial investment has been made in treatment technology and injection in order to reduce oil discharged with produced water. On some fields, several billion kroner have been spent on treatment solutions for oily water. Running such facilities also costs from a few to several tens of millions of kroner per annum. New treatment technology and improved operation have reduced the concentration of oil in produced water on a number of fields. While most fields have discharges far below the regulatory ceiling of 30 mg/l, some experience problems for various reasons in achieving stable operation of injection facilities and treatment processes.

On behalf of Norwegian Oil and Gas, DNV GL has reviewed discharge data and treatment technologies on the NCS. Its findings emphasise facts which have also been reported earlier by the environmental authorities:

- A good treatment effect can be achieved on some fields with simple techniques, while others face more challenging conditions and require additional measures. Even when the latter are implemented, variations in conditions can lead to significant fluctuations in the treatment effect.
- Different treatment techniques have limitations related to operational conditions, including oil type, water quality and volume, pressure changes, use of chemicals, phasing in wellstreams from other fields and so forth.
- A technique which works well in one location can accordingly be less suitable or inappropriate elsewhere.
- The success of treatment can fluctuate substantially over time – from one month to another and from year to year – as a result of varying operating conditions.

The best available techniques (BAT) are assessed when evaluating a solution for the individual field. Such assessments extend far beyond simply looking at dispersed oil in water. Energy consumption and cost are other key subjects, for example. Where new fields on the NCS are concerned, injection is always assessed as a possible strategy for handling produced water. However, not all fields have reservoirs with the right properties for injecting produced water. Where conditions are appropriate for injection, this is often a preferred option based on environmental assessments. The volume of produced water discharged to the sea declined in 2016, and the latest forecasts from the NPD indicate that it will fall even further.

Substantial investment has been made in treatment technology and investment to reduce oil discharged in produced water. Injection is always considered on new fields as a possible strategy for handling produced water.

4.4 CHEMICAL DISCHARGES

Chemicals are assessed on the basis of their environmental properties, including persistence, potential for bioaccumulation and toxicity (PBT). The Norwegian government has also specified criteria in the activities regulations and in guidelines for reporting from offshore petroleum operations.

Chemical additives covered by requirements in emission/discharge permits are divided into four categories (green, yellow, red and black) in accordance with the classification in the activities regulations:

1) GREEN Chemicals considered to have no or very limited environmental impact. Can be discharged without special conditions.

2) YELLOW Chemicals in use, but not covered by any of the other categories. Can normally be discharged without specified conditions.

3) RED Chemicals which must be given priority for substitution, but which can be discharged with government permission.

4) BLACK Chemicals which the government can permit to be discharged in special circumstance – where this is crucial for safety, for instance.

The NEA's table for classifying and reporting chemicals is presented in table 1. A more detailed description is provided in the NEA's M-107 guideline on reporting from offshore petroleum operations (in Norwegian only).

Discharges of chemical additives from Norwegian petroleum operations totalled just over 152 000 tonnes in 2016. Overall discharges have declined steadily since 2013. Green chemicals accounted for almost 91 per cent of the total, while the red and black categories accounted jointly for some 0.047 per cent of discharges. Yellow chemicals represented 9.4 per cent.

Replacing chemicals with less environmentally harmful alternatives – known as the substitution duty – represents an important part of efforts to reduce possible environmental effects from offshore discharges. Operators regularly assess the chemicals used to see if they can be substituted. Extensive substitution of chemicals has reduced the release of the most environmentally harmful substances to a fraction of the level only 10 years ago.

A marked increase in reported discharges of black chemicals occurred in 2011-14, but this trend has been reversed in the past couple of years. Where red chemicals are concerned, a steady rise has occurred since 2013. Discharges fell from 6.6 tonnes in 2015 to 3.6 tonnes for black chemicals and rose from 67 tonnes to 103 tonnes for the red category.

Complex factors underlie the variations in recent years, but changed requirements for both reporting and substitution work are the most important. An important contribution has been that discharges of fire-extinguishing foam were not reported earlier because this was a safety chemical with no alternative products able to offer satisfactory extinguishing properties (see the HSE regulations). Alternatives with less environmentally harmful properties are now available. These are now being phased in, but it will be several years before all fields on the NCS have replaced the old types with new versions. Mandatory drills and system tests will therefore lead to discharges of black chemicals for a number of years to come. The new alternatives still contain components categorised as red. That explains the marked increase in discharges for this category of chemicals. A further contribution has been made by reclassifying certain chemicals from yellow to red categories.

FIGURE 13 BREAKDOWN OF DISCHARGES OF CHEMICAL ADDITIVES FROM THE NCS BY THE NEA'S CATEGORIES (2016)

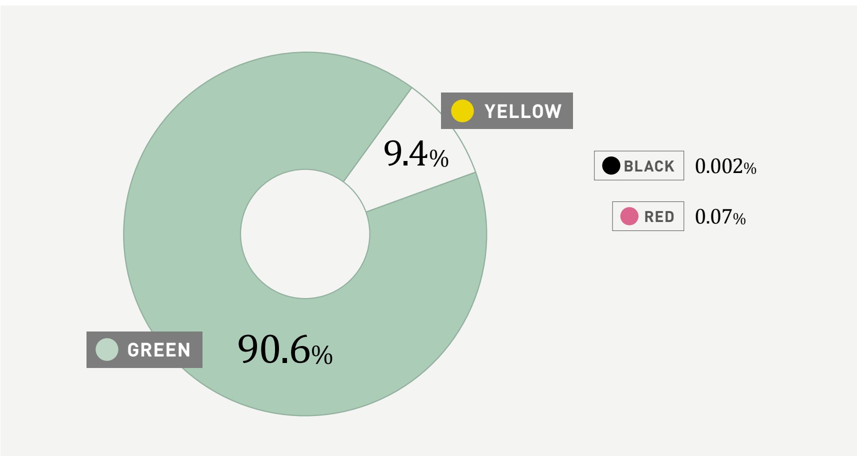


TABLE 01 THE NEA'S TABLE FOR CLASSIFYING AND REPORTING CHEMICALS.
SEE THE M-107 GUIDELINE FOR EXPLANATIONS WITH CHAPTER REFERENCES.

Discharge	Category[1]	NEA colour category
Vann		
Substances on Ospar's Plonor list	201	Green
Substances covered by Reach annex IV [2]	204	Green
Certain substances covered by Reach annex V [3]	205	Green
Substances with no test data	0	Black
Substances thought to be, or which are, hazardous to genes or reproduction [4]	1.1	Black
List of prioritised substances in result objective 1 (priority list)	2	Black
Biodegradability < 20% and log Pow ≥ 5 [5, 4]	3	Black
Biodegradability < 20% and toxicity EC_{50} or LC_{50} ≤ 10 mg/l [4]	4	Black
Two out of three categories: biodegradability < 60%, log Pow ≥ 3, EC_{50} or LC_{50} ≤ 10 mg/l [4]	6	Red
Inorganic and EC_{50} or LC_{50} ≤ 1 mg/l	7	Red
Biodegradability < 20% [4]	8	Red

Discharge	Category[1]	NEA colour category
Substances in yellow category:		
Substances with biodegradability > 60%	100	Yellow
Substances with biodegradability 20-60%		
Sub-category 1: expected to biodegrade fully	101	Yellow
Sub-category 2: expected to biodegrade to environmentally non-hazardous substances	102	Yellow
Sub-category 3: expected to biodegrade to substances which could be environmentally hazardous	103	Yellow

[1] A description of the category is provided in the flow diagram. Category in table 5-1 has been related to category in table 6-1 to ensure correspondence with reported figures in the two tables.

[2] Removed from the black category in the activities regulations.

[3] Substances hazardous to genes or reproduction are understood to mean mutagen categories (Mut) 1 and 2 and reproduction categories (Rep) 1 and 2, see appendix 1 to the regulations on labelling, etc, of hazardous chemicals or self-classification.

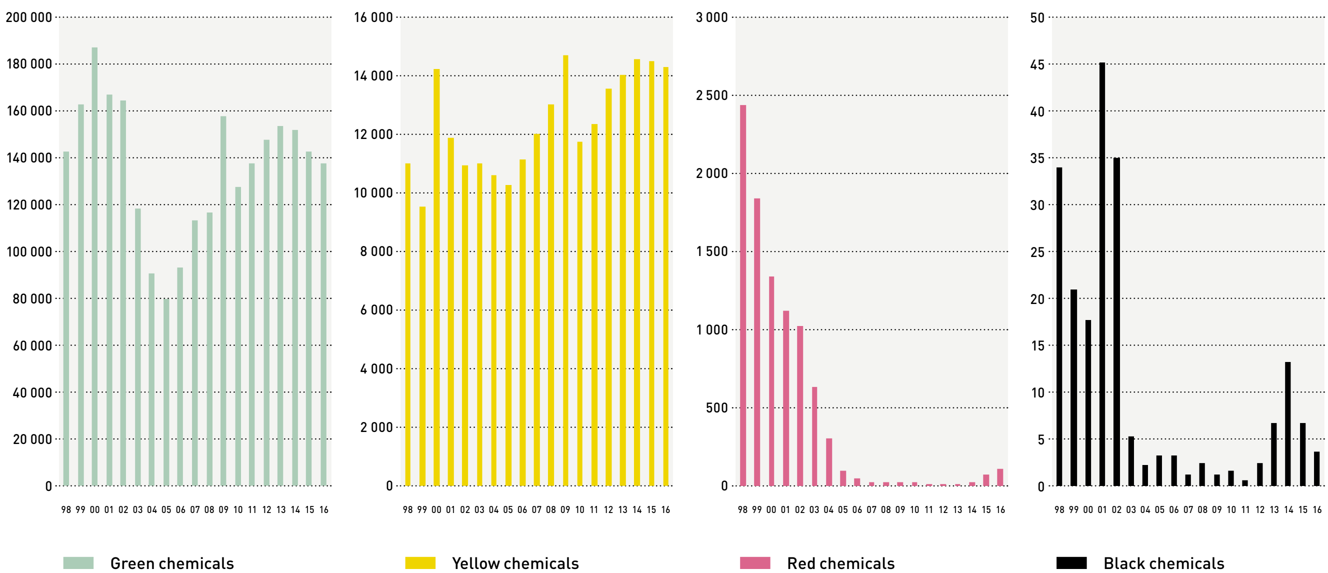
[4] Data for degradability and bio-accumulation must accord with approved tests for offshore chemicals.

[5] Removed from the red category in the activities regulations.

[6] Commission regulation 987/2008. The NEA must assess whether the substance is covered by annex V.

- **Green** Chemicals considered to have no or very limited environmental impact. Can be discharged without special conditions.
- **Yellow** Chemicals in use, but not covered by any of the other categories. Can normally be discharged without specified conditions.
- **Red** Chemicals which must be given priority for substitution, but which can be discharged with government permission.
- **Black** Chemicals which the government can permit to be discharged in special circumstance – where this is crucial for safety, for instance.

FIGURE 14 DISCHARGES OF CHEMICAL ADDITIVES FROM THE NCS BY THE NEA'S CATEGORIES (TONNES)



4.5 UNINTENTIONAL SPILLS

Unintentional spills are defined as unplanned emissions/discharges which occur suddenly and are not covered by a permit. Possible environmental consequences of such releases will depend on the properties and quantity of the substance emitted/spilt, and when and where the incident occurred.

Unintentional spills are classified in three principal categories:

- oil: diesel, heating, crude, waste and others
- chemicals and drilling fluid
- emissions to the air.

Norway's oil and gas industry pays great attention to adopting measures to reduce incidents which cause unintentional spills. All spills down to less than a litre are reported to the NEA in the annual emission/discharge reports.

UNINTENTIONAL OIL SPILLS

Unintentional oil spills have generally declined in number over the past 20 years, with a clear downward trend since 2008. The marked fall in the number of spills from 2013 to 2014 reflects a clarification of the regulations which reduced oil discharges but correspondingly increased unintentional releases of chemicals smaller than 50 litres. Thirty-nine incidents involving spillage of oil occurred in 2016, compared with 47 the year before. Spills larger than 50 litres have become steadily less frequent since 1997. There were nine of these in 2016, compared with 23 the year before.

A similar long-term decline can be observed for crude oil spills alone. There were 13 of these in 2016, including 10 smaller than 50 litres, one in the range from 0.05 to one cubic metre and two above one cubic metre.

The total volume of oil unintentionally spilt varies substantially from year to year, with the statistics affected by large single incidents. Totalling more than 4 000 cubic metres, the second largest oil spill on the NCS occurred in 2007. The combined volume in 2016 was 17 cubic metres.

UNINTENTIONAL CHEMICAL SPILLS

No similar declining trend can be seen for unintentional chemical spills. These have generally lain around 150-160 incidents annually over the past six-seven years, but rose substantially in 2014 to 237 spills. Most of this increase occurred in the size category below 50 litres, where the number doubled as a result of clarifications to the regulations which led to fewer spills being classed as oil and more grouped as chemicals. Just over 160 spills occurred in 2016.

Unintentional chemical spills had an overall volume of 351 cubic metres in 2016, including 367 tonnes of green chemicals, 113 tonnes of yellow, just under three tonnes of red and 0.5 tonnes of black.

Discharged volumes were dominated in 2007-10 by individual years when leaks from injection wells were discovered. These are now shut in. The biggest leak in 2016 was just under 75 cubic metres from a tank holding monoethylene glycol (MEG), which mainly comprises green chemicals.

FIGURE 15 UNINTENTIONAL OIL SPILLS TO THE SEA ON THE NCS

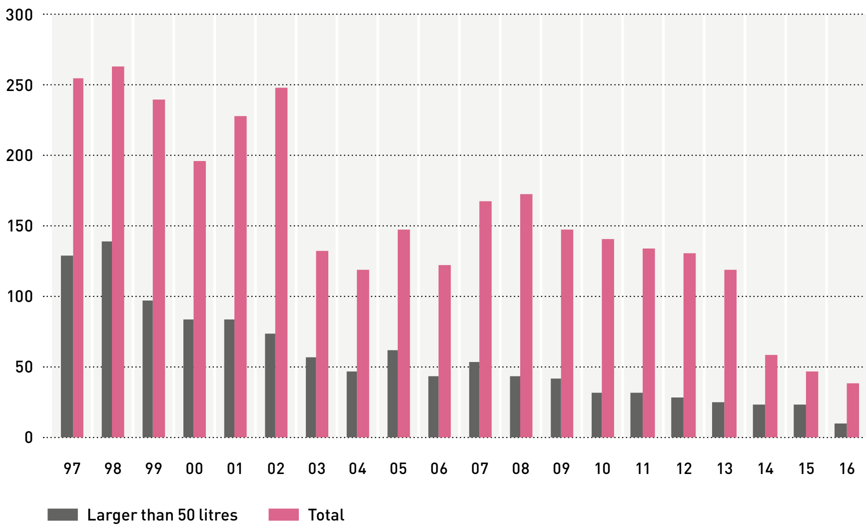


FIGURE 16 UNINTENTIONAL CRUDE OIL SPILLS TO THE SEA ON THE NCS

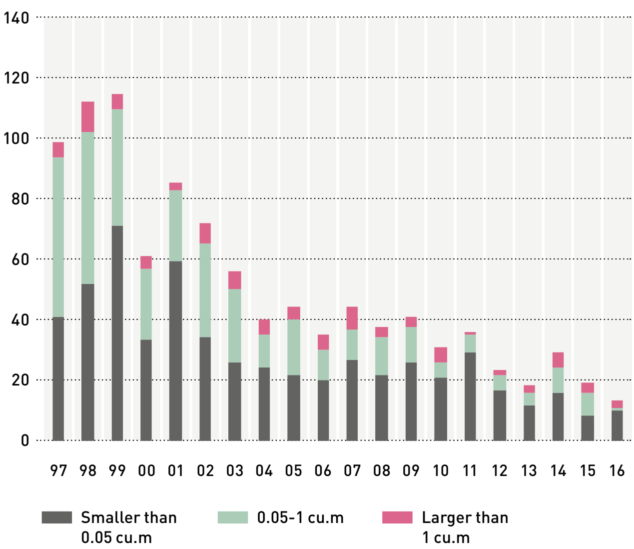


FIGURE 17 VOLUME OF UNINTENTIONAL OIL SPILLS ON THE NCS (CU.M)

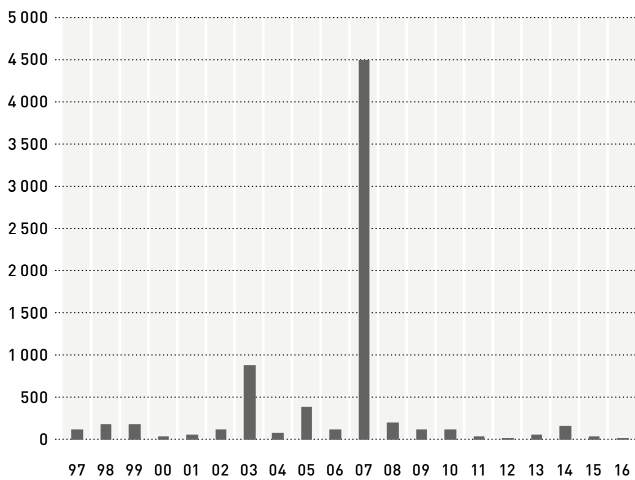


FIGURE 18 UNINTENTIONAL CHEMICAL SPILLS ON THE NCS BY THREE SIZES OF SPILL

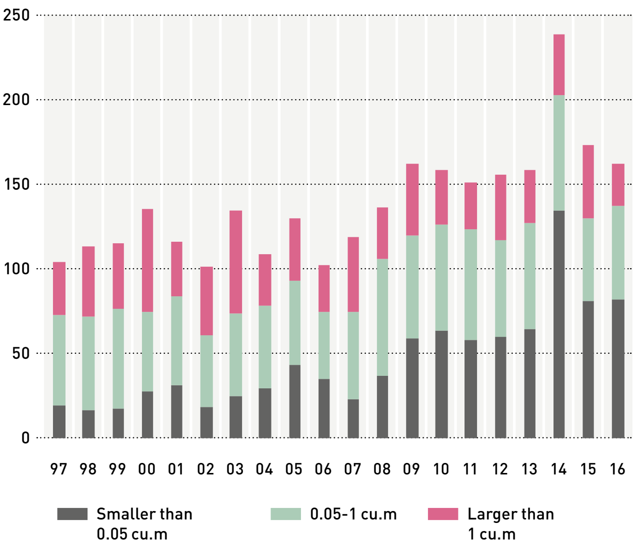
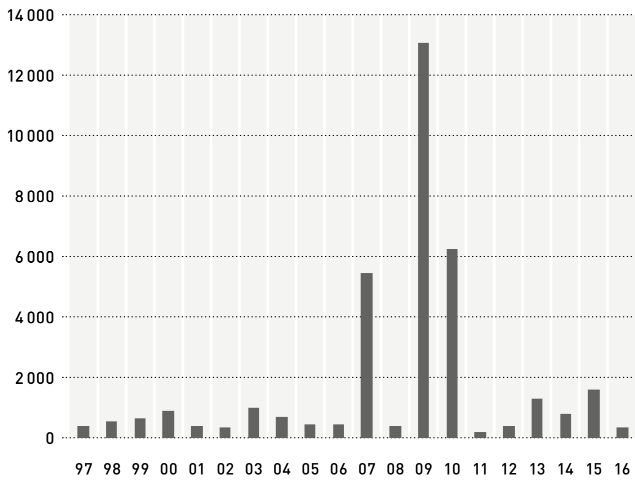


FIGURE 19 TOTAL VOLUME OF UNINTENTIONAL CHEMICAL SPILLS (CU.M)



5 OFFSHORE OPERATIONS AND THE MARINE ENVIRONMENT

LIKE ALL OTHER HUMAN ACTIVITY, OIL AND GAS PRODUCTION INVOLVES A RISK OF AFFECTING THE ENVIRONMENT. SUCH EFFECTS CAN BE CAUSED BY BOTH OPERATIONAL DISCHARGES AND ACUTE (UNINTENTIONAL) INCIDENTS WHICH LEAD TO DISCHARGES TO THE SEA.

5.1 ENVIRONMENTAL MONITORING

The industry has worked systematically to reduce and prevent discharges. Substantial resources have also been devoted to understanding which discharges could cause effects, so that the most effective measures can be implemented. This commitment covers mapping and monitoring of the climate to assess its condition, developing better methods for environmental monitoring, and research. Both preventive and consequence-reducing measures are utilised, such as replacing chemicals (see section 4.4) and oil spill clean-up.

The oil and gas sector conducts extensive environmental monitoring of the NCS on an annual basis. This aims to document the condition of the environment and its development as a result of both human impacts and natural variations. Substantial research work is also being pursued by individual companies as well as through funding from Norwegian Oil and Gas to such bodies as the Research Council of Norway. These activities cover both the development of monitoring methods and improved understanding of the impact of petroleum industry discharges on the marine environment.

Monitoring covers investigations of the water column and benthic sediments and fauna, as well as visual inspection of the seabed in areas where species assumed to be particularly vulnerable to discharges (corals, sponges and so forth) are present.

WATER-COLUMN MONITORING

Produced water discharged to the sea contains chemical compounds which could be toxic for marine organisms. Possible effects of discharges are assessed with the aid of both risk analyses (EIF, see section 4.3) and environmental monitoring.

Extensive changes to procedures for water column monitoring have been made by the NEA. The recommended approach is now to conduct a large-scale survey every three years, rather than the smaller annual inspections carried out previously. This will provide better time for further development of methods in the intervening periods, while each survey will acquire more data. The next major survey is scheduled for 2017. Surveillance will continue to be based on investigating caged mussels at increasing distances (500, 1 000 and 2 000 metres) from the installations and on wild fish caught around the discharge sites. The research institutions which will conduct the water column monitoring are the International Research Institute of Stavanger (Iris), the Norwegian Institute for Water Research (Niva), Sintef and the Norwegian Institute of Marine Research. The programme is designed to identify possible effects in the immediate vicinity of a discharge as well as regional impacts.

This year's survey will concentrate on the immediate vicinity of Statfjord A and on regional stations in the Tampen area, the Egersund Bank and the southern end of the NCS. Attention will be focused on produced water and possible links with the drill cuttings pile at Statfjord A.

Discharges of produced water from all fields on the NCS totalled roughly 138 million cubic metres in 2016, down by about seven per cent from the year before. Some 1 700 tonnes of dispersed oil were discharged in produced water during 2016, spread across all discharge points.

Produced water is rapidly diluted by ocean currents after discharge from the installations. This has been verified by water column monitoring. An independent panel of experts reviewed both monitoring techniques and the results of this surveillance work. It concluded that theoretically possible toxic concentrations extend no more than 1 000-2 000 metres from the release point, and that significant biological effects are limited to a distance of less than 1 000 metres.

SEDIMENT MONITORING – SEABED INVESTIGATIONS

Environmental monitoring has been under way since the early 1970s. A major meeting of scientists, civil servants and industry representatives in the late 1980s laid the basis for more systematic conduct of sediment surveillance.

A regional approach, with monitoring of each region every three years, was introduced in 1996. In addition, a baseline investigation must be conducted for each field before it comes on stream to document its natural environmental condition. The NCS is divided into 11 geographic regions for seabed monitoring, which is conducted in accordance with standards described in the NEA's guidelines. Carried out by independent consultants, the scale of this work must be related to offshore petroleum activities in each region. Scope, methods used and results are reviewed and quality assured by a panel of experts on behalf of the NEA.

Monitoring of benthic habitats involves sampling the seabed – usually with the aid of a grab – followed by sediment analyses to establish its physical, chemical and biological condition. Some stations have been investigated regularly for more than 30 years, and the data are therefore very valuable to scientists and government in assessing both natural and anthropogenic changes to the environment over time. Great interest therefore exists in applying this material to the government's administrative work, along with data from the big Mareano mapping programme. A project has accordingly been pursued in 2016-17 to assess the comparability of the two data sets. Its findings will be published during 2017.

The monitoring programme is one of the most extensive conducted regularly on the North Atlantic seabed, and covers an estimated 1 000 stations on the NCS. Of these, about 700 are in the North Sea. Once the production phase has ceased, two further rounds of investigations are conducted at three-year intervals.

All data are stored in the MOD database, which can be accessed by scientists and government agencies. The MOD was modernised and transferred to an improved software platform in 2016, and the new version is now available. Its information can also be exchanged with the Norwegian Maritime Data Centre (NMDC), which has a large number of partners (www.nmdc.no). Updated reports will be issued in the autumn of 2017, when the final environmental monitoring results from 2016 also become available.

A number of major research projects and programmes have been pursued by independent scientists to study possible effects of oil and gas industry discharges to the sea. These include the Research Council of Norway's Marinforsk programme, launched in 2015, and the earlier Oceans and Coastal Areas (Proof/Proofny) which has run for more than a decade. Surveillance results have been used in a number of scientific papers. Both Proofny and the environmental monitoring data have been presented in review articles or reports where all results and earlier papers are reviewed. [1, 2]

Both reviews conclude that the potential for environmental harm from the discharges is generally moderate, and that the concentrations which have yielded effects in laboratory studies do not normally occur more than about a kilometre from the discharge sources and usually only a few hundred metres from the installations. The impact of discharges from drilling operations is only detectable in the immediate vicinity of the well site. Effects on benthic organisms primarily derive from physical factors (particle discharges) and often cannot be distinguished from the impact of the actual structure (platform) on currents and thereby on particle size in the sediment.

Since these publications appeared, the Barents Sea drill cuttings research initiative has begun. Initiated by Eni Norge, this project has a time frame of five years. It aims to provide information about the extent of effects from drill cutting discharges over time through studies of seabed biology and ecology, geology and oceanography. The initiative is a collaboration between the University of Tromsø, Akvaplan-Niva and the Northern Research Institute (Norut). Wells drilled from 1989 to 2015 are being investigated. Samples were taken in a straight line from the discharge point to distances of 30, 60, 125 and 250 metres. This is closer than regular sediment monitoring, where samples are not taken at distances of less than 250 metres.

The preliminary conclusion is that drilling operations which involve discharging drill cuttings cause local effects, such as reduced oxygen levels and a smaller number of faunal species. However, their scope is limited to the immediate vicinity of the discharges (less than 300 metres) and their impact is greatest in the first three years after their release. The area where visual effects can be seen is within 100-200 metres for new wells. Older wells show such impacts at a distance of only 10-30 metres, which indicates a rapid re-establishment of normal fauna.

[1] Bakke et al, 2013. "Environmental impacts of produced water and drilling waste discharges from the Norwegian offshore petroleum industry". *Marine Environmental Research*, vol 92, pp 154–169.
[2] Bakke et al, 2012, *Langtidsvirkninger av utslipp til sjø fra petroleumsvirksomheten. Resultater fra ti års forskning*. Report from the Research Council of Norway (ISBN 978-82-12-03027).

VISUAL INSPECTIONS

Visual inspections are carried out before planned exploration drilling can begin in areas which may contain organisms regarded, on the basis of the precautionary principle, as particularly vulnerable to drilling discharges. The industry has developed guidelines for such surveys where deepwater corals are present. At the same time, substantial work is being devoted to developing methods and procedures for preliminary investigations to avoid physical damage to coral reefs, sponge communities and the like. The Norwegian Institute of Marine Research has concluded that no harm to coral reefs from petroleum activities has ever been demonstrated. This work is now being extended to cover sponge communities and various sponge species.

DNV GL presented a collation of results from many studies of areas with vulnerable benthic habitats, with the emphasis on sponges, to the 2016 Environmental Monitoring Forum. This work was based on Ospar's regional divisions from Spain in the south (region V) to region I, which embraces the Norwegian coast from the 62nd parallel to north of Spitsbergen. Particularly important sponge communities with high densities of genera such as *Geodia* are found on the Tromsø Patch. Sponges are sensitive to physical stress from such activities as mooring rigs, installing structures on the seabed or fishing – particularly with bottom trawls. The results suggest that trawling is the most important source of stress for sponge communities. Some areas experience up to 27 000 trawling hours per annum at peak, and trawl-door tracks were registered – as frequently as every 25 metres in some areas – on the seabed where dead sponges could be found.

The Norwegian Institute of Marine Research has concluded that no harm to coral reefs from petroleum activities has been demonstrated. This work is now being extended to cover sponge communities and various sponge species.

5.2 ENVIRONMENTAL RISK AND THE PRECAUTIONARY PRINCIPLE

Historical data from the NCS show that no acute discharges have occurred during 50 years of oil and gas operations which have caused significant environmental harm – whether from offshore activities, associated transport or related land-based plants.

Information from a number of sources indicates that operations are becoming steadily safer, with a declining frequency of both actual discharges (see section 4.6) and near misses which could lead to acute discharges. See the RNNP acute discharge report from the Petroleum Safety Authority Norway (PSA). This reflects an extensive commitment by the industry, with the emphasis on preventive measures.

Choosing the right action to reduce environmental risk also calls for good knowledge of which environmental components could be exposed and their vulnerability to the relevant stress (incident). That includes knowing when the environmental resources are at their most vulnerable, when they are present and which activity poses the highest environmental risk. A priority for the oil and gas industry has therefore been to learn more about actual potentials for damage, and to develop methods to communicate this in a way which provides a satisfactory picture of uncertainties and the uncertainty range. Examples of such activities are seabird mapping (Seapop and Seatrack), researching effects on fish and other resources in the water column (including Symbioses) and research on and development of models for predicting the presence of seabirds and marine mammals (including ERA Acute and Marambs).

SYMBIOSES – IMPACT OF ACUTE OIL SPILLS ON FISH STOCKS

The seas off Norway are among the world's most productive, with big fish stocks which lay the basis for important commercial fisheries. As well as a focus on preventing emissions, a priority for the industry is to acquire a good understanding of the possible effects of discharges. The waters off Lofoten and Vesterålen are a special case in this context, as important spawning grounds for several large fish populations. Several years ago, Statoil therefore took the initiative to launch the major Symbioses research project to secure valuable information on the possible effects of a big acute oil spill on cod stocks in the area. Uncertainty over this question has been one of the most important and fundamental areas of conflict over coexistence between the fishing and petroleum industries in Lofoten-Vesterålen. Involving the leading research communities in Norway (including Akvaplan-Niva, the Institute of Marine Research and Sintef) and internationally (such as Imares and Cowi) ensures that the project has been conducted on an independent basis and with a high level of scientific integrity. The Research Council of Norway has also supported it through the Petromax and Demo2000 programmes.

Symbioses is a tool which integrates recognised models for ecosystems (fish, fish eggs and larvae as well as plankton) and dispersal of oil spills. The models for fish eggs, larvae and adult cod are used as the basis for Norwegian fisheries management when calculating permissible catches under fish quotas. Symbioses simulates an oil spill in time and space, estimates the losses of an annual cod cohort and the consequent effect on fish stocks over time in the same way that the Institute of Marine Research calculates permissible quota catches and the subsequent effect on stocks. This has contributed to understanding the potential effects of major spills in the worst imaginable areas at the height of the spawning season (the worst imaginable time). Results show that the consequences are smaller than previously assumed. Such an extensive scientific study of this ecosystem has never been done before.

The findings indicate that the population of spawning cod would be little affected even with the worst conceivable spill at the worst imaginable time. Most spill scenarios yield a loss of eggs and larvae which reduces the adult population by less than three per cent. A worst-case incident involving the discharge of 4 500 cubic metres per day over 90 days (just over 400 000 cubic metres in total) leads to a 12 per cent reduction and shows no effect on the population's reproductive ability. Such a spill would be the third largest ever from an offshore oil field. By comparison, about 25-30 per cent of the adult population is fished every year under quotas (figures from the Institute of Marine Research for 2016).

Norwegian Oil and Gas believes that results from the Symbiosis project itself, as well as the fact that new and substantial research is under way on this issue, support the view that an impact assessment should now be carried out for the whole area to clarify how concerns over fisheries, natural diversity and spin-offs can be reconciled with oil activity.

ENVIRONMENTAL EFFECTS OF ACTUAL INCIDENTS – MACONDO 2010

On behalf of Norwegian Oil and Gas, Niva and international scientists have jointly reviewed published scientific papers on the effects of the *Deepwater Horizon* spill on the Macondo field in the Gulf of Mexico in 2010. This collation of research results was published as a compilation article in the reputable *Marine Pollution Bulletin* in 2016. It aimed to improve understanding of possible environmental effects from large crude oil spills which could also be relevant for Norwegian conditions.

The Macondo spill was extensive and ranks as the largest-ever offshore. Its volume is estimated at 780 000 cubic metres, while large quantities of dispersants were also used. Much of the oil was entrained in the water column at a depth of 1 100-1 300 metres. Substantial quantities came to the surface, and part of these beached along the coast. Factors such as biological degrading, ocean currents and clean-up measures reduced the amount of oil, but about 2 100 kilometres of the shoreline were polluted. The compilation article concludes that a large number of biological effects were identified, but that "worst-case impact scenarios did not materialise". This is comparable with investigations into the effects of shipwrecks along the Norwegian coast (including *Full City, Server* and *Godafoss*). Findings in the Gulf of Mexico included:

- biomarkers in individuals gave more information than population and community indicators
- salt meadows and seabirds were hard-hit, but also demonstrated a considerable ability to resist the effects at population level
- monitoring identified little pollution of seafood considering the extensive use of dispersants
- chemical and biological degrading of the oil was extensive, and faster than expected.

Extensive research projects are still under way to investigate possible long-term effects on fish populations, deepsea corals, sea turtles and marine mammals.

PRECAUTIONARY APPROACH

The precautionary approach is often adopted in consultation processes to argue against opening new areas for oil operations or applications for exploration and production permits. It relates to both operational and unintentional incidents.

Where environmental management is concerned, the precautionary principle applies when scientific documentation is inadequate, deficient or uncertain, and relevant scientific assessments indicate grounds for concern that substantial harmful effects for the environment could occur which would conflict with necessary or politically determined levels of protection. It means that action must not be delayed until complete assurance has been acquired.

In Norwegian environmental policy, the principle is described in such documents as the White Paper on environmental policy for sustainable development.[3] Section 9 of the Nature Diversity Act gives legal force to the principle. The preamble to the Act[4] emphasises that indications of significant or irreversible harm should exist before the principle is utilised as the basis for decisions.

Uncertainty often arises over whether environmental harm will be caused by an activity, and in the event how great it would be. The precautionary principle should not be applied "for safety's sake" when general or hypothetical uncertainty exists. Indications (findings or observations) must exist which provide the basis for a genuine risk assessment. Lack of information is not in itself sufficient for applying the precautionary principle in assessing whether to permit an activity or intervention.

A precautionary approach is appropriate at a decision-making level in order to ensure that account is taken of uncertainties in an objective, fact-based and scientifically supported decision basis. It is inappropriate to involve the principle in the underlying scientific basis and present it to decision-makers as an enhanced potential for damage, an extension to the uncertainty range or an increase in specified uncertainty. The role of science and scientific institutions is to produce the best factual understanding and the most accurate possible estimates, which also highlight the actual uncertainty range and the uncertainty indicated by the material.

The precautionary principle does not mean the risk should be equal to zero. In administrative areas where it is well entrenched in decision process, these decisions are also based on an acceptance of risk and the precautionary approach is viewed in relation to cost/benefit assessments.

Helping to increase understanding of actual damage potentials has been a priority for the petroleum industry, along with developing methods for communicating this in a way which provides a full picture of uncertainties and their range.

[3] Report no 58 to the Storting (1996-97).
[4] Proposition no 52 to the Odelsting (2008-09), p 103.

6 EMISSIONS TO THE AIR

EVEN WITH SOMEWHAT HIGHER OIL AND GAS PRODUCTION IN 2016, THE OVERALL AMOUNT OF CO_2 RELEASED DIRECTLY FROM OPERATIONS ON THE NCS WAS DOWN A LITTLE FROM THE YEAR BEFORE. CO_2 EMISSIONS PER UNIT PRODUCED WERE THEREFORE ALSO REDUCED.

6.1 EMISSION SOURCES

Emissions to the air from the oil and gas industry consist primarily of exhaust gases containing CO_2, NO_x, SO_x, CH_4 and nmVOC from different types of combustion equipment. In most cases, emissions to the air are calculated from the amount of fuel gas and diesel oil used on the facility. The emission factors are based on measurements from suppliers, standard factors produced by the industry itself, or field-specific measurements and calculations.

The main sources of emissions to the air from oil and gas activities are:

- fuel gas exhaust from gas turbines, engines and boilers
- diesel exhaust from gas turbines, engines and boilers
- gas flaring
- combustion of oil and gas in connection with well testing and well maintenance.

Other sources of hydrocarbon gas (CH_4 and nmVOC) emissions are:

- gas venting, minor leaks and fugitive emissions
- evaporation of hydrocarbon gases from offshore storage and loading of crude oil.

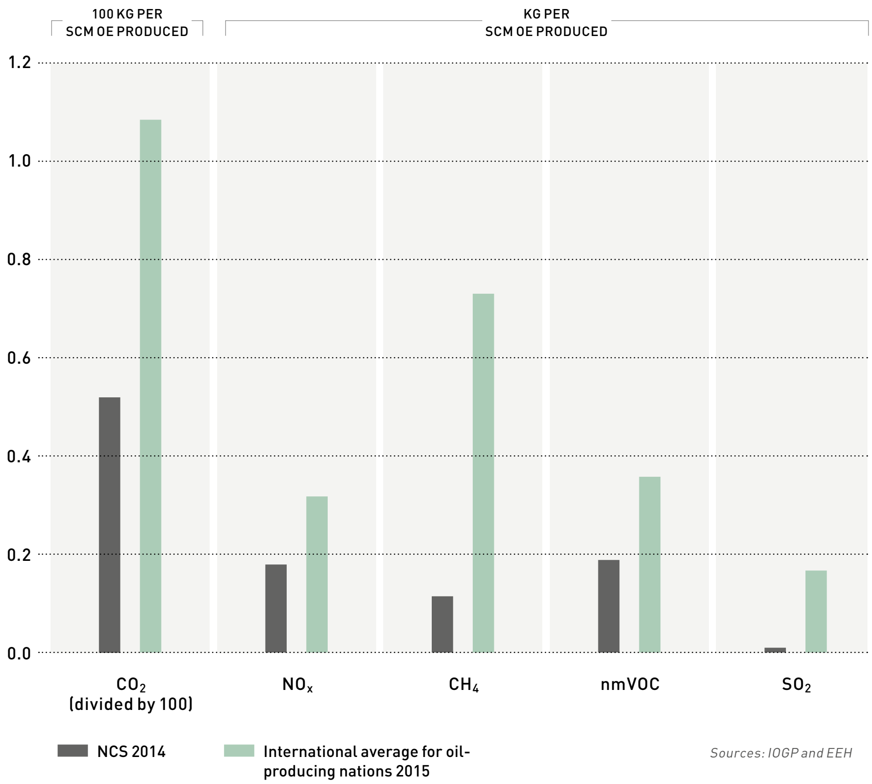
Power generation using natural gas and diesel oil as fuel is the main source of CO_2 and NO_x emissions. Their level depends mainly on energy consumption by the facilities and the energy efficiency of power generation. Gas flaring is the second largest source of these emission types. It only takes place to a limited extent, pursuant to the provisions of the Petroleum Act, but is permitted for safety reasons during operation and in connection with certain operational problems.

The most important sources for CH_4 are fugitive emissions and cold venting. Principal nmVOC sources are offshore storage and loading of crude oil. Emissions of nmVOC occur when gas from tanks gets vented to the air as crude oil displaces it.

SO_x emissions derive primarily from the combustion of sulphur-containing hydrocarbons. Since Norwegian gas is generally low in sulphur, diesel oil is the principal source of such emissions on the NCS. Low-sulphur diesel oil is accordingly used.

Figure 20 presents emissions to the air on the NCS compared with international averages, specified per scm oe produced in 100 kilograms for CO_2 and in kilograms for the other substances. All figures are from 2015 because international figures for 2016 are not available in June 2017.

FIGURE 20 EMISSIONS TO THE AIR ON THE NCS COMPARED WITH THE INTERNATIONAL AVERAGE



Sources: IOGP and EEH

6.2 EMISSIONS OF GREENHOUSE GASES

Global warming is one of the very greatest challenges of the age. Extensive reductions in anthropogenic GHG emissions are therefore essential.

The UN climate summit in Paris (COP21) adopted ambitious climate goals. This agreement came into force on 4 November 2016, 30 days after it had been ratified by 55 states representing at least 55 per cent of global GHG emissions.

Each country's nationally determined contributions (NDCs) are regarded as its official climate plans. A status report is to be prepared every five years to assess these goals, when it will only be possible to maintain or increase the national ambitions.

The overall goal of the climate convention is to stabilise GHG concentrations in the atmosphere at a level where the most serious anthropogenic climate changes can be avoided. While the aim of keeping the average rise in global temperatures below 2°C still applies, COP21 also adopted an ambition of trying to limit this increase to 1.5°C. In addition, the summit resolved that anthropogenic GHG emissions should not be higher in 2050-2100 than can be absorbed by nature and by carbon capture and storage (CCS). These positions will provide the framework for the low-emission society of the future.

A commitment to reduce GHG emissions in 2030 by at least 40 per cent compared with 1990 has been made by the EU. An important instrument for the petroleum industry in meeting this target is the EU's emission trading system (ETS). Roughly half of Norway's GHG emissions are subject to the ETS, including those from the oil and gas sector, land-based industry and aviation. Emission allowances will be cut step-by-step towards a reduction target for 2030 of 43 per cent compared with 2005 in the sectors subject to the ETS.

The Norwegian government is working now to secure a bilateral agreement with the EU on joint fulfilment of their climate commitments for sectors both inside and outside the ETS by 2030. No formal agreement can be entered into until the EU has finalised the current revision of its regulations.

GHG EMISSIONS FROM THE NCS

Several sources report figures for emissions to the air from Norwegian oil and gas production. However, they can differ considerably in both reported figures and development trends from year to year. This reflects a number of factors, but by far the most important is different definitions of which activities are included in the Norwegian oil and gas industry.

- The Norwegian Oil and Gas environmental report, published annually in early June, contains total emission figures from the industry. Which emissions to include are based on the definitions in the Petroleum Tax Act. These cover all exploration and production activities on the NCS, including emissions related to pipeline transport of oil and gas even if these may occur at land-based plants such as Kårstø and Kollsnes. All activities at Melkøya are also included. Information is taken from the EEH database, which has been developed to simplify reporting of emission figures and the submission of annual emission reports from the operators to the government.

- Statistics Norway (SSB) publishes preliminary figures for the whole industry in May, and emissions broken down by various sources in oil and gas production during December. These figures are reported to the UN under the climate and long-range transport conventions. They vary from the amounts reported via the EEH to the NEA by including more of the land-based activities, such as the gas processing plant at Kårstø. The SSB's emission figures will therefore normally be higher than corresponding data based on the EEH, while figures from the various sources will generally be comparable. Figures from the SSB also form the basis for the Miljøstatus.no website.

- The NEA has its own database for Norwegian emissions, which is open to the general public and contains figures from all sources in the country – including oil and gas production. Generally speaking, these are the same amounts found in the EEH. However, the top-level category of "offshore petroleum operation" excludes land-based facilities and exploration activities. Totals for the industry will therefore be lower than those presented in the environmental report and by the SSB.

In addition come emission figures from activities on the NCS subject to the ETS and from that part of Norwegian oil and gas production liable to CO_2 tax. These categories are defined differently both from each other and in relation to the three sources described above, and their figures not only in total but also from different sources will therefore vary.

6.2.1 ROADMAP FOR THE NCS

Norwegian petroleum production is already in the global premier division for low GHG emissions. The average amount emitted per unit produced is about half the world average. This industry is subject to a number of instruments, such as the EU ETS, the CO_2 tax, flaring restrictions in production licences, emission permits with conditions covering energy management, and requirements to use BAT and to assess power from shore for new developments.

These instruments have had a significant effect, and the industry is documented to have adopted emission-reduction measures corresponding to more than five million tonnes of CO_2 per annum since 1996. Efforts to improve recovery will normally boost energy consumption per barrel produced, but emissions per unit produced have been kept low on the NCS while the recovery factor has risen substantially. That represents a significant achievement.

All sectors must contribute in achieving the climate goals. The petroleum industry on the NCS works continuously to reduce its emissions, and a number of processes have been initiated to reinforce these efforts even further.

A roadmap for the NCS drawn up by the petroleum industry sets specific goals and ambitions for further cuts in GHG emissions from oil and gas production. It has been compiled by Norwegian Oil and Gas and the Federation of Norwegian Industries through KonKraft, a collaboration arena for these two organisations as well as the Norwegian Shipowners Association and the Norwegian Confederation of Trade Unions (LO).

The Norwegian petroleum sector has set the following overall climate and commercial goals for 2030:

"Maintain safe and profitable production at the present level, and implement CO_2 reduction measures from 2020 which correspond cumulatively to 2.5 million tonnes of CO_2 equivalent per annum by 2030."

The ambition for GHG includes emission cuts related to electricity and heat supply on oil installations, to short-lived climate forcers such as CH_4, and to drilling operations from mobile rigs, as well as enhanced energy efficiency at field and area level.

In addition, oil companies, suppliers and ship/rig owners will help to reduce emissions from the maritime part of the sector. By 2030, maritime operations on the NCS will be conducted with low- or zero-emission technologies in the offshore fleet.

Where 2050 is concerned, the industry has the following ambition: "Maintain its position as Norway's most important value creator and increase the average recovery factor to at least 60 per cent. The NCS will remain the world leader for low CO_2 emissions, and the sector will develop and adopt technology and solutions which substantially reduce average CO_2 emissions per unit produced compared with the 2030 level."

An action plan forms part of the roadmap. In following this up, the petroleum industry will study the potential for further emission reductions which specify how the companies are to pursue the necessary technology developments and efforts to identify and implement measures for reducing GHG emissions.

The most important competitive advantage for the NCS is the collective expertise and innovative drive in Norway's offshore cluster, which has been developed through collaboration and competition, and a labour market based on open dialogue between employers, employees and government.

Published simultaneously with the roadmap in 2016, the KonKraft report on *Climate and the Norwegian continental shelf* addresses technological and industrial opportunities for low-carbon technology in the petroleum sector. It also assesses how the available instruments can be strengthened to encourage further technological progress.

6.2.2 THE KONKRAFT 2020 GOAL AND GREATER ATTENTION TO ENERGY MANAGEMENT AND EFFICIENCY

In KonKraft report no 5 on *The petroleum industry and climate issues*, the petroleum sector set itself the target of implementing measures to cut GHG emissions by 800 000 tonnes of CO_2 equivalent annually by 2013, with 2007 as the base year. This goal was increased in 2011 to one million tonnes of CO_2 equivalent, with 2020 defined as the new year for reaching the target.

A review of measures implemented by all operators will be completed by Norwegian Oil and Gas during 2017 in order to report on the status of KonKraft's 2020 goal. According to a preliminary status review, the companies are well placed to meet the target before 2020.

Over the past two years, Norwegian Oil and Gas has also implemented a joint industry project on energy management and enhanced energy efficiency. This work has boosted the attention paid to energy management through mapping, efficiency enhancement measures, knowledge-sharing between operators and the development of tools and calculation methods. The industry has also strengthened its collaboration with Enova.

6.3 GREENHOUSE GAS EMISSIONS

FROM NORWEGIAN AND INTERNATIONAL PETROLEUM OPERATIONS

Norway's oil and gas industry is in the global premier division for recovery factors. This means that more fields are mature and that producing their oil and gas is energy-intensive. Nevertheless, emissions per unit produced on the NCS are among the lowest in the world.

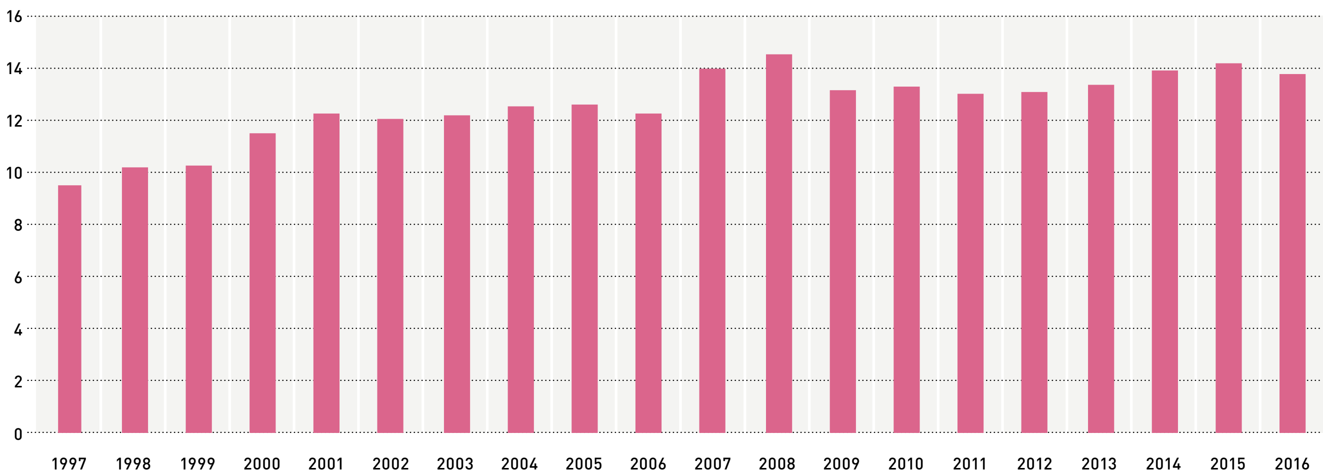
Figure 21 shows that total GHG emissions from the NCS and land-based facilities subject to the Petroleum Tax Act came to 13.8 million tonnes of CO_2 equivalent in 2016. That compares with 14.2 million the year before. The main reason for this drop in overall emissions was a reduced level of activity related to mobile rigs, lower emissions from existing NCS fields and a decline in the quantity of CH_4 emitted because the emission factors previously used off Norway were conservative. That means actual emissions were lower than had previously been assumed (see section 6.6). At the same time, total output rose because new fields such as Goliat and Edvard Grieg came on stream. Relatively speaking, emissions from these developments are lower than from older fields. CO_2 intensity therefore also declined somewhat.

According to SSB, overall Norwegian emissions in CO_2 equivalent came to 53.4 million tonnes during 2016. The petroleum industry accounted for about a quarter of this.

As described above in section 6.2.1, several instruments are in use to regulate emissions from oil and gas operations on the NCS. These have unleashed a number of measures in Norway's petroleum sector.

The result is a Norwegian oil and gas industry in the premier division for energy-efficient production and low CO_2 emissions per unit produced (see figure 22, which presents figures reported to the International Association of Oil & Gas Producers – IOGP). At the same time, certain other oil provinces are increasingly able to point to clear environmental improvements by instituting production patterns similar to those on the NCS, such as reduced flaring. This is very positive. Less flaring both cuts CO_2 emissions and boosts energy supplies for more people, since the gas will be consumed rather than flared.

FIGURE 21 EMISSIONS OF CO_2 EQUIVALENT ON THE NCS (MILL TONNES)



Every company in Norway reports all its emissions pursuant to the applicable regulations. This is not the case in many other petroleum-producing countries. In the Middle East, for example, emission figures were reported to the IOGP for only 23 per cent of production in 2015. (See also Rystad Energy's comparison, which shows significantly higher emissions from the Middle East as a region because of the substantial amount of flaring by some countries there.)

The Norwegian offshore sector is a world leader from a recovery factor perspective. That means a number of fields are mature, and recovering their remaining reserves is energy-intensive. Norway's petroleum sector nevertheless also ranks among the best in the world for low CO_2 emissions per unit produced.

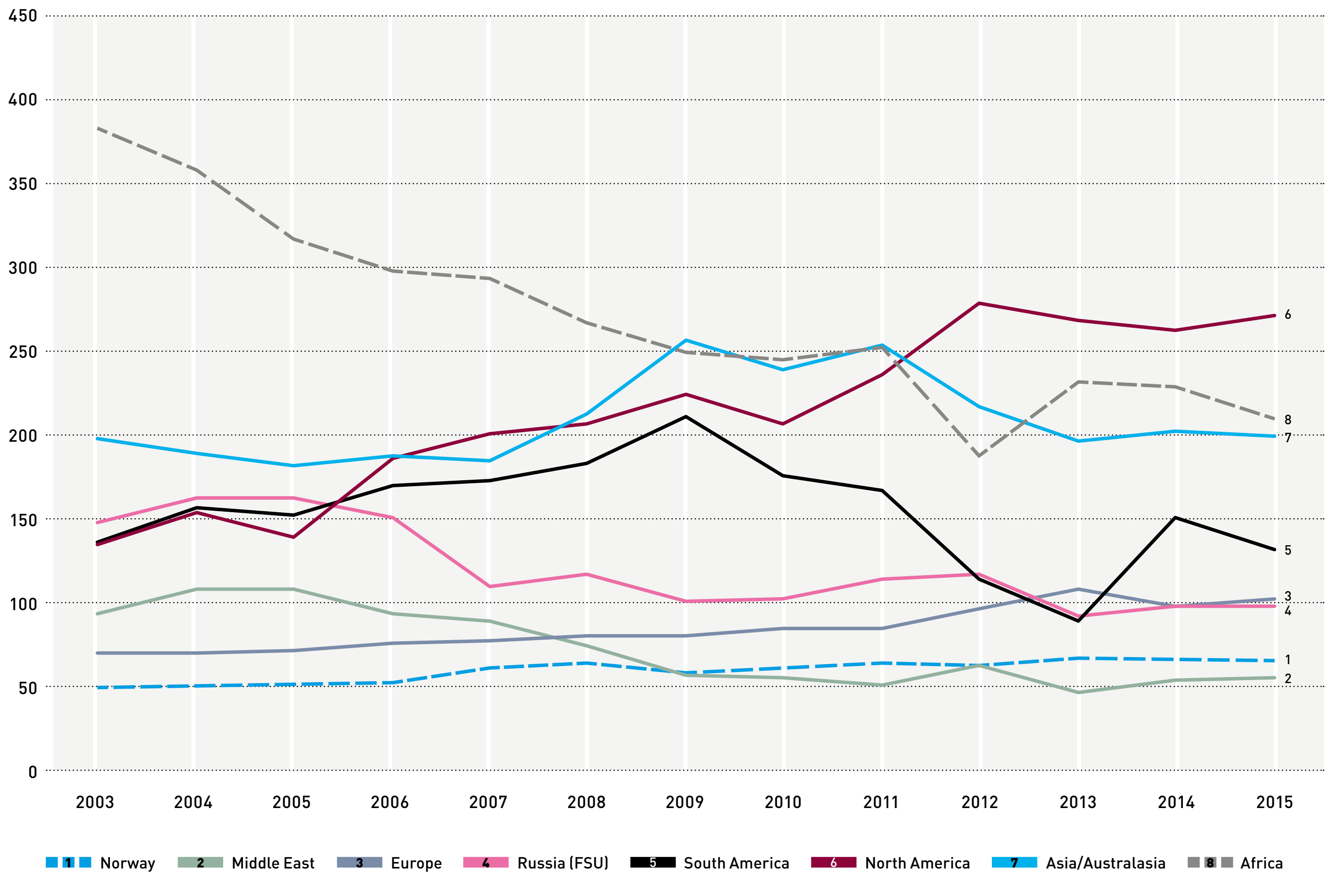
This conclusion is based on an annual report from the IOGP, which presents the figures at regional rather than national level.

Norwegian Oil and Gas has commissioned Rystad Energy to provide a more detailed comparison of world oil production and associated emissions. This consultancy has a database covering global oil and gas output at field level, and has now also developed a methodology for assessing emissions from each field which incorporates not only production but also refining and emissions of combusted oil and gas. On that basis, Rystad has compared the 20 largest producer countries responsible for 83 per cent of world oil and gas output.

The results show that the most significant factor for CO_2 emissions is the type of hydrocarbons in the reservoir. Technology development and regulatory management

FIGURE 22 **GHG EMISSIONS PER UNIT PRODUCED IN VARIOUS PETROLEUM PROVINCES 2003-15**
(KG OF CO_2 EQUIVALENT PER TONNE OF OE PRODUCED)

Sources: IOGP and EEH



also play a part, along with the extent of flaring and power from shore as well as the maturity of the continental shelf. The NCS comes out best in Rystad's comparison with regard to overall emissions per unit produced when viewing the whole chain from production to refining and the combustion of oil and gas.

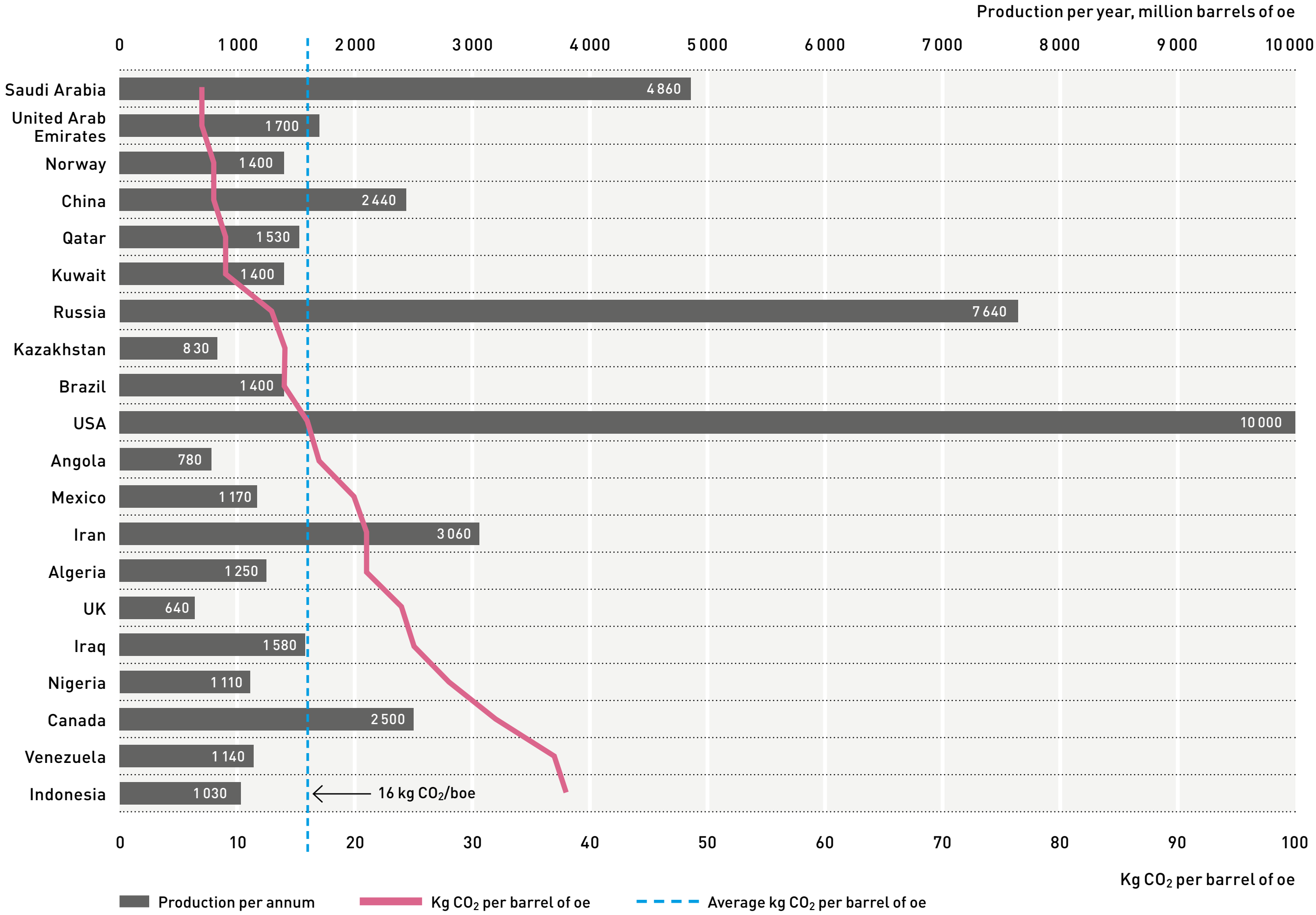
While certain other countries benefit from large fields which are relatively easy to produce, as in the Middle East, Norway has organised itself with large platforms covering several fields. This provides economies of scale and thereby low emissions. On a global scale, moreover, the Norwegian industry has many fields with power from shore and little flaring. The results from Rystad (see figure 23) show that, when looking solely at production in individual countries, Saudi Arabia and the United Arab Emirates have rather lower emissions per unit produced than the NCS. However, emissions in the Middle East as a whole are more than 60 per cent higher than those from petroleum production in Norway, in part because of high levels of flaring in Iraq and Iran.

Rystad's comparison shows that CO_2 intensity on the NCS is roughly half the world average. CH_4 emissions from production and transport are not covered by the investigation, but other known studies indicate that they would also have shown that Norway occupies an advantageous position.[5]

[5] Kate Larsen et al, April 2015. *Untapped Potential. Reducing Global Methane Emissions from Oil and Natural Gas Systems*, Rhodium Group.

FIGURE 23 **GHG EMISSIONS PER UNIT PRODUCED IN 2015 (KG OF CO_2 EQUIVALENT PER TONNE OF OE PRODUCED)**

Source: Rystad Energy



6.4 DIRECT EMISSIONS OF CO_2

Total direct CO_2 emissions from operations on the NCS and land-based facilities subject to the Petroleum Tax Act amounted to 13.34 million tonnes in 2016, compared with 13.49 million the year before (figure 24).

The main reasons for the decline in the total amount of CO_2 released directly were reduced activity related to mobile rigs and lower emissions from existing fields on the NCS. At the same time, overall output from the NCS rose because new fields such as Goliat and Edvard Grieg came on stream. Relatively speaking, emissions from such developments are smaller than from older fields. CO_2 intensity on the NCS therefore also declined somewhat.

Norway's oil and gas industry released 13.34 million tonnes of CO_2 in 2016 and accounted for a quarter of Norwegian emissions. This percentage was more or less unchanged from the year before.

Figure 25 presents the development of CO_2 emissions and the volume of gas flared in 1990-2016.

Figure 26 shows the development of direct and indirect CO_2 emissions per volume of hydrocarbons delivered in 1990-2016. Specific CO_2 emissions were 52.5 kilograms per scm oe produced in 2016 – an improvement from 2014 and 2015. This is positive and in line with the industry's ambition of keeping CO_2 emissions per unit produced at a low level.

FIGURE 24 HISTORICAL DEVELOPMENT OF DIRECT CO_2 EMISSIONS (MILL TONNES) AND BREAKDOWN BY SOURCE IN 2016 (PER CENT)

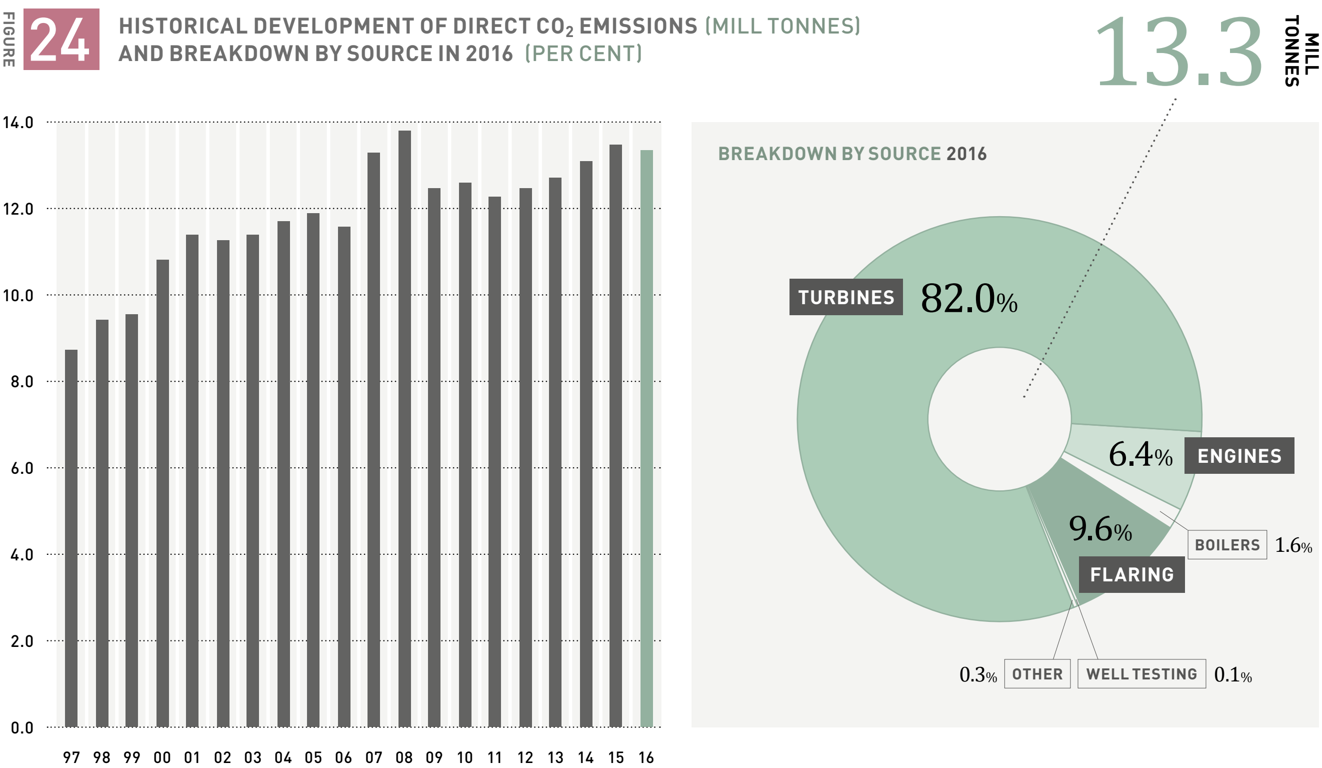


FIGURE 25 HISTORICAL DEVELOPMENT OF FLARE GAS CONSUMPTION (SCM) AND ASSOCIATED CALCULATED CO_2 EMISSIONS (TONNES)

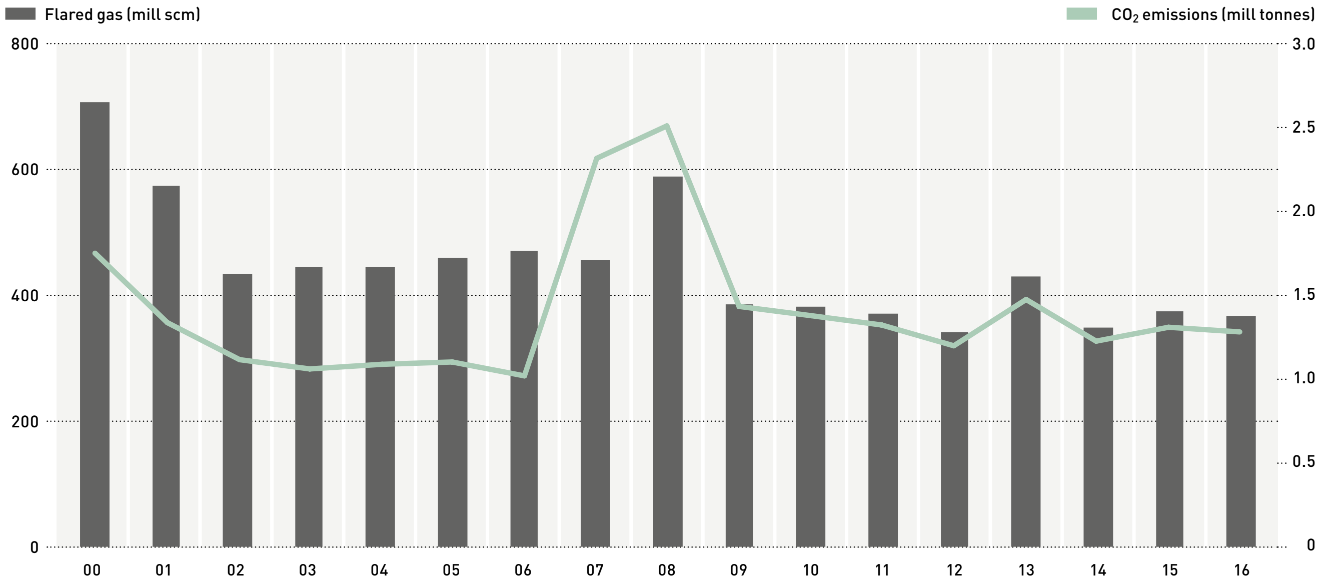
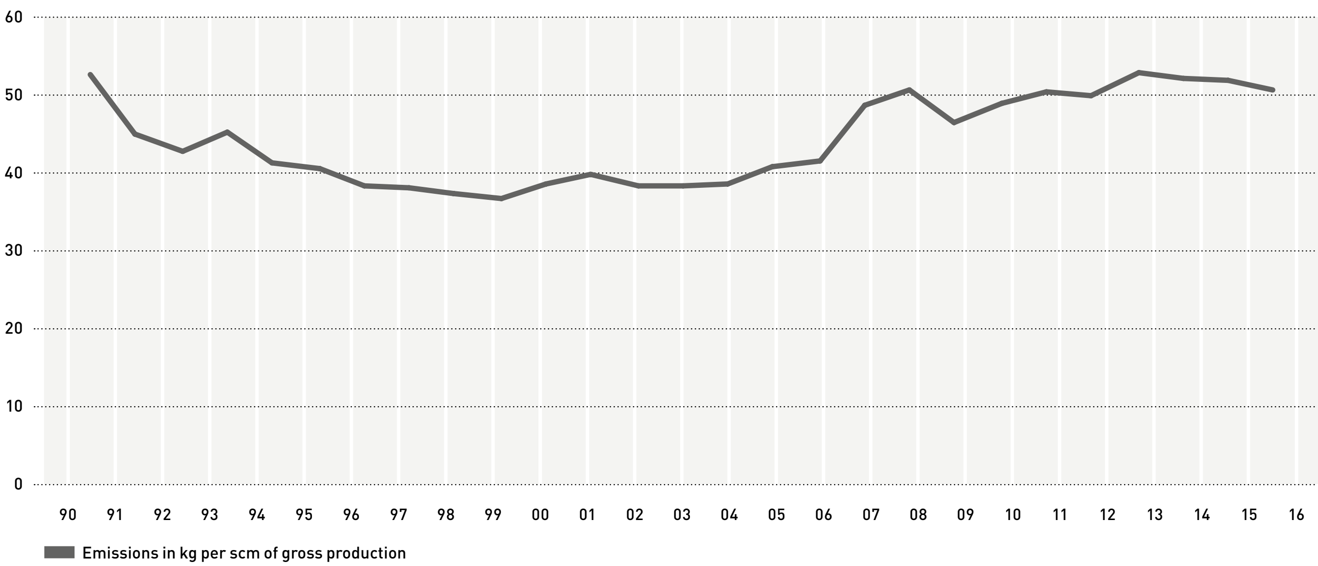


FIGURE 26 SPECIFIC CO_2 EMISSIONS (KG/SCM OE)



6.5 SHORT-LIVED CLIMATE FORCERS

Short-lived climate forcers comprise particles and gases which survive briefly in the atmosphere but have a negative effect on the climate and human health. Success in reducing these emissions will therefore provide both climate and health benefits.

CH_4 and nmVOC released from cold venting and fugitive emissions are the most important sources in the offshore industry. The increased attention paid to these emissions has generated a need to update and acquire further knowledge of the various sources for direct CH_4 and nmVOC emissions.

The quantity of short-lived climate forcers released from production on the NCS is already low by international standards. Results from a joint project with the NEA showed that the emission factors previously used on the NCS were conservative, and that the actual amounts emitted are therefore lower than earlier assumed.

6.5.1 CH_4 EMISSIONS ASSOCIATED WITH GAS EXPORTS TO EUROPE

The natural gas exported to continental Europe and the UK for use by households, industry and gas-fired power stations consists almost entirely of CH_4.

Earlier studies of emissions from the EU's 2.2 million kilometres of gas pipeline, including the transmission and distribution networks, have shown that overall CH_4 emissions from the whole gas value chain from the NCS is around 0.6 per cent. A recent Statoil study put the proportion even lower, at roughly 0.3 per cent. The reason is that the earlier studies utilised an excessively high leak rate for seabed pipelines on the NCS, which are fully welded and have much lower leakage than land lines.

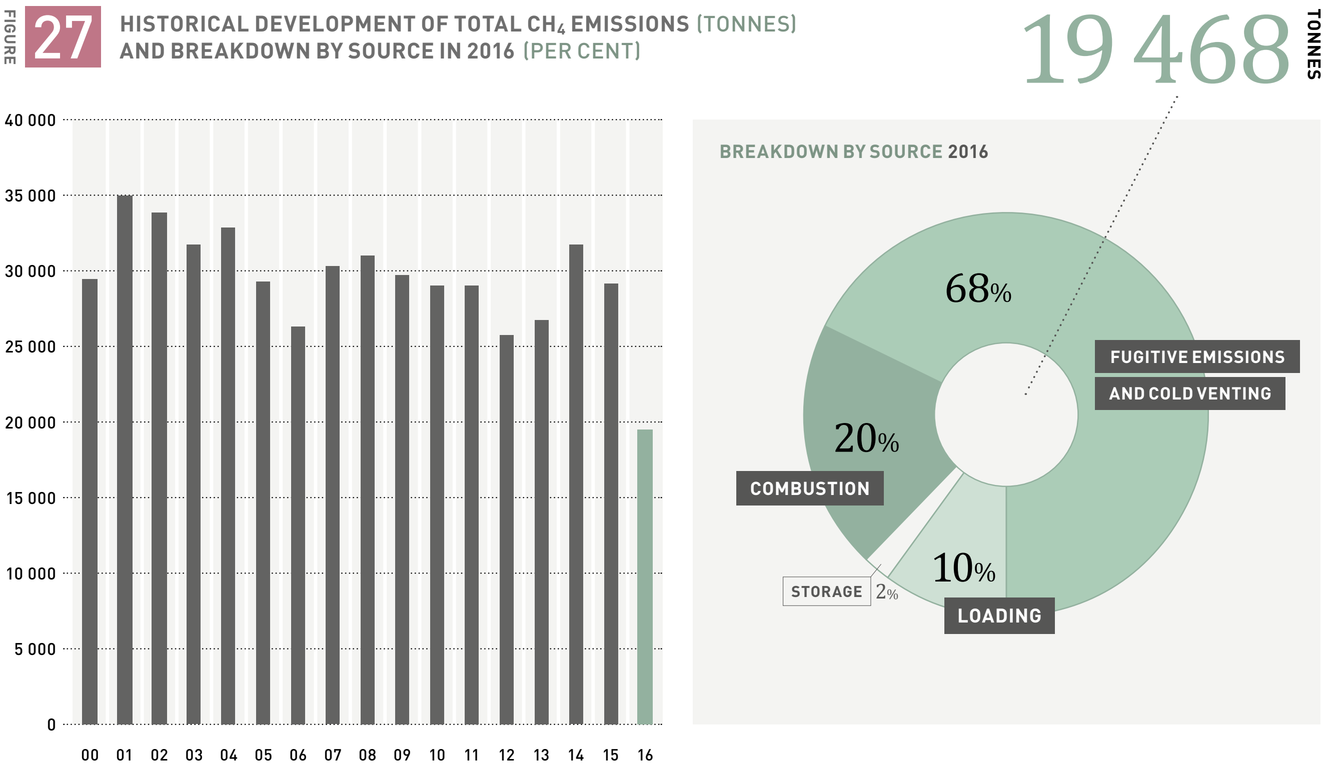
Efforts to avoid leaks have long been given priority on the NCS for both safety and environmental reasons. As a result, emissions related to upstream gas production from the NCS are only about 0.1 per cent of the volume produced. Extensive studies conducted by the National Oceanic and Atmospheric Administration (NOAA) in the USA also show that contributions to atmospheric CH_4 from coal mines and burning coal have been significantly underestimated. This demonstrates that a transition to electricity generation based on natural gas will be a good climate measure.

6.6 EMISSIONS OF CH_4

Figure 27 presents CH_4 emissions from operations on the NCS and a breakdown of these by source in 2016, when a total of 19 468 tonnes was released – down by more than 30 per cent from the year before. This is because conservative emission factors were previously used, with the actual quantities released lower than the figures reported. Guidelines for reporting will be changed from 2017. However, Statoil also applied the new factors for the 2016 reporting year.

Cold venting and fugitive emissions from flanges, valves and various types of process equipment represent the biggest sources of CH_4 from the oil and gas sector.

FIGURE 27 HISTORICAL DEVELOPMENT OF TOTAL CH_4 EMISSIONS (TONNES) AND BREAKDOWN BY SOURCE IN 2016 (PER CENT)



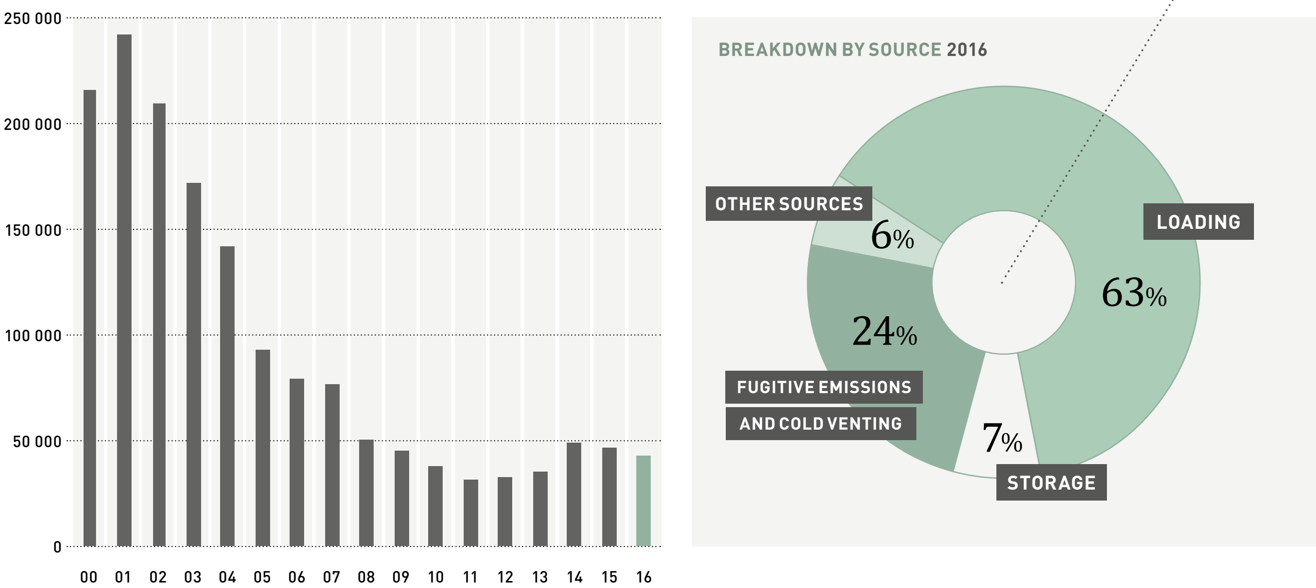
6.7 EMISSIONS OF nmVOC

Overall nmVOC emissions have been cut significantly since 2001. These substantial reductions reflect investment in new facilities for removing and recovering oil vapour on storage ships and shuttle tankers.

Offshore storage and loading of crude oil are the most important sources for nmVOC (oil vapour) emissions. When filling the tanks, volatile hydrocarbons vaporise into the internal atmosphere and mix with the inert gas required for safety reasons. Emissions occur when this gas blend is vented to the air as it gets displaced by crude oil entering the tanks. A substantial reduction in emissions has been achieved through investment in new facilities for removal and recovery of oil vapour on storage ships and shuttle tankers. The total quantity of nmVOC emitted from the NCS declined from 47 344 tonnes in 2015 to 42 379 tonnes. This reduction primarily reflected the joint project with the NEA described in section 6.6.

FIGURE 28 HISTORICAL DEVELOPMENT OF TOTAL nmVOC EMISSIONS (TONNES) AND BREAKDOWN BY SOURCE IN 2016 (PER CENT)

42 379 TONNES



6.8 THE NO_X AGREEMENT AND INTERNATIONAL OBLIGATIONS

The environmental agreement on NO_x regulates the commitments made to the government by Norway's industry associations on reducing their overall NO_x emissions. Norway has already met its NO_x commitments for 2020 under the Gothenburg Protocol. Efforts to reduce emissions through the NO_x fund have been crucial for this result.

All the companies signed up to the agreement report their emissions to the business fund for NO_x as the basis for calculating their obligation to pay into the fund. At 31 March 2017, 938 enterprises were signed up to the agreement, including all the operator companies on the NCS. Since its launch in 2008, the fund has resulted in 851 verified measures which have received investment grants. These yielded an overall reduction of 33 948 tonnes of NO_x between 1 January 2008 and 31 March 2017. The commitment at 31 December 2017 under the environmental agreement is 34 000 tonnes of NO_x.

Although it is a substantial contributor to the fund, the oil industry has few implemented projects in receipt of grants because the cost of measures on the NCS is generally high. The fund model used for this agreement ensures that emission reductions are implemented where they yield the biggest environmental return per krone spent.

The fund has also made an important contribution to the development of new environmentally efficient solutions, and of new markets and market players. Examples include the further development of solutions for gas-fuelled ships, environment-friendly conversion of marine engines, use of catalytic converters to treat emissions with urea, and the installation of fuel-efficient solutions. Viewed overall, the market has both secured new developments and expanded the use of established NO_x-reducing solutions. New suppliers have also secured help in a vulnerable phase in order to establish themselves in the market with support from the fund.

A positive additional effect is that measures which reduce NO_x emissions by cutting fuel consumption also cut the amount of CO_2 released. DNV GL has estimated the reduction potential for annual CO_2 emissions at 670 000 tonnes of CO_2 equivalent at the expiry of the present agreement.

Experience indicates that the emission reductions achieved are significantly higher with an environmental agreement than they were with the fiscal NO_x tax imposed in 2007. Financing measures from the fund means increased cuts at a significantly lower financial burden for the companies, while the reductions in the agreement are achieved with a greater degree of certainty.

The present environmental agreement expires at 31 December 2017. To continue work on reducing NO_x emissions to meet national targets, maintaining this accord will be important. The abatement potential is still substantial for coming years, and investment decisions are taken on a continuous basis in the enterprises. Both industry and the government want an extension of the agreement from 2018. The 15 industry associations which belong to the NO_x fund signed a new agreement for 2018-25 in May 2017.

> The NO_x fund ensures that emission reductions are implemented where they yield the biggest environmental return per krone spent.

6.9 EMISSIONS OF NO_X

Petroleum industry operations emitted a total of 44 717 tonnes of NO_x in 2016, down from 46 788 tonnes the year before. This reduction reflected lower emissions from diesel engines because the use of mobile units declined.

Figure 29 presents NO_x emissions from operations on the NCS and how these broke down by source in 2016.

Specific NO_x emissions for the year totalled 0.17 kilograms per scm oe delivered, down from 2015. The primary reasons for this reduction were a lower level of activity by mobile rigs and a decline in the consumption of diesel oil as fuel.

The biggest source of NO_x emissions from petroleum activities is combusted gas in turbines on offshore installations.

FIGURE 30 NO_X EMISSIONS PER VOLUME DELIVERED OF HYDROCARBONS, 1997-2016 (KG/SCM OE)

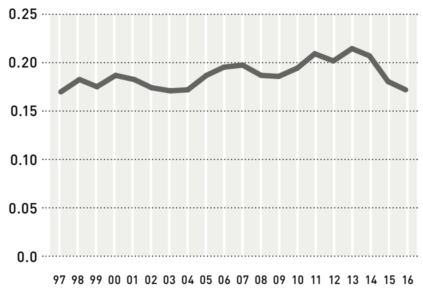
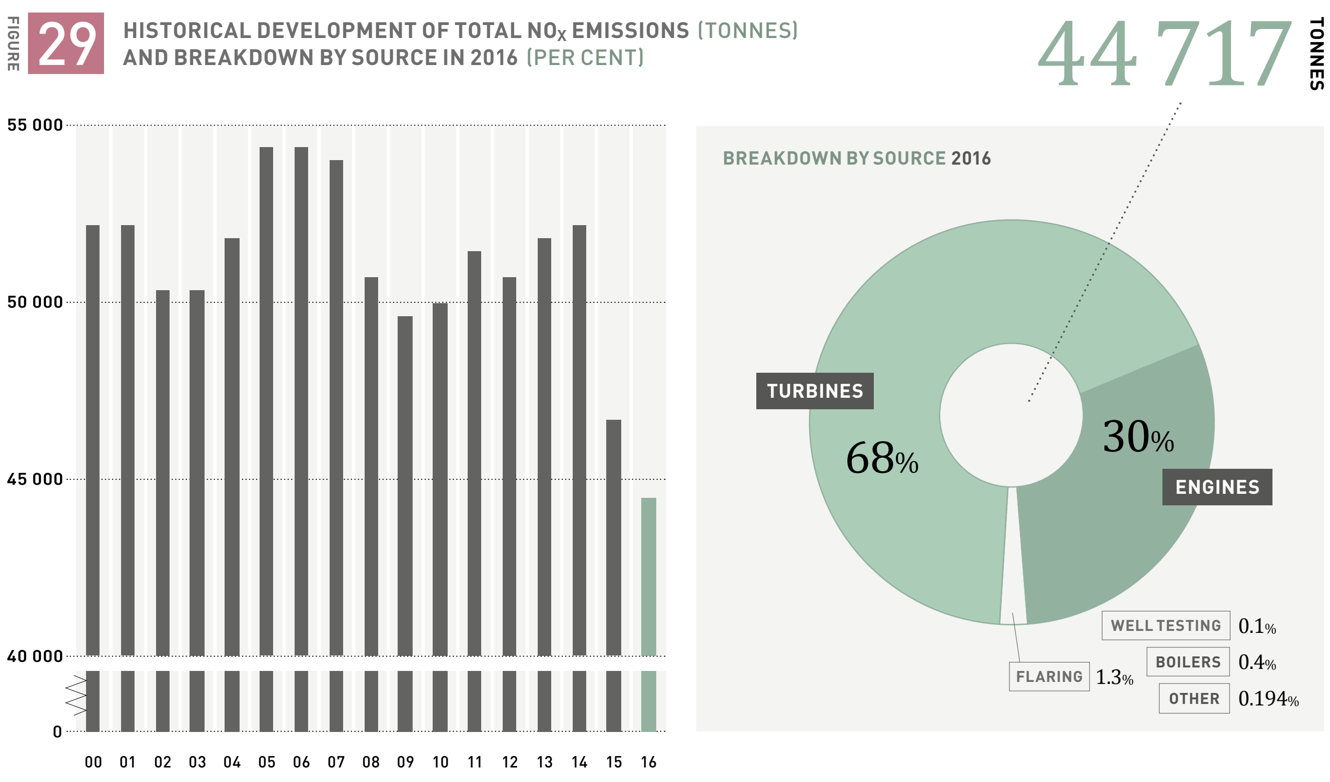


FIGURE 29 HISTORICAL DEVELOPMENT OF TOTAL NO_X EMISSIONS (TONNES) AND BREAKDOWN BY SOURCE IN 2016 (PER CENT)

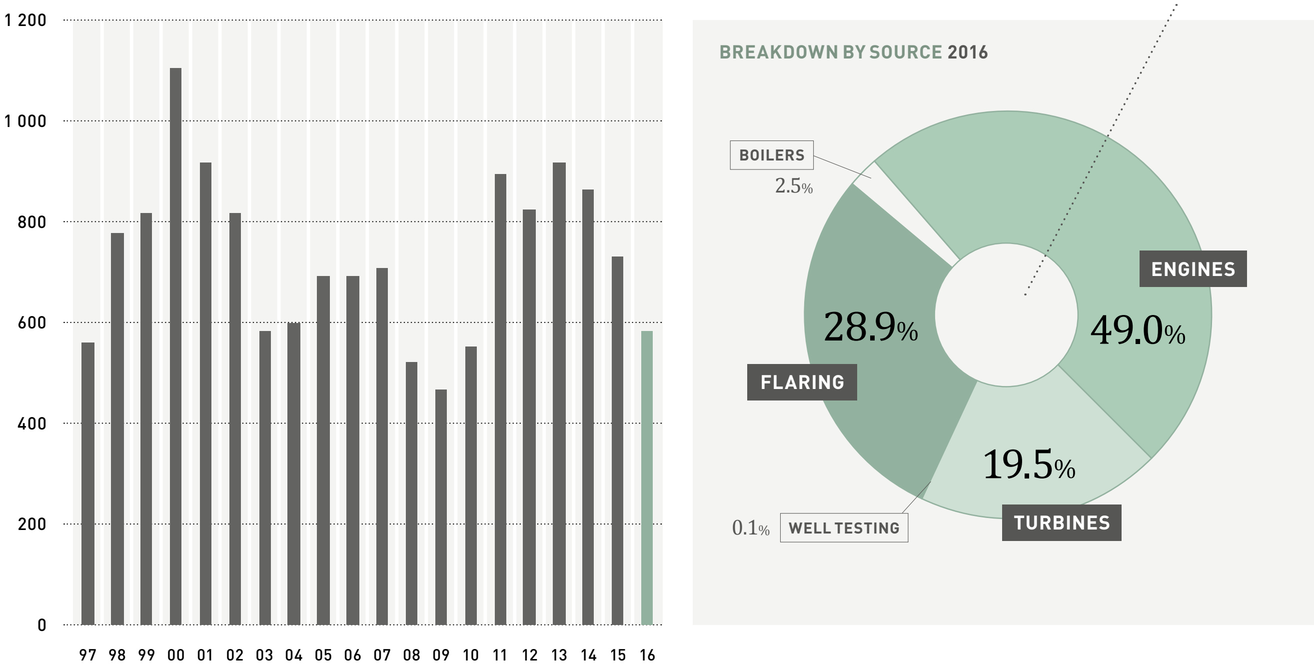


6.10 EMISSIONS OF SO_X

Figure 31 shows SO_x emissions from operations on the NCS and their breakdown by source in 2016. Total emissions in 2016 came to 584 tonnes, a marked decline from 736 tonnes the year before. This primarily reflected reduced consumption of diesel oil related to lower mobile rig activity.

FIGURE 31 HISTORICAL EMISSIONS OF SO_X FROM THE NCS (TONNES) AND BREAKDOWN BY SOURCE IN 2016 (PER CENT)

583.7 TONNES



7 WASTE

THE INDUSTRY PLACES GREAT EMPHASIS ON PRUDENT WASTE MANAGEMENT. GENERALLY SPEAKING, WASTE IS DIVIDED INTO HAZARDOUS AND NON-HAZARDOUS CATEGORIES IN ACCORDANCE WITH APPLICABLE REGULATIONS. IT MUST BE DECLARED PURSUANT TO NATIONAL REGULATIONS AND INTERNATIONAL GUIDELINES.

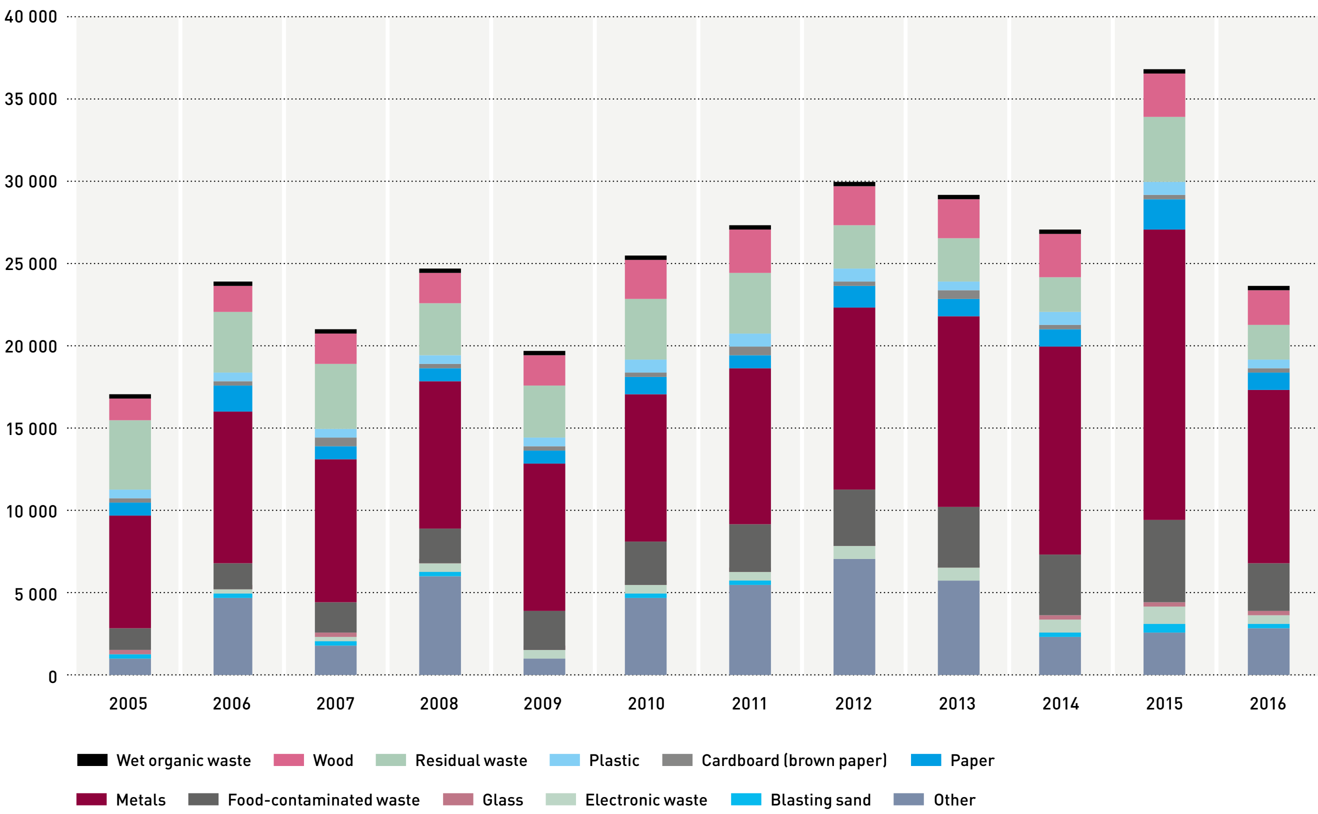
The principal goals of the operators are to generate a minimum of waste and to establish systems for recycling as much of it as possible. Norwegian Oil and Gas has developed its own guidelines for waste management in the offshore sector. These are used in declaring and further treatment of the waste. All waste is sent ashore in accordance with the industry's guidelines.

NON-HAZARDOUS WASTE
Non-hazardous waste totalled just under 25 000 tonnes in 2016, down by more than 10 000 tonnes from the year before. This primarily reflected smaller quantities of metal sent ashore.

HAZARDOUS WASTE
Just under 530 000 tonnes of hazardous waste were delivered for treatment on land in 2016, up from 465 000 tonnes the year before.

The largest proportion, as much as 259 000 tonnes, comprised drilling waste – primarily cuttings contaminated with oil-based fluid. However, this volume included substantial quantities of water added as part of the slurrification process to make the cuttings easier to handle. In addition came just over 200 000 tonnes of oily process water, again from drilling operations.

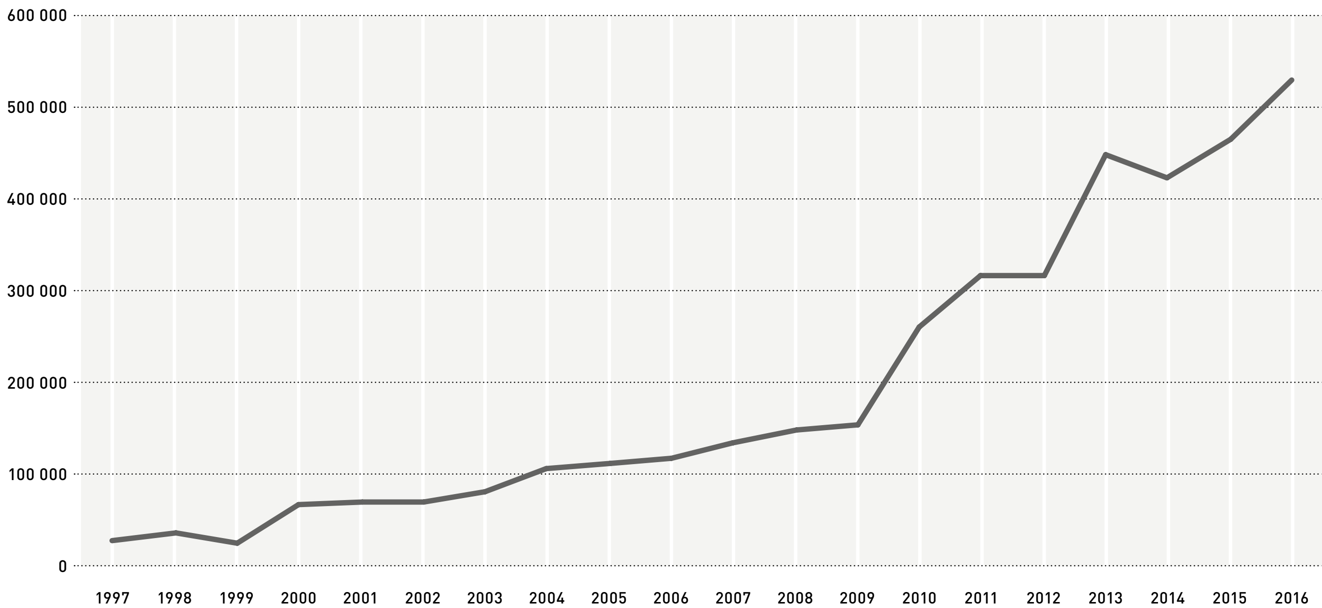
FIGURE 32 BREAKDOWN OF NON-HAZARDOUS WASTE FROM THE OFFSHORE INDUSTRY BY VARIOUS CATEGORIES IN 2016 (TONNES)



Growth in the quantity of oily waste since 2009 largely reflects problems with leaks from injection wells on several fields in 2009-10 and a subsequent halt to further injection. Oily waste which was previously injected had to be sent ashore for treatment. Methods for handling cuttings on these installations are based on slurrification with a view to injection. This process involves crushing the cuttings and adding water, and it is not unusual for the volume of cuttings to expand between four- and 10-fold as a result. That practice continued, with cuttings sent ashore as slurry. The result was a marked increase in the quantity of drilling waste from certain fields. Injection provides substantial environmental benefits and can be cost-efficient compared with final treatment on land. Drilling new injection wells on certain fields means that the quantity of injected liquids is again rising a little (see section 4.1). Work to reduce slurrification and thereby cut the quantity of waste is under way on those installations and fields where injection will not be resumed.

In cooperation with the NEA, Norwegian Oil and Gas introduced new codes in 2014 for hazardous waste from the industry. This move was intended to ensure good handling of waste streams with correct declaration of their content. However,

FIGURE 33 **HAZARDOUS WASTE SENT ASHORE FROM THE OFFSHORE INDUSTRY IN 2016** (TONNES)

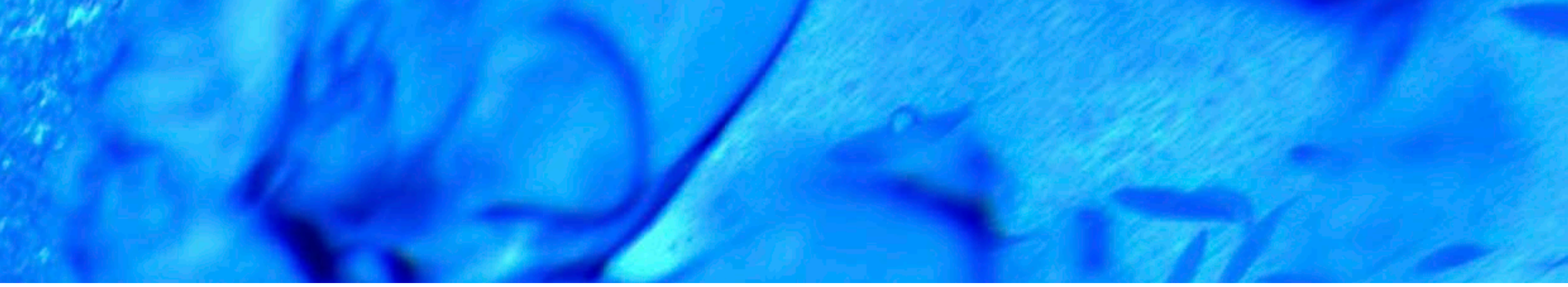


the change makes it difficult to compare the various waste types with earlier statistics. A number of the categories have been split into several sub-types, while others have been merged.

LOW-LEVEL RADIOACTIVE WASTE

Rocks beneath the seabed contain varying amounts of radium and other radioactive isotopes. These naturally occurring radioactive substances accompany oil, gas and – primarily – water to the surface during production. On some fields, sludge cleaned from oil-water separators can contain varying levels of measurable radioactivity. The concentration of these substances is measured through analyses of water and sludge by accredited laboratories. Such waste is divided into and declared in three categories – no enhanced concentrations, radioactivity below 10 becquerels per gram and radioactivity above 10 Bq/g. Both of the radioactive categories are treated in accordance with regulations issued by the Norwegian Radiation Protection Authority. Waste with the highest activity is sent to a special landfill site in Gulen.

Just over 134 tonnes of low-level radioactive waste were dealt with in 2016, a reduction from the year before.



8 EFFECTS OF SEISMIC SURVEYS ON FISH AND FISH STOCKS

MARINE SEISMIC SURVEYING IS THE MOST IMPORTANT TOOL AVAILABLE TO THE GOVERNMENT AND THE OIL INDUSTRY FOR MAPPING POSSIBLE OIL AND GAS DEPOSITS BENEATH THE SEABED AND FOR MONITORING RESERVOIR DEVELOPMENTS.

Seismic surveys are conducted by transmitting sound waves beneath the seabed. The time these take to reflect back from sub-surface formations and the energy content of the reflected signals provide the basis for assessing the properties of the sedimentary deposits.

Extensive studies have been conducted to identify possible effects of seismic surveys on marine organisms. In Norway, this research has looked primarily at the impact on fish. Both possible harmful outcomes and behavioural responses to the disturbance have been investigated.

Injuries to individual fish have been confined almost exclusively to early life stages, such as eggs, larvae and fry. Adult fish in the immediate vicinity of the sound source (airgun) largely suffer only temporary hearing loss, but immature individuals have died at distances of less than five metres from the source.

Work at the Institute of Marine Research in the early 1990s showed that injuries occurred most frequently at distances out to about 1.5 metres. The report found that harm caused by seismic surveying would not affect fish stocks negatively even during the spawning season.

Numerous investigations exist on behavioural responses of fish to noise, with varying results. Most have been conducted in Norway. A number of studies indicate that adult fish actively avoid the airguns, and many suggest that a substantial proportion of them move from the survey area. Other research has failed to document such effects, and finds that fish stocks in the area remain unchanged during the survey period.

An investigation by the Institute of Marine Research on the North Cape Bank in 1993 showed substantially reduced catches of cod and haddock out to about 30 kilometres from the airgun. The seismic survey lasted for more than a week in a limited area, and is not representative of the way such work is conducted today. Nevertheless, the trial indicated that seismic surveying can prompt behavioural changes which reduce the amount of fish in an area.

The most extensive investigation so far was carried out in 2009 in connection with seismic data acquisition by the NPD off Vesterålen. This project aimed to establish whether various commercial species changed their behaviour because of surveying, and whether this had a negative impact on the fisheries. The results showed that the fish reacted to the sound of the airguns in that catches increased for some species and gear and declined for others when seismic surveying was under way. Generally speaking, net catches rose during and after the survey compared with the preceding period, while long-line fishing for certain species declined during the survey but rose again soon afterwards. Where haddock were concerned, differences in catching rates before and during surveying were not statistically certain. Results for saithe indicated a decline in net catches during and after the survey, but this was not statistically significant. The Institute of Marine Research nevertheless assumed, on the basis of echosounder and sonar surveys, that saithe partially withdrew from the area. No changes in fish distribution during seismic surveying were established for other species.

The conclusion for herring was that it did not change its behaviour when surveying was under way.

These results correspond with the somewhat divergent findings from international studies, which have demonstrated varying degrees of behavioural change. Some investigations have found such alterations out to a few kilometres, while others show small variations or none. According to a Canadian collation of the reports, it is unclear whether the identified behavioural changes reflect natural migration. A number of studies also suggest that fish adapt to influences (get used to the sound), particularly where seismic surveys are conducted over large areas so that the sound level experienced by the fish varies over a large range.

However, field surveys face significant methodological problems – not least the inability to secure controls (similar investigations of the same fish population unaffected by airguns). This means that several similar studies in comparable conditions are needed to assess whether behavioural responses actually exist or natural reasons cause fish to leave the area. Efforts are also being made to develop alternative methods which can determine fish reactions to airgun noise with greater certainty.

The available data nevertheless appear to be sufficient to conclude that adult fish from a number of species may respond to sound waves from seismic activity, causing them to avoid the source.

This behavioural response will vary with topography, physical conditions in the sea, fish species and the status of the fish (migrating for food, spawning, grazing, etc), as well as the way the seismic survey is conducted.

No work has been done on whether fish will be affected by such sounds when migrating to their spawning grounds or during spawning itself. A precautionary approach has accordingly been adopted, with strict constraints on when seismic surveying can be conducted in spawning areas for important species and in areas with concentrated spawning migrations. Further investigations will be needed to clarify whether this presents a challenge.

Generally speaking, relatively few conflicts have arisen between the fishing and oil industries on the NCS. These clashes have largely concerned access to areas, and then particularly when conducting seismic surveys. The latter require lots of space both because they often cover a large area and because survey vessels towing equipment need plenty of extra room to manoeuvre. Where the desire to conduct seismic surveying coincides with local fishing or the use of gear which also calls for lots of room (such as bank long-lining), an open and positive dialogue is necessary between the oil and gas sector and the fishing industry to find the best possible solutions and forms of collaboration. Dialogue and adjustments of this kind have been pursued in association with the annual mackerel fishery in the northern North Sea, with good results.

Generally speaking, relatively few conflicts have arisen between the fishing and oil industries on the NCS.

9 TABLES

TABLE 01

HISTORICAL PRODUCTION DATA FOR OIL, CONDENSATE AND GAS (MILL SCM OE)

Reporting year	Net oil	Net condensate	Net NGL	Net gas
2007	128.28	3.13	16.63	89.51
2008	122.66	3.92	16.94	99.46
2009	114.94	4.44	16.98	103.68
2010	104.39	4.16	15.52	106.53
2011	97.51	4.58	16.31	100.3
2012	89.2	4.57	17.8	113.06
2013	84.94	3.99	17.72	107.05
2014	87.74	2.91	18.95	106.6
2015	90.97	2.47	19.6	114.92
2016	94.05	2.01	20.16	114.62

TABLE 02

INJECTION DATA (SCM)

Reporting year	Water	Gas	Gross fuel gas	Gross flared gas
2007	209 974 371	39 803 147 192	3 843 055 567	457 262 849
2008	197 868 634	34 127 615 683	3 838 474 433	588 743 054
2009	166 939 471	33 429 627 740	3 765 463 281	384 917 773
2010	153 851 370	29 408 435 484	3 697 531 369	380 399 245
2011	134 912 328	26 838 327 689	3 567 088 643	371 340 687
2012	130 556 861	26 370 349 599	3 650 843 648	342 420 089
2013	119 829 977	29 345 848 869	3 557 334 571	431 543 601
2014	134 058 242	34 826 426 142	3 881 091 232	348 514 868
2015	143 317 328	35 323 271 891	4 031 096 122	301 537 572
2016	137 922 774	35 497 388 158	3 943 853 919	352 101 062

TABLE 03 DRILLING WITH OIL-BASED FLUIDS (TONNES)

Reporting year	Base fluids Consumption	Base fluids Discharged	Base fluids Injected	Base fluids Transported to land	Base fluids Lost to formation
2006	183 702	0	58 205	38 989	48 343
2007	182 381	0	53 301	42 877	50 636
2008	185 891	0	51 819	50 888	51 165
2009	219 217	0	45 728	71 157	53 745
2010	147 447	0	27 438	55 220	64 789
2011	118 305	0	14 954	55 895	47 456
2012	117 308	0	18 356	56 238	42 713
2013	147 487	0	38 527	60 690	48 270
2014	128 187	0	26 789	60 019	41 378
2015	171 386	47	29 209	70 217	71 912
2016	162 460	0	29 490	72 097	60 873

TABLE 04 DRILLING WITH SYNTHETIC FLUIDS (TONNES)

Reporting year	Base fluids Consumption	Base fluids Discharged	Base fluids Injected	Base fluids Transported to land	Base fluids Lost to formation
2007	0	0	0	0	0
2008	968	0	0	630	338
2009	0	0	0	0	0
2010	0	0	0	0	0
2011	2 888	0	0	1 126	1 762
2012	0	0	0	0	0
2013	1 444	0	0	601	843
2014	816	0	395	0	421
2015	0	0	0	0	0
2016	0	0	0	0	0

TABLE 05 DRILLING WITH WATER-BASED FLUIDS (TONNES)

Reporting year	Base fluids Consumption	Base fluids Discharged	Base fluids Injected	Base fluids Transported to land	Base fluids Lost to formation
2006	267 310	196 680	22 139	9 956	23 634
2007	270 999	203 487	27 243	9 938	17 515
2008	274 337	175 292	33 151	20 590	26 471
2009	412 719	280 013	20 320	24 600	31 268
2010	290 684	231 378	12 162	15 341	31 802
2011	316 379	228 222	30 302	21 888	35 967
2012	331 820	238 652	25 371	26 272	41 525
2013	387 426	295 668	18 545	23 277	49 936
2014	388 739	280 276	21 051	31 497	55 915
2015	328 851	219 158	33 209	20 978	55 506
2016	314 729	194 618	25 120	18 467	76 523

TABLE 06 **DISPOSAL OF CUTTINGS FROM DRILLING WITH OIL-BASED FLUIDS** (TONNES)

Reporting year	Base cuttings **exported to other fields**	Base cuttings **Discharged to sea**	Base cuttings **Volume injected**	Base cuttings **Transported to land**	**Total amount cuttings/ mud generated**
2006	0	0	54 433	22 679	77 435
2007	467	0	50 321	28 066	78 961
2008	0	0	49 108	24 854	73 562
2009	424	0	47 640	38 316	86 386
2010	0	0	26 938	81 188	108 126
2011	0	0	19 699	68 190	87 810
2012	0	0	23 409	65 689	89 098
2013	0	0	37 896	53 232	91 128
2014	0	0	22 253	55 061	77 314
2015	0	2 460	36 189	71 299	109 949
2016	0	0	33 249	84 492	117 741

TABLE 07 **DISPOSAL OF CUTTINGS FROM DRILLING WITH WATER-BASED FLUIDS** (TONNES)

Reporting year	Base cuttings **exported to other fields**	Base cuttings **Discharged to sea**	Base cuttings **Volume injected**	Base cuttings **Transported to land**
2006	325	80 757	1 423	2 226
2007	0	91 761	1 191	894
2008	651	73 639	2 717	2 501
2009	0	129 674	1 624	104
2010	0	207 655	664	9 896
2011	0	195 062	5 741	10 885
2012	0	171 842	1 169	3 774
2013	0	123 005	50	2 210
2014	0	113 840	24	525
2015	1 239	99 424	-	2 405
2016	0	105 070	-	1 334

TABLE 08 **TOTAL AMOUNT OF CUTTINGS/MUD IMPORTED TO FIELDS** (TONNES)

Reporting year	**Oil-based**
2006	2 383
2007	1 668
2008	3 692
2009	7 579
2010	14 994
2011	91
2012	0
2013	0
2014	0
2015	0
2016	0

TABLES

TABLE 09

SELECTED GROUPS OF ORGANIC COMPOUNDS DISCHARGED IN PRODUCED WATER (KG)

Substance	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
BTEX	1 826 674	1 803 998	1 902 925	1 818 173	1 675 059	1 855 037	1 922 626	1 909 696	2 268 533	2 221 241
Phenols	566 762	544 857	508 365	487 429	492 449	523 242	505 708	653 851	633 705	575 592
Oil in water	1 178 851	947 549	1 156 501	1 200 078	1 235 608	1 325 326	1 712 316	1 560 328	1 645 533	1 600 312
Organic acids	35 818 064	31 263 700	27 204 909	24 752 275	22 251 835	22 144 558	53 789 394	31 592 634	30 415 062	28 437 629
PAH compounds	126 343	129 468	153 177	142 408	157 778	168 160	157 896	169 764	131 426	125 702
Heavy metals	7 959 150	8 838 787	7 814 585	7 905 978	8 611 126	8 424 293	7 979 933	9 063 413	9 845 943	8 705 495

TABLE 10

BTX COMPOUNDS DISCHARGED IN PRODUCED WATER (KG)

Substance	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Benzene	871 200	862 411	868 175	832 031	771 333	848 713	867 970	973 116	1 021 530	1 038 496
Ethylbenzene	34 565	34 675	46 135	41 758	37 913	43 761	45 992	53 131	52 764	51 915
Toluene	674 719	672 398	722 851	700 550	655 169	710 617	736 238	725 968	828 299	805 875
Xylene	246 189	234 513	265 764	243 835	210 644	251 946	272 427	157 481	365 941	324 955

TABLE 11

HEAVY METALS DISCHARGED IN PRODUCED WATER (KG)

Substance	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Arsenic	660	614	483	895	656	604	622	645	746	642
Barium	6 939 336	7 762 350	7 008 907	7 071 530	7 639 584	7 554 262	7 321 592	8 219 090	9 061 675	8 007 224
Lead	255	386	290	239	428	309	70	191	84	91
Iron	1 008 440	1 058 121	797 369	825 822	959 698	863 198	653 691	833 664	780 463	695 635
Cadmium	28	41	28	22	32	18	7	11	5	6
Copper	103	102	102	89	162	143	109	249	128	155
Chrome	175	213	154	225	221	131	107	124	99	183
Mercury	6	11	9	9	15	13	8	8	9	8
Nickel	299	299	142	200	223	198	119	128	1 210	116
Zinc	9 847	16 651	7 100	6 948	10 108	5 418	3 608	9 303	1 523	1 436

TABLE 12

PHENOLS
DISCHARGED IN PRODUCED WATER (KG)

Substance	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
C1-Alkylphenols	226 609	207 855	203 376	199 007	186 923	190 276	182 387	266 814	242 415	232 258
C2-Alkylphenols	82 571	87 634	80 707	83 860	82 207	70 392	74 647	89 033	98 818	82 488
C3-Alkylphenols	32 074	29 137	26 108	27 350	29 194	39 995	40 560	43 232	43 471	35 436
C4-Alkylphenols	10 438	10 451	11 624	8 707	11 195	11 315	9 470	9 393	10 482	9 218
C5-Alkylphenols	2 076	2 022	1 325	1 551	3 165	4 577	3 742	3 453	3 455	2 694
C6-Alkylphenols	86	84	78	125	81	52	40	46	66	55
C7-Alkylphenols	26	61	22	55	61	53	96	120	88	62
C8-Alkylphenols	33	39	20	71	45	11	7	15	16	10
C9-Alkylphenols	28	13	64	44	31	8	4	50	7	7
Phenol	212 822	207 560	185 041	166 660	179 546	206 564	194 754	241 695	234 887	213 363

TABLE 13

ORGANIC ACIDS
DISCHARGED IN PRODUCED WATER (KG)

Substance	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Butyric acid	777 200	714 602	627 237	519 296	453 964	456 609	552 567	343 341	506 640	438 843
Acetic acid	30 327 152	26 381 307	22 509 255	20 693 558	19 028 018	19 045 328	48 550 063	28 083 291	26 327 349	24 676 259
Formic acid	449 707	314 221	563 669	493 913	450 016	341 274	1 294 782	517 012	495 495	408 644
Naphthenic acid	283 637	250 405	264 051	179 185	99 691	96 547	126 423	124 885	16 343	11 341
Valeric acid	374 276	341 590	338 214	241 354	159 998	165 674	175 702	167 286	176 567	163 812
Propionic acid	3 606 091	3 261 575	2 902 484	2 624 969	2 060 148	2 039 125	3 089 857	2 356 819	2 892 668	2 738 730

TABLE

14 PAH COMPOUNDS
DISCHARGED IN PRODUCED WATER (KG)

Substance	EPA PAH 16	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Acenaphthene	Yes	200	164	198	196	225	217	418	350	203	188
Acenaphthylene	Yes	45	174	93	83	94	93	127	158	381	196
Anthracene	Yes	36	60	10	7	9	8	36	49	75	46
Benzo(a)anthracene	Yes	13	18	9	8	8	9	15	23	16	13
Benzo(a)pyrene	Yes	6	5	4	3	3	3	7	13	4	4
Benzo(b)fluoranthene	Yes	13	16	9	9	10	10	8	14	16	14
Benzo(g,h,i)perylene	Yes	5	7	6	6	6	6	6	5	8	6
Benzo(k)fluoranthene	Yes	2	4	2	1	1	1	10	5	11	2
C1-dibenzothiophene	No	690	761	667	601	716	808	1 082	1 097	734	671
C1-Phenanthrene	No	1 886	1 589	2 438	2 222	2 873	2 957	2 860	3 086	2 767	2 424
C1-naphthalene	No	43 939	44 155	47 410	45 000	49 202	54 446	32 299	41 387	31 553	31 588
C2-dibenzothiophene	No	663	634	939	878	1 160	1 217	1 470	1 612	1 262	1 124
C2-Phenanthrene	No	1 823	1 976	2 706	2 598	3 747	3 748	4 040	4 247	3 668	3 389
C2-naphthalen	No	16 086	19 636	24 669	21 880	26 936	27 707	31 184	27 602	18 388	18 816
C3-dibenzothiophene	No	71	92	20	22	27	26	4 845	6 822	825	691
C3-Phenanthrene	No	375	306	662	694	1 157	1 111	1 604	1 743	1 557	1 351
C3-naphthalene	No	7 813	11 614	21 719	17 219	22 363	23 230	26 265	22 525	13 253	14 131
Dibenz(a,h)anthracene	Yes	3	4	3	2	3	2	2	2	3	2
Dibenzothiophene	No	429	394	435	407	465	518	492	517	465	411
Phenanthrene	Yes	1 518	1 565	1 712	1 576	1 775	1 781	1 674	2 008	1 981	1 815
Fluoranthene	Yes	38	28	25	27	45	37	35	43	52	43
Fluorene	Yes	1 132	1 166	1 175	1 126	1 384	1 327	1 473	1 599	1 696	1 404
Indeno(1,2,3-c,d)pyrene	Yes	2	3	2	1	1	2	2	1	17	1
Chrysene	Yes	40	61	42	30	41	38	77	122	97	74
Naphthalene	Yes	49 450	44 963	48 175	47 770	45 492	48 816	47 806	54 669	52 338	47 242
Pyrene	Yes	64	74	49	43	34	41	60	64	57	55

TABLE

15 DISCHARGE AND CONSUMPTION OF CHEMICALS BY NEA COLOUR CATEGORY (TONNES)

NEA colour category	Reporting year	2007	2008	2009	2010*	2011	2012**	2013	2014	2015	2016
Green	Consumption	338 485	351 815	382 892	374 541	351 387	368 849	451 433	420 988	409 276	387 682
	Discharge	113 159	116 614	158 201	127 249	138 019	147 773	153 671	152 255	142 807	137 797
Yellow	Consumption	94 905	95 348	91 886	103 061	80 141	82 881	100 990	95 101	104 137	110 981
	Discharge	12 005	12 957	14 649	11 727	12 305	13 533	14 019	14 546	14 418	14 231
Red	Consumption	5 376	4 323	3 206	2 894	1 842	2 088	3 004	3 172	3 464	3 047
	Discharge	23	15	21	16	8	8	8	14	67	103
Black	Consumption	50	60	16	1 259	1 140	746	531	691	401	609
	Discharge	1	2	1	1	1	2	7	13	7	4

* Use of hydraulic oils was included for all fields from 2010. These substances had not been tested at the time and were therefore registered as black.
** Some fields reported discharges of fire extinguishing foam before this became mandatory from 2012. Reporting of these discharges covers all fields with effect from 2014.

TABLES

TABLE **16** DISCHARGE OF OIL-CONTAMINATED WATER

Water type	2007	2008	2009	2010
OTHER				
Discharges of dispersed oil (tonnes)				
Discharges of water (cu.m)				
Total water volume (cu.m)				
Water injected (cu.m)				
DRAINAGE				
Discharges of dispersed oil (tonnes)	8	10	6	8
Discharges of water (cu.m)	905 416	953 964	917 986	727 811
Total water volume (cu.m)	963 971	993 156	1 099 819	763 736
Water injected (cu.m)	53 474	36 298	184 247	19 875
DISPLACEMENT				
Discharges of dispersed oil (tonnes)	94	58	55	47
Discharges of water (cu.m)	42 080 398	35 781 227	31 567 044	31 953 823
Total water volume (cu.m)	42 080 398	35 781 227	31 567 050	31 953 823
Water injected (cu.m)	-	-	-	-
PRODUCED				
Discharges of dispersed oil (tonnes)	1 532	1 569	1 487	1 443
Discharges of water (cu.m)	161 825 645	149 241 700	134 770 215	130 842 793
Total water volume (cu.m)	182 807 754	173 375 110	158 559 726	157 890 256
Water injected (cu.m)	26 665 258	30 379 135	29 547 450	33 217 136
JETTING				
Discharges of dispersed oil (tonnes)	26	13	24	65

	2011	2012	2013	2014	2015	2016
		0	0	0	0	0
		4 414	25 506	49 276	26 249	8 768
		4 414	27 101	49 871	40 073	9 293
		-	2 267 368	267	12 298	463
	8	8	8	11	8	8
	867 531	953 596	954 377	984 216	1 014 435	1 015 018
	891 951	979 802	991 618	1 065 755	1 124 895	1 100 171
	16 740	18 831	33 566	86 527	102 389	78 131
	51	58	56	43	40	38
	27 025 783	31 491 555	32 227 733	33 230 953	33 830 308	30 510 835
	27 025 783	31 491 555	32 227 733	33 230 953	33 830 308	30 510 835
	-	-	-	-	-	-
	1 478	1 535	1 541	1 761	1 819	1 698
	128 550 571	130 909 973	127 833 805	141 006 271	148 181 942	138 101 839
	160 758 982	162 958 696	161 188 862	176 840 378	186 681 015	178 111 199
	31 095 328	32 756 572	37 292 502	39 360 701	42 479 952	43 421 496
	53	43	37	43	59	61

TABLE 17 **TOTAL CONSUMPTION, DISCHARGE AND INJECTION OF CHEMICALS BY APPLICATION** (TONNES)

Application		2007	2008	2009	2010
A - DRILLING AND WELL CHEMICALS	Consumed	358 412	365 902	399 053	409 337
	Injected	78 130	88 506	65 682	44 204
	Discharged	91 239	93 190	135 589	104 966
B - PRODUCTION CHEMICALS	Consumed	29 131	31 278	27 720	26 816
	Injected	3 323	4 046	4 499	4 403
	Discharged	15 317	17 208	17 021	16 001
C - INJECTION CHEMICALS	Consumed	15 361	15 517	12 997	11 487
	Injected	1 464	1 486	1 485	1 367
	Discharged	332	235	200	188
D - PIPELINE CHEMICALS	Consumed	5 189	3 385	2 973	2 477
	Injected	-	-	146	599
	Discharged	2 015	516	917	1 308
E - GAS TREATMENT CHEMICALS	Consumed	18 804	22 257	21 381	17 905
	Injected	757	1 502	1 634	1 406
	Discharged	11 619	13 124	11 849	9 698
F - AUXILIARY CHEMICALS	Consumed	6 300	7 135	7 886	8 091
	Injected	250	810	501	420
	Discharged	3 653	4 031	4 795	4 244
G - CHEMICALS ADDED TO THE EXPORT FLOW	Consumed	5 180	5 443	5 085	5 094
	Injected	-	-	-	-
	Discharged	311	439	1 664	1 847
H - CHEMICALS FROM OTHER PRODUCTION LOCATIONS	Consumed	434	614	475	536
	Injected	41	210	25	117
	Discharged	697	847	753	753
K - RESERVOIR MANAGEMENT	Consumed	2	15	12	14
	Injected	0	0	-	0
	Discharged	2	0	9	5

	2011	2012	2013	2014	2015	2016
	357 665	373 746	470 793	429 087	425 201	411 370
	37 685	36 627	59 664	54 161	62 018	58 125
	111 839	113 521	119 005	117 402	107 797	104 873
	28 564	29 018	31 815	31 802	32 953	37 325
	4 598	4 082	4 867	4 020	4 973	8 880
	17 272	19 577	21 968	21 852	20 365	20 801
	9 830	9 155	9 340	10 011	10 451	9 686
	1 492	2 945	1 115	1 334	8 076	7 717
	212	176	1 173	1 356	1 040	518
	4 609	7 138	3 490	7 161	6 610	5 007
	936	494	917	1 282	1 558	575
	3 245	4 153	2 361	3 217	4 015	2 014
	21 061	22 563	25 535	26 342	25 123	23 429
	1 628	4 133	668	5 390	5 330	3 541
	11 097	16 079	16 133	16 697	17 302	17 169
	8 073	7 671	9 095	9 407	9 645	8 767
	377	190	394	334	589	1 920
	4 489	4 903	5 451	5 236	4 223	4 383
	4 665	5 269	5 875	6 121	7 281	6 728
	-	-	-	-	-	-
	1 483	1 951	615	383	1 781	1 585
	-	-	-	-	-	-
	114	150	100	895	2 690	1 618
	692	952	986	677	773	792
	6	4	16	25	14	7
	0	-	0	2	5	6
	2	3	12	9	4	1

TABLE 18 CONSUMPTION AND DISCHARGE OF CHEMICALS BY ENVIRONMENTAL PROPERTIES (KG)

NEA category description	NEA colour category	Category		2006	2007	2008
Substances on the Plonor list	Green	201	Consumption	227 536	251 003	259 361
			Discharge	63 424	72 585	76 539
Water	Green	200	Consumption	76 440	87 482	92 454
			Discharge	29 717	40 575	40 075
Other chemicals	Yellow	100	Consumption	90 592	94 905	95 348
			Discharge	11 078	12 005	12 957
Biodegradability < 20%	Red	8	Consumption	2 928	3 017	3 141
			Discharge	18	13	11
Two out of three categories: biodegradability < 60%, log Pow ≥ 3, EC_{50} or LC_{50} ≤ 10 mg/l	Red	6	Consumption	2 730	2 359	1 182
			Discharge	21	10	5
Inorganic and EC_{50} or LC_{50} ≤ 1 mg/l	Red	7	Consumption		0	
			Discharge		0	
Biodegradability < 20% and toxicity EC_{50} or LC_{50} ≤ 10 mg/l	Black	4	Consumption	32	4	1
			Discharge	2	0	0
Biodegradability < 20% and log Pow ≥ 5	Black	3	Consumption	7	1	1
			Discharge	1	1	1
Hormone-disrupting substances	Black	1	Consumption	0	-	20
			Discharge	0	0	1
List of priority chemicals included in result target 1 (priority list), White Paper no 25 (2002-2003)	Black	2	Consumption	1	0	0
			Discharge	0	0	0
Substances thought to be, or which are, hazardous to genes or reproduction	Black	1.1	Consumption		44	38
			Discharge		-	-

	2009	2010	2011	2012	2013	2014	2015	2016
	287 182	286 277	273 274	282 848	347 659	322 308	311 326	282 995
	109 905	90 612	99 503	104 496	114 955	107 671	93 929	88 867
	95 710	88 264	78 114	86 001	103 774	98 679	97 414	104 161
	48 296	36 638	38 515	43 277	38 716	44 584	48 735	48 774
	91 886	103 061	80 141	68 454	83 779	77 067	85 617	88 471
	14 649	11 727	12 305	7 575	8 088	8 803	8 904	9 152
	2 145	2 387	1 493	1 287	1 664	1 821	2 004	1 871
	16	14	6	4	4	5	8	17
	1 061	507	349	801	1 340	1 351	1 411	1 040
	5	2	2	4	3	9	16	11
	0	0	0	0	0	0	50	135
	0	0	0	0	0	0	44	75
	1	21	12	11	5	14	4	2
	0	0	0	1	0	4	3	2
	1	1 238	1 128	694	476	631	322	517
	1	1	0	0	3	4	4	2
	14	-	0	0	0	0	0	
	0	0	0	0	0	0	0	
	0	0		0	0			
	0	0		0	0			
				0	0	0	0	0
				0	0	0	-	0

TABLES

TABLE 18 **CONSUMPTION AND DISCHARGE OF CHEMICALS BY ENVIRONMENTAL PROPERTIES** (KG)

NEA category description	NEA colour category	Category		2012	2013	2014	2015	2016
Reach annex IV	Green	204	Consumption				261	227
			Discharge				137	132
Reach annex V	Green	205	Consumption				275	298
			Discharge				6	24
Yellow in sub-category 1. Expected to biodegrade fully	Yellow	101	Consumption	7 336	8 124	7 755	6 902	6 800
			Discharge	3 709	3 843	3 673	3 257	3 199
Yellow in sub-category 2. Expected to biodegrade to environmentally non-hazardous substances	Yellow	102	Consumption	4 989	7 472	5 403	5 346	10 291
			Discharge	1 768	1 714	1 702	1 507	1 533
Yellow in sub-category 3. Expected to biodegrade to substances which could be environmentally hazardous	Yellow	103	Consumption	1	6	1	1	-
			Discharge	0	1	0	1	0
Calcium hydroxide, sodium hydroxide, hydrochloric acid, sulphuric acid, nitric acid and phosphoric acid	Yellow	104	Consumption					5 419
			Discharge					347
Chemicals exempted from ecotoxicological testing. Include Reach annexes IV and V	Yellow	99	Consumption	2 100	1 609	4 876	6 272	
			Discharge	482	373	368	749	
Polymers which are exempted from test requirements and not tested	Red	9	Consumption					1
			Discharge					-
Additive packages which are exempted from test requirements and not tested	Black	0.1	Consumption					6
			Discharge					0
Test data lacking	Black	0	Consumption	40	50	46	74	84
			Discharge	1	4	5	0	0
Substances on the priority list or Ospar's priority list	Black	2	Consumption					0
			Discharge					0

TABLE 19

DISCHARGE OF CONTAMINANTS IN CHEMICALS (TONNES)

Substance	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Arsenic	0.07	0.19	0.20	0.15	0.18	0.51	0.48	0.23	0.21	0.28
Lead	2.35	1.51	2.52	1.47	1.48	3.51	3.86	2.80	2.44	3.29
Cadmium	0.01	0.01	0.02	0.01	0.01	0.06	0.03	0.06	0.02	0.03
Copper	2.02	2.22	3.88	3.13	1.67					
Chrome	0.57	0.55	0.81	0.73	0.77	0.88	1.01	0.85	0.61	0.59
Mercury	0.00	0.00	0.01	0.00	0.01	0.01	0.02	0.02	0.02	0.02
Organohalogens	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00

TABLE 20

DISCHARGE OF ADDITIVES IN CHEMICALS TOTAL VOLUME (TONNES)

Substance	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Lead	0.001	0.000	0.000	0.000	0.003	0.001	0.000	0.000	0.000	0.000
Copper	0.001	0.000	0.000	0.001						
Organohalogens	1.578	1.887	1.528	0.062	0.066	1.026	0.271	3.537	2.358	0.000

TABLE 21 ACUTE DISCHARGES TO THE SEA

Discharge type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
CHEMICALS										
Number < 0 cu.m	23	37	59	64	58	60	65	134	81	82
Number 0 – 1 cu.m	52	69	61	62	65	57	62	68	49	55
Number > 1 cu.m	44	30	42	32	28	39	31	36	43	25
Volume < 0 cu.m	0.3	0.4	0.6	0.6	0.6	0.7	0.6	1.1	0.6	0.9
Volume 0 – 1 cu.m	12.6	19.6	22.9	20.0	24.5	16.5	17.9	21.2	15.6	17.9
Volume > 1 cu.m	5 436.3	347.0	13 028.6	6 244.9	175.6	388.3	1 267.2	736.8	1 563.5	331.8
Total number	119.0	136.0	162.0	158.0	151.0	156.0	158.0	238.0	173.0	162.0
Total volume (cu.m)	5 449.2	366.9	13 052.1	6 265.5	200.7	405.5	1 285.7	759.2	1 579.7	350.6
OIL										
Number < 0 cu.m	113	130	106	109	102	103	94	36	24	30
Number 0 – 1 cu.m	42	34	37	24	29	24	19	15	17	6
Number > 1 cu.m	12	9	4	7	2	4	6	8	6	3
Volume < 0 cu.m	1.1	1.0	0.6	0.6	0.6	0.7	0.6	0.3	0.2	0.2
Volume 0 – 1 cu.m	11.2	7.9	9.3	4.9	8.8	6.5	5.6	4.3	6.0	1.4
Volume > 1 cu.m	4 475.5	185.8	104.0	105.0	15.0	9.3	40.8	157.7	33.8	15.1
Total number	167.0	173.0	147.0	140.0	133.0	131.0	119.0	59.0	47.0	39.0
Total volume (cu.m)	4 487.8	194.7	113.9	110.5	24.3	16.5	47.1	162.3	40.0	16.7

TABLE 22 EMISSIONS TO THE AIR (TONNES)

Reporting year	Emissions CO_2 (tonnes) direct	Emissions NOx (tonnes)	Emissions SOx (tonnes)	Emissions PAH (g)	Emissions PCB (g)	Emissions dioxins (mg)	Volume fuel gas (scm)	Volume diesel oil (tonnes)	Volume oil (tonnes)	Discharges to the sea from well tests (tonnes)
2007	13 263 691	53 997	713	28 997	816	38	5 328 169 872	272 199	3 951	1
2008	13 776 426	50 870	526	46 757	1 319	61	5 361 668 937	279 529	7 517	1
2009	12 444 220	49 804	473	62 365	1 757	80	4 824 405 725	312 627	6 920	1
2010	12 581 242	50 048	557	93 851	1 721	78	4 800 873 166	316 645	25 039	3
2011	12 283 631	51 475	899	1 593 389	1 740	79	4 725 836 624	377 017	10 105	3
2012	12 448 717	50 648	825	168 099	2 331	84	4 797 865 506	394 669	10 891	3
2013	12 722 253	52 057	921	47 472	870	40	4 702 505 527	436 831	4 827	1
2014	13 096 390	52 375	868	132 093	2 422	110	5 031 178 493	424 027	11 313	6
2015	13 484 751	46 789	736	58 407	1 071	49	5 291 070 354	356 844	4 854	2
2016	13 343 013	44 717	584	49 165	902	32	5 278 635 719	335 510	4 081	2

TABLE 23 **EMISSIONS TO THE AIR BY SOURCE** (TONNES)

Source	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
OTHER SOURCES										
Emissions nmVOC	211	809	685	1 363	1 137	49	24	32	36	6
Emissions CH_4	92	581	537	1 635	2 559	185	90	122	134	10
Emissions SO_x	-	-	-	-	-	-	-	0	0	0
Emissions NO_x	-	-	151	63	15	0	2	2	1	2
Emissions CO_2	76 603	106 978	91 028	113 691	100 019	62 058	35 031	44 910	42 228	12 539
WELL WORKOVERS										
Emissions nmVOC										5
Emissions CH_4										2
Emissions SO_x										0
Emissions NO_x										85
Emissions CO_2										29 084
WELL TESTING										
Emissions nmVOC	9	13	20	85	30	25	18	38	16	10
Emissions CH_4	2	1	3	8	3	9	0	5	0	1
Emissions SO_x	1	4	12	47	60	13	21	19	5	0
Emissions NO_x	117	69	160	470	168	146	32	98	40	50
Emissions CO_2	30 990	23 197	46 011	152 940	55 619	59 745	18 481	52 586	20 027	17 478
FLARING										
Emissions nmVOC	2 074	236	92	73	76	75	126	75	23	55
Emissions CH_4	3 879	827	321	263	278	267	264	238	90	200
Emissions SO_x	11	3	3	3	224	215	200	201	172	169
Emissions NO_x	3 472	979	607	606	589	556	650	553	574	572
Emissions CO_2	2 317 829	2 514 504	1 438 349	1 379 989	1 319 289	1 199 815	1 471 010	1 217 906	1 306 594	1 278 434
BOILERS										
Emissions nmVOC	194	11	17	21	37	33	21	26	38	36
Emissions CH_4	68	79	22	37	32	31	30	19	59	48
Emissions SO_x	4	10	26	12	23	27	16	26	20	14
Emissions NO_x	85	250	78	85	185	155	170	176	206	169
Emissions CO_2	122 527	196 580	152 171	115 056	113 354	242 413	235 646	235 658	230 476	218 121
ENGINES										
Emissions nmVOC	1 089	1 072	1 217	1 283	1 554	1 502	1 713	1 721	1 415	1 318
Emissions CH_4	29	30	19	16	14	15	16	15	18	6
Emissions SO_x	523	402	320	387	488	415	494	486	411	287
Emissions NO_x	15 227	14 982	16 302	16 822	19 980	19 703	21 546	21 065	14 419	13 240
Emissions CO_2	779 922	778 988	823 882	856 490	1 025 526	998 860	1 132 633	1 138 908	955 720	853 505
TURBINES										
Emissions nmVOC	905	898	883	890	867	883	864	933	990	981
Emissions CH_4	3 450	3 418	3 354	3 692	3 563	3 653	3 538	3 874	4 118	3 742
Emissions SO_x	173	106	112	108	105	156	190	136	129	114
Emissions NO_x	35 096	34 590	32 506	32 003	30 538	30 088	29 658	30 480	31 549	30 599
Emissions CO_2	9 935 821	10 156 180	9 892 780	9 963 076	9 669 825	9 885 826	9 829 452	10 406 423	10 929 706	10 933 853

TABLE 24 EMISSIONS OF CH_4 AND nmVOC FROM DIFFUSE SOURCES AND COLD VENTING (TONNES)

Reporting year	nmVOC emissions	CH_4 emissions
2007	7 712	14 984
2008	9 114	19 023
2009	9 161	18 483
2010	7 186	18 068
2011	8 254	19 181
2012	10 083	18 267
2013	9 184	19 854
2014	13 553	24 922
2015	13 354	22 475
2016	10 224	13 137

TABLE 25 EMISSIONS FROM WELL TESTING

Reporting year	Combusted diesel (tonnes)	Combusted gas (cu.m)	Combusted oil (tonnes)
2007	-	8 502 039	3 951
2008	-	4 609 552	3 864
2009	14	11 509 318	6 302
2010	48	31 426 218	24 989
2011	88	11 266 462	8 555
2012	-	8 560 987	10 891
2013	27	1 173 525	4 827
2014	21	4 804 194	11 007
2015	28	1 796 427	4 854
2016	15	3 313 607	2 694

TABLE 26 EMISSIONS OF CH_4 AND nmVOC FROM STORAGE AND LOADING (TONNES)

Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
STORAGE										
Emissions nmVOC	2 099	3 578	6 397	4 655	4 041	2 978	7 160	5 170	3 724	3 121
Emissions CH_4	119	332	998	1 107	596	337	1 114	703	355	321
LOADING										
Emissions nmVOC	61 954	34 714	27 032	22 646	15 072	17 409	16 144	28 205	27 747	26 623
Emissions CH_4	7 521	6 631	5 890	4 141	2 711	2 894	1 783	1 703	1 801	2 002

TABLE 27 SEPARATED WASTE BY SOURCE (TONNES)

Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Other	1 763	6 094	951	4 747	5 425	7 043	5 700	2 279	2 581	2 766
Blasting sand	0	3	-	1	3	-	-	161	482	296
EE waste	647	631	530	590	773	692	775	986	990	645
Glass	104	86	98	94	115	115	104	114	316	118
Food-contaminated waste	1 969	2 042	2 198	2 622	2 781	3 390	3 694	3 667	5 067	3 085
Metals	8 653	8 856	8 945	9 059	9 432	11 180	11 538	12 637	17 531	10 480
Paper	711	810	828	926	980	1 100	1 005	1 119	1 841	983
Cardboard (brown paper)	537	442	414	440	483	457	465	326	420	127
Plastic	465	427	490	597	635	676	736	748	670	600
Residual waste	4 028	3 211	3 079	3 718	3 750	2 586	2 503	2 183	3 873	2 155
Wood	1 939	1 916	1 855	2 385	2 604	2 338	2 441	2 461	2 630	2 044
Wet organic waste	207	143	120	107	89	115	270	361	418	214

TABLE 28 HAZARDOUS WASTE (TONNES)

Type	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Other waste	5	2	0	5	7	12	28	90	95	107
Batteries	1	99	79	73	143	111	140	200	127	109
Blasting sand	8	148	238	146	454	479	465	684	11 486	742
Drilling-related waste	134 220	143 326	148 719	257 968	303 500	311 541	386 309	360 142	396 148	461 522
Well-related waste							14 626	7 781	6 747	3 154
Spent catalysts					2				10	
Chemicals	1	73	101	89	162	152	1 003	3 086	2 613	1 671
Fluorescent tubes	0	26	23	26	28	27	35	33	29	33
Solvents	14	245	89	39	777	273	457	699	307	9 382
Paint, all types						0	80	108	235	197
Oily waste	145	2 544	2 447	2 031	6 810	2 288	6 438	8 499	10 508	18 610
Process-related waste							72	517	558	417
Cement								11	22	32
Spray cans	2	18	18	19	20	20	22	25	19	18
Tank washing waste		395	1 834	378	3 870	2 314	37 598	41 747	35 563	32 241

10 TERMS AND ABBREVIATIONS

CH_4	Methane
CO_2	Carbon dioxide
GHG	Greenhouse gas
NGL	Natural gas liquids
nmVOC	Non-methane volatile organic compounds
NO_x	Nitrogen oxides
SO_x	Sulphur oxides
SO_2	Sulphur dioxide
b/d	Barrels per day
oe	Oil equivalent
scm	Standard cubic metres
BAT	Best available techniques
EEH	Epim Environment Hub
ETS	EU emission trading system
EIF	Environmental impact factor
HSE	Health, safety and the environment

IOGP
International Association of Oil & Gas Producers

NCS
Norwegian continental shelf

NEA
Norwegian Environment Agency

NGL
Natural gas liquids

NPD
Norwegian Petroleum Directorate

SSB
Statistics Norway

Ospar
Oslo-Paris convention for the protection of the marine environment of the north-east Atlantic. Fifteen countries with coasts on or rivers emptying into these waters are signatories.

Plonor
"Pose little or no risk to the marine environment", a list from Ospar of chemical compounds considered to have little or no impact on the marine environment if discharged.

Conversion factors
based on the energy content in hydrocarbons. Calculated in accordance with definitions from the NPD:

Oil 1 cu.m = 1 scm oe
Oil 1 barrel = 0.159 scm
Condensate 1 tonne = 1.3 scm oe
Gas 1 000 scm = 1 scm oe
NGL 1 tonne = 1.9 scm oe

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