# 2018 ENVIRONMENTAL REPORT

**ENVIRONMENTAL WORK BY THE OIL AND GAS INDUSTRY**

FACTS AND DEVELOPMENT TRENDS

Norsk olje&gass

**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).

**Front cover photo:** The *Roaldnes* saithe trawler near Kvitebjørn.

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# 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 COMMUNICATING ALL EMISSION/DISCHARGE DATA FROM THE INDUSTRY'S ACTIVITIES AS WELL AS INFORMATION ON ITS 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 the climate.

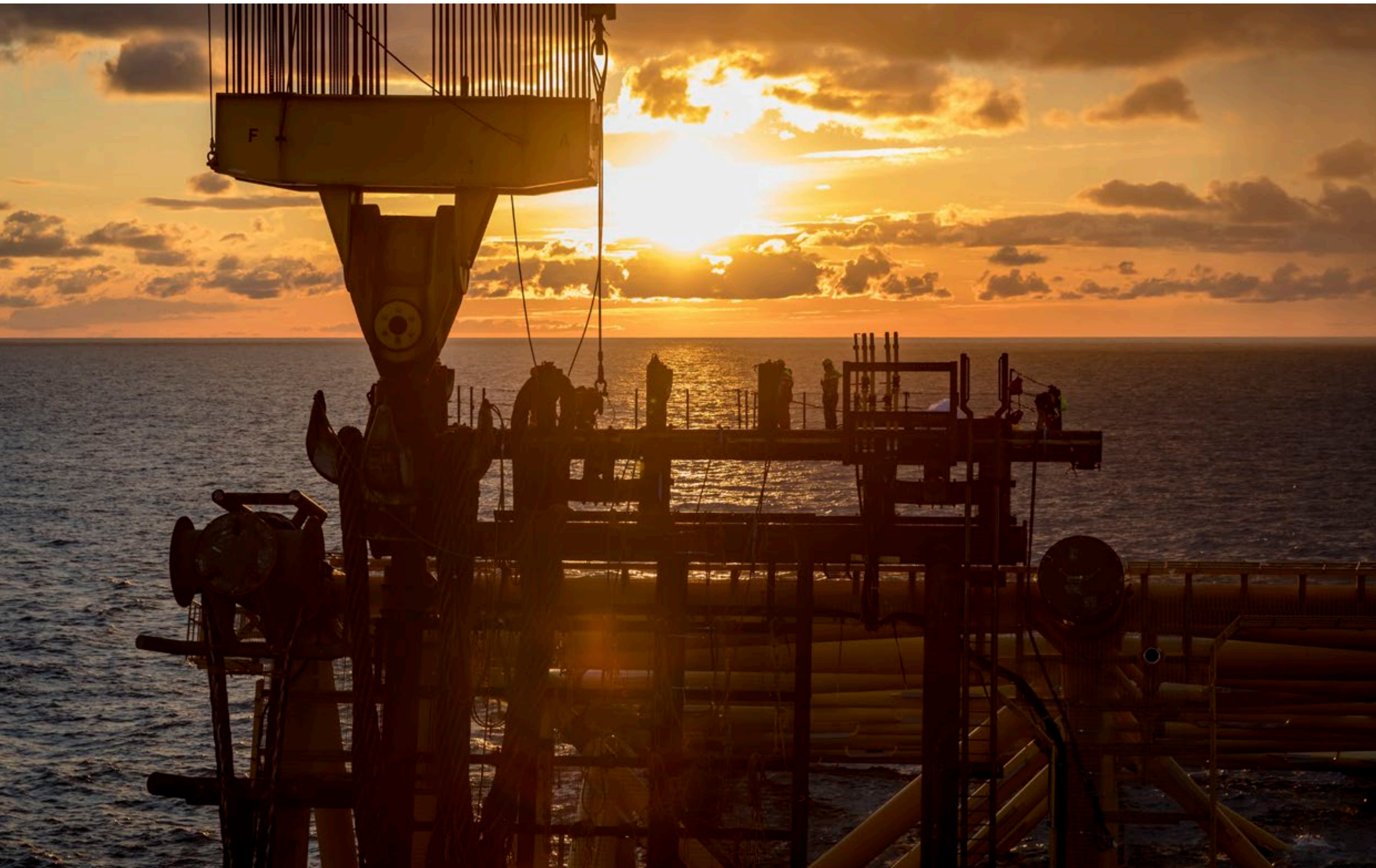
The definition of the petroleum industry accords with the one provided in the Norwegian Petroleum Tax Act. Emissions/discharges from the construction and installation phase, maritime support services, helicopter traffic, and those parts of onshore plants which do not relate to offshore production are 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.

‹ The Martin Linge platform arrives in Stavanger on 29 March 2018.

# 2 SUMMARY

**EMISSIONS/DISCHARGES FROM OPERATIONS ON THE NCS ARE DECLINING AT THE SAME TIME AS OVERALL PRODUCTION INCREASED IN 2017 FOR THE FOURTH YEAR IN A ROW – GAS EXPORTS HAVE NEVER BEEN HIGHER. THIS MEANS THAT $CO_2$ INTENSITY (EMISSIONS PER UNIT PRODUCED) DECLINED FOR THE FOURTH YEAR IN A ROW. DISCHARGES OF PRODUCED WATER AND DRILL CUTTINGS WERE ALSO REDUCED IN 2017.**



**Optimism once again prevails in the Norwegian petroleum sector. A broad range of measures have been initiated in the planning, execution and operational phases, and costs for new developments have been cut by 30-50 per cent over the past couple of years. The past year saw a number of new projects unleashed, and a turning point for oil investment is due in 2018.**

Despite low oil prices, the production trend on the NCS has been rising. Norway has never sold so much offshore gas as it did in 2017. Oil production fell slightly, but overall output of oil and gas nevertheless climbed for the fourth year in a row. Drilling activity was slightly higher than in 2016 thanks to production wells. Thirty-six exploration wells – 24 wildcat and 12 appraisal – were spudded in 2017, unchanged from the year before. Eleven discoveries were made, seven fewer than in 2016.

Despite the increase in activity and production, emissions to the air and discharges to the sea are both declining overall. Total greenhouse gas (GHG) released from the NCS in 2017 amounted to 13.6 million tonnes of $CO_2$ equivalent, compared with 13.8 and 14.2 million in 2016 and 2015 respectively. The main reason why emissions have fallen for two years in a row is a significant reduction in flaring on existing NCS fields as well as lower amounts from engines. Reported methane emissions declined further in 2017 because of the transition to more detailed mapping of emission sources and representative emission factors for the individual sources. Specific GHG emissions per unit produced ($CO_2$ intensity) therefore also went down for the fourth year in a row.

A status review in 2017 showed that the industry's KonKraft goal for 2020 was already exceeded by the end of 2016. Drawn up by the petroleum industry in 2016, a roadmap for the NCS sets specific goals and ambitions for further cuts in GHG emissions. The companies are working systematically to identify and implement measures, and collaborate through various fora to benefit from experience transfer in order to reduce emissions from oil and gas production on the NCS.

Carbon capture and storage (CCS) is crucial for achieving the ambitions expressed in the Paris agreement. The Norwegian government's ambition is to realise a full-scale CCS facility by 2022. Crucial for reducing emissions from its land-based industry, Norway's projects represent a major industrial potential for the nation. Sintef produced a report on industrial opportunities and employment from CCS in Norway during the spring of 2018, which presents the potential for creating value and jobs from investing in domestic CCS infrastructure. $CO_2$ storage would allow natural gas to be sold as emission-free hydrogen, the process industry on land can be safeguarded and developed towards a low-emission society, and storing $CO_2$ from industrial sources elsewhere in Europe would represent a new business opportunity for petroleum companies on the NCS.

Discharges to the sea derive primarily from drilling wells and from the produced water which comes up with the oil. Drilling discharges mainly comprise drilling fluid and rock particles (drill cuttings) from the borehole. Discharges are only permitted from wells drilled with water-based fluid, while spent oil-based drilling fluids and cuttings contaminated with them are either shipped ashore as hazardous waste for safe treatment or injected back underground in dedicated wells. Both the consumption of oil-based fluids and the quantity of waste sent ashore from drilling operations declined in 2017 compared with earlier years. Discharges of drill cuttings with water-based fluids amounted to roughly 90 000 tonnes in 2017, down by just under 14 per cent from the year before.

Discharges of oily water from petroleum operations on the NCS have three main sources, with produced water making the biggest contribution at 134 million standard cubic metres (scm). Annual produced water discharges peaked in 2007 at almost 162 million scm, and have since varied between 130-150 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 increased substantially in 2002 and has been around 20 per cent of the total quantity in recent years. Just over 23 per cent was injected in 2017. 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

‹ Installation work on the Johan Sverdrup field.

between the various fields. The oil content in produced water averaged 12.1 milligrams per litre (mg/l) across the NCS in 2017, down from 12.3 in 2016. The regulatory threshold is 30 mg/l.

Discharges of both produced water and cuttings contain chemicals – either naturally occurring in the sub-surface or additives. 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 the figure only 10 years ago. However, a marked rise in reported discharges of black chemicals occurred in 2011-14. Discharges of red chemicals have also gone up since 2011. These increases primarily reflect changed reporting and substitution requirements. Discharges of fire-extinguishing foam were not reported earlier because this was a safety chemical with no alternative products able to offer a satisfactory extinguishing performance. Alternatives with less environmentally harmful properties are now available. These are currently being phased in, and are part of the reason why discharges of red chemicals have risen. Mandatory fire drills and system tests will lead to the release of foam. Discharges of black chemicals amounted to about 4.7 tonnes in 2017, less than a third of the 2014 figure.

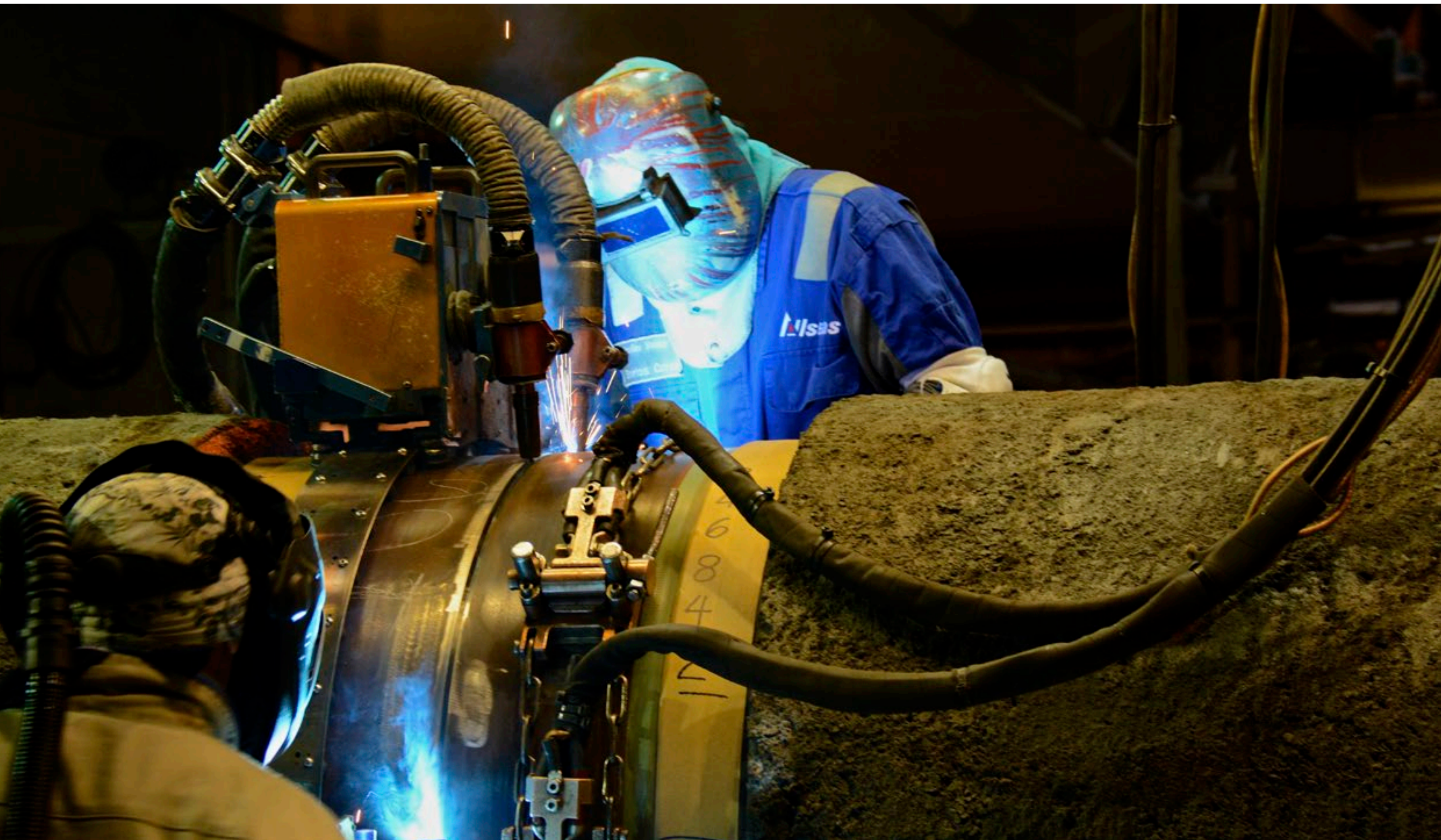
New fire-extinguishing foams still contain components which fall into the red category. This contributed significantly to a marked increase in red-chemical discharges in 2013-16. Reclassification of certain chemicals from yellow to red also contributed to this rise. Discharges of red chemicals came to 96 tonnes in 2017, down from 103 tonnes in 2016.

Extensive preventive work by the operators to avoid unintentional discharges has led to a continued decline in the number of oil spills. They totalled 46 in 2017, of which 18 had a volume larger than 50 litres. Looking only at crude oil discharges larger than one cubic metre, just two such discharges occurred during the year – unchanged from 2016.

The oil content in produced water averaged 12.1 mg/l across the NCS in 2017, compared with 12.3 in 2016. The regulatory threshold is 30 mg/l.

# 3 LEVEL OF ACTIVITY ON THE NCS

**NORWAY'S PETROLEUM SECTOR HAS BEEN THROUGH THREE DEMANDING YEARS SINCE OIL PRICES BEGAN TO FALL IN THE SUMMER OF 2014. HOWEVER, OIL PRICES STABILISED AT A HIGHER LEVEL IN 2017, WHILE COSTS IN THE INDUSTRY HAVE BEEN CUT SUBSTANTIALLY THROUGH EFFICIENCY IMPROVEMENTS, REDUCED SUPPLIER PRICES AND SIMPLIFICATIONS.**



**Optimism once again prevails in the Norwegian petroleum sector. The past year saw a number of new development projects unleashed, and a turning point for oil investment is due in 2018.**

The oil and gas industry on the NCS has been through a demanding time since the sharp fall in oil prices began in the summer of 2014. Much has since been done by the industry to cut costs through a broad range of measures in the planning, execution and operational phases, and costs for new developments have been cut by 30-50 per cent over the past couple of years. The general picture is therefore that new projects have good profitability and are robust against prices significantly below the present level. At the same time, oil prices have again recovered and the companies are seeing a number of profitable opportunities. The investment decline of the past few years is flattening out, with the petroleum industry again heading for brighter times.

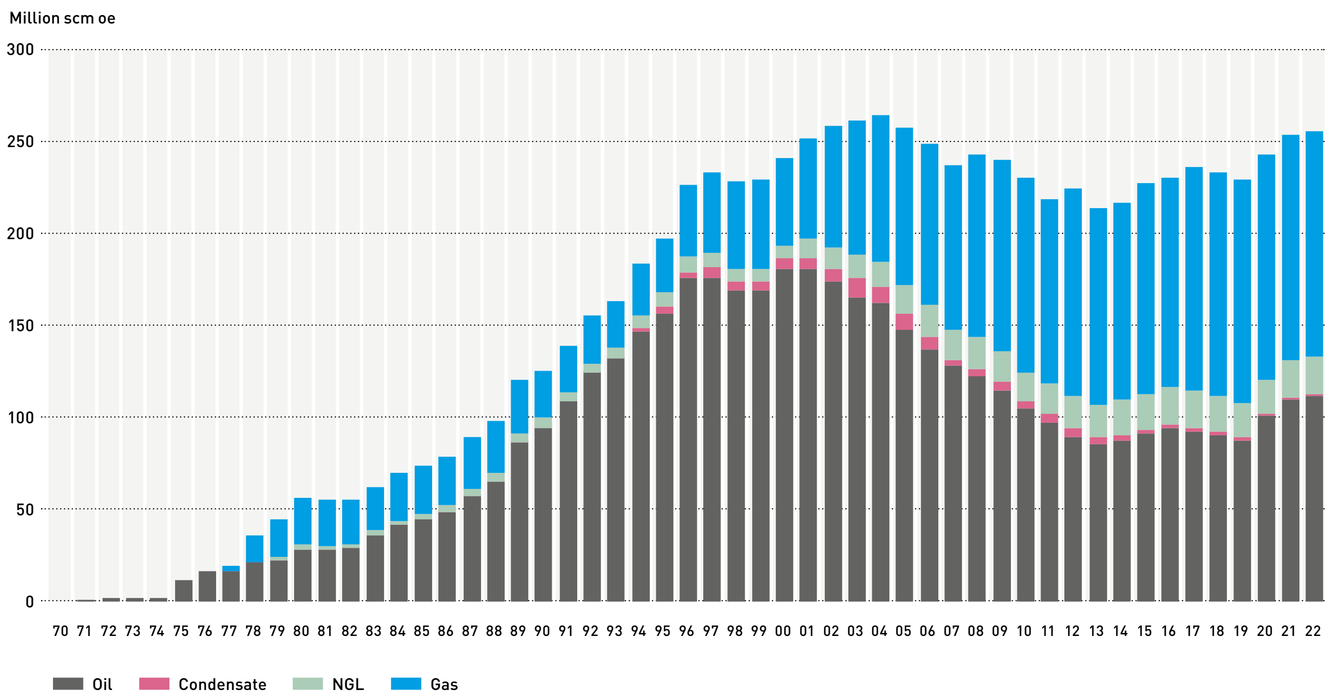
### RISING PRODUCTION TREND

Despite low oil prices, output from the NCS has been on an upward trend. Gas sales set a new record in 2017. Oil production declined slightly, but overall petroleum output rose for the fourth year in a row.

Final figures show that 92 million scm (1.59 million barrels per day – b/d) of oil were produced in 2017, compared with 94 million scm (1.61 million b/d) the year before – a two per cent reduction. The NPD's forecast for 2017 did not expect oil production to fall from the year before. Most of the decline reflected an unplanned maintenance shutdown on Goliat. A further two per cent drop to 90.2 million scm (1.55 million b/d) is predicted by the NPD for 2018. Oil production is expected to continue falling until 2020, but Johan Sverdrup will then contribute to a recovery.

FIGURE 01 **HISTORICAL AND EXPECTED PETROLEUM PRODUCTION (MILLION SCM OE)**

Source: NPD



Gas sales in 2017 amounted to 124.2 billion scm, a new Norwegian record. These sales are difficult to predict, even in the short term. They were 6.6 per cent higher in 2017 than the NPD forecast at the same time last year. This development partly reflects continued high demand from continental Europe and the UK. A number of the fields on stream have increased production. Short-term gas sale predictions show that the level is expected to remain high and stable, with a slight increase over the next five years.

The NPD's overall production forecast up to 2022 shows a rise from 2020. Oil and gas output in 2022 is expected to approach the previous record set in 2004. Gas will then account for about half the amount produced.

**NEW PRODUCTION PEAK IN PROSPECT FOR 2023**

The contribution from petroleum covered by a production decision is expected to be high and stable over the next five years. Output will rise in the early years of the period because of new measures on the fields, discoveries sanctioned for development, and when these come on stream. The contribution from discoveries where development has yet to be decided will rise later. Output from undiscovered resources is expected to acquire greater significance up to 2030. Based on these assumptions, total production from the NCS is expected to reach a new peak in 2023.

**36 EXPLORATION WELLS SPUDDED**

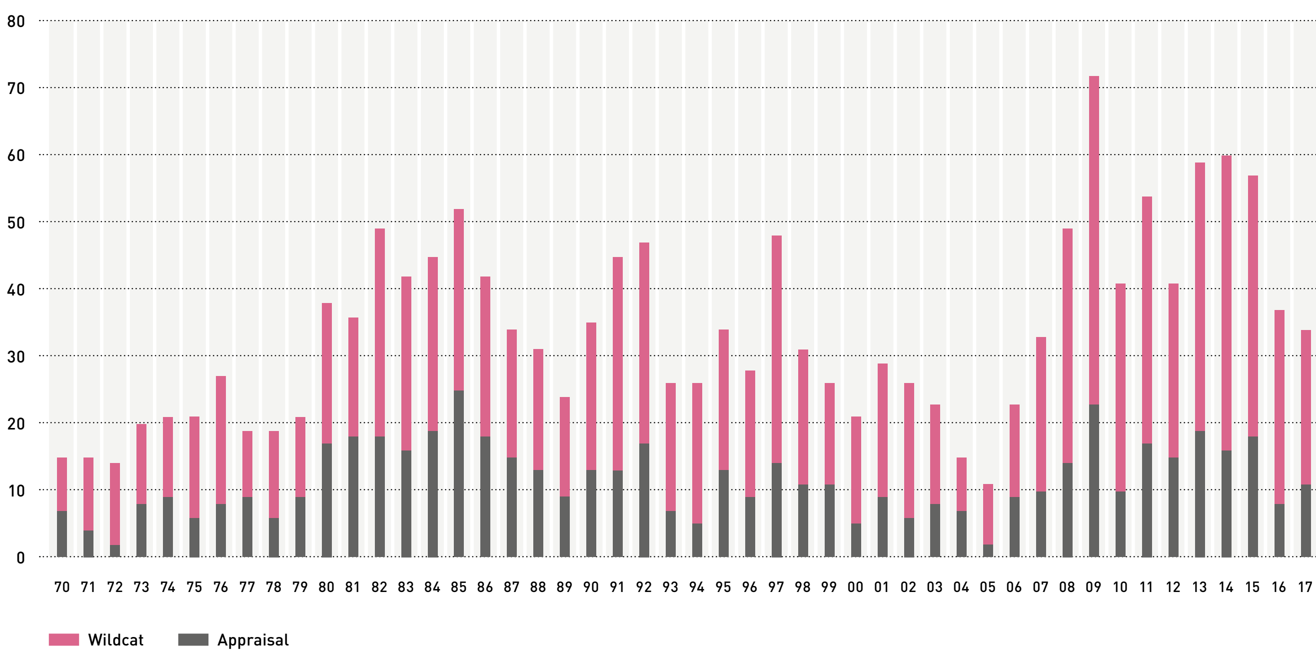
Thirty-six exploration wells were spudded in 2017, the same number as the year before. While oil company spending on wildcatting came to NOK 11 billion in 2016, it dropped to NOK 8.7 billion in 2017. Wildcats accounted for 24 of last year's exploration wells, and appraisals for 12. Eleven discoveries were made, seven fewer than in 2016.

**48 PER CENT OF RESOURCES SOLD AND DELIVERED**

The NPD's base estimate for total proven and unproven petroleum resources on the NCS is about 15.6 billion scm of oil equivalent (oe). Of this, 7.1 billion or 45 per cent has been sold and delivered. The overall resource base has increased by 1.3 billion scm oe since 31 December 2016. This is because the NPD mapped areas not opened for petroleum activities in the north-eastern Barents Sea during 2016-17. Forty-four per cent of remaining petroleum resources at 31 December 2017 are now estimated to lie in the North Sea, 20 per cent in the Norwegian Sea and 36 per cent in the Barents Sea.

FIGURE 02 EXPLORATION WELLS SPUDDED ON THE NCS (MILLION SCM OE)

Source: NPD



**10 PDOS SUBMITTED IN 2017**

The government received 10 plans for development and operation (PDOs) in 2017, covering Njord further development, Bauge, Ekofisk 2/4 Victor Charlie, Valhall flank west, Yme, Skogul, Snorre further development, Ærefugl, Fenja and Johan Castberg. Snorre further development is one of the biggest improved recovery projects on the NCS, and among the Norwegian fields with the biggest remaining oil volumes.

**24TH ROUND – MOST APPLICATIONS IN BARENTS SEA**

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. At the deadline of 30 November 2016, 11 companies had applied for production licences. The largest number of applications related to the Barents Sea, and the companies were particularly interested in the north-western part of the area on offer. Furthermore, applicants were dominated by large and medium-sized companies with good technical and financial capacity for exploring such areas. Fishing- and environment-related conditions are set for the blocks on offer, which was made clear in the announcement letter. The Ministry of Petroleum and Energy aims to award new licences under the 24th round before the summer of 2018.

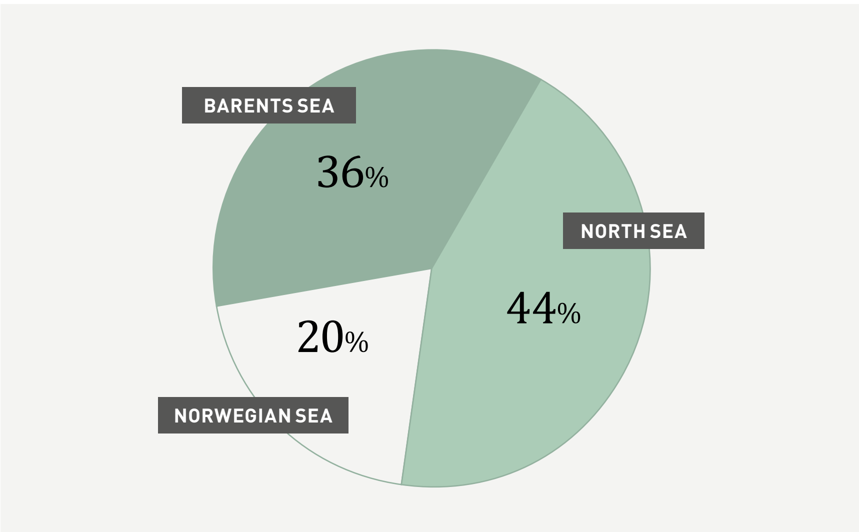
**TURNAROUND FOR OIL INVESTMENT IN 2018**

According to the investment survey for the petroleum sector from Statistics Norway (SSB), capital spending on oil and gas recovery and pipeline transport came to NOK 148.8 billion in 2017. That was down by NOK 15.7 billion or 9.5 per cent from the year before. This decline primarily reflected lower investment in fields on stream, land-based activity, and cessation and removal, and represented the third year of falling petroleum investment. However, oil prices stabilised at a higher level in 2017 while costs have been cut substantially through efficiency improvements, reduced supplier prices and simplifications. Over the past year, these developments have unleashed a number of new projects with break-even prices considerably below today's oil price.

In the investment survey for the first quarter of 2018, operators on the NCS estimate that capital spending in the sector will come to NOK 160 billion for the full year. This represents an upward adjustment of 11 per cent from the 2018 estimate in the previous quarter. Field development accounts for virtually the whole increase. PDOs submitted for no less than seven development projects in December 2017 are now included in the figures. At the same time, such plans are expected for several more projects later this year. If timetables for these are maintained, investment in field development – viewed in isolation – could be even higher than the figure presented in the survey so far.

FIGURE 03 REMAINING PETROLEUM RESOURCES BY SEA AREA (MILLION SCM OE)

Source: NPD



# 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 167 MILLION SCM IN 2007. THE OVERALL AMOUNT DISCHARGED IN 2017 CAME TO 134 MILLION SCM.**

# 4.1 DISCHARGES FROM DRILLING

**Drilling discharges mainly comprise drilling fluid and rock particles (drill cuttings) from the borehole. 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. Drilling activity in 2017 was somewhat higher than the year before, but lower than in 2015.**

Drilling activity rose somewhat in 2017 from the year before (see figure 4) to 177 new production wells, but was slightly down from 2015. Exploration wells were unchanged from 2016, at 36, but considerably fewer than in 2013-15.

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.

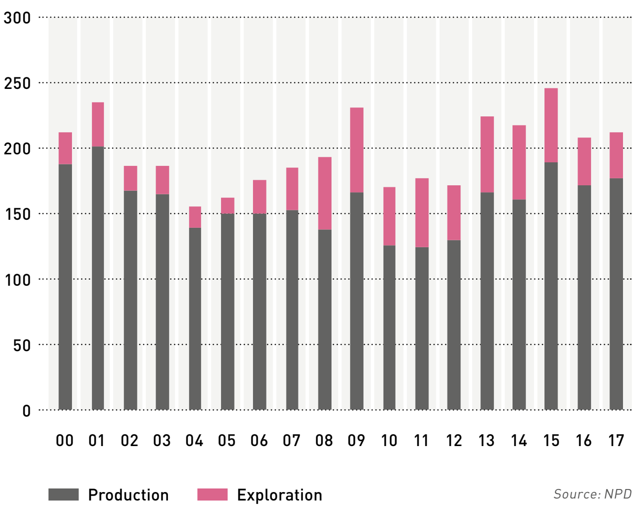
Discharging oil-based or synthetic drilling fluids, or cuttings contaminated with these, is prohibited if the oil concentration exceeds one per cent by weight – in other words, 10 grams of oil per kilogram of cuttings. Cuttings contaminated with less than one per cent of oil-based or synthetic drilling 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 2017 was down by more than 20 per cent from the year before, despite rather higher drilling activity.

The proportion of drilling fluid injected was 30 per cent, somewhat higher than in 2016. Injection wells have been drilled on a number of new fields, but have not been replaced on certain older fields where they were found to contain fractures and leaks in 2007-09.

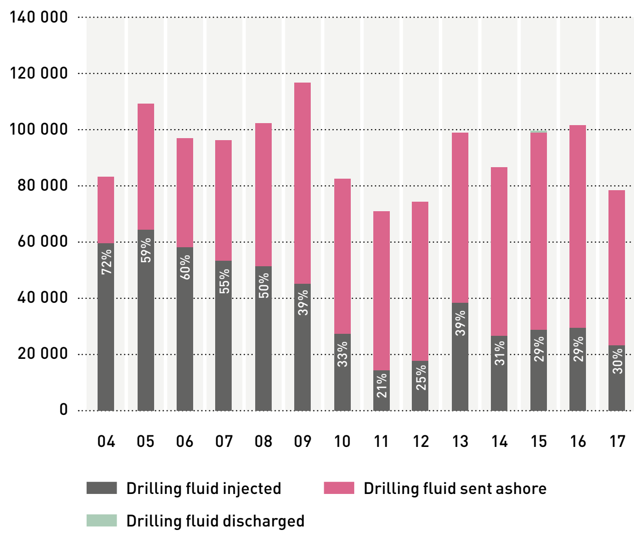
A permit to discharge treated drill cuttings was issued for the Johan Sverdrup field in December 206. This specifies that discharges will start in 2019, when the permanent drilling rig has been installed.

FIGURE 04 **WELLS DRILLED ON THE NCS AFTER 2000**




Source: NPD

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




‹ Part of the Troll A platform.

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. The variation accordingly reflects water added to the cuttings before reception ashore.

Oil-contaminated cuttings delivered as waste totalled just over 53 000 tonnes in 2013, rising to almost 118 000 tonnes in 2016. A substantial reduction to almost 80 000 tonnes occurred in 2017. Water and cuttings are separated on land, with the former treated and discharged to the 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 2017 came to roughly 90 000 tonnes, down by just under 14 per cent from the year before. 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)

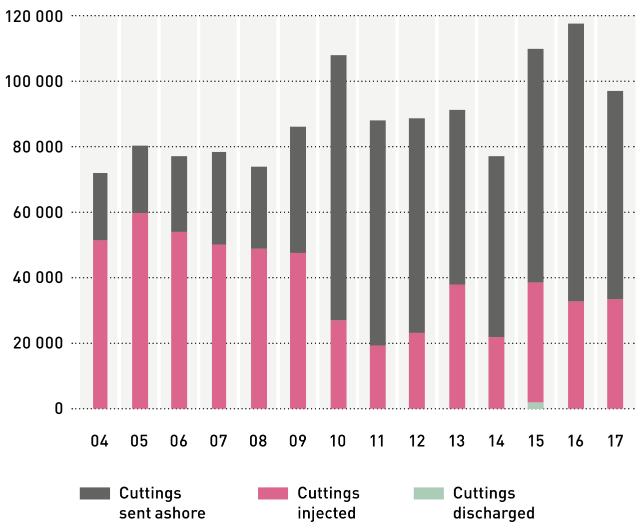
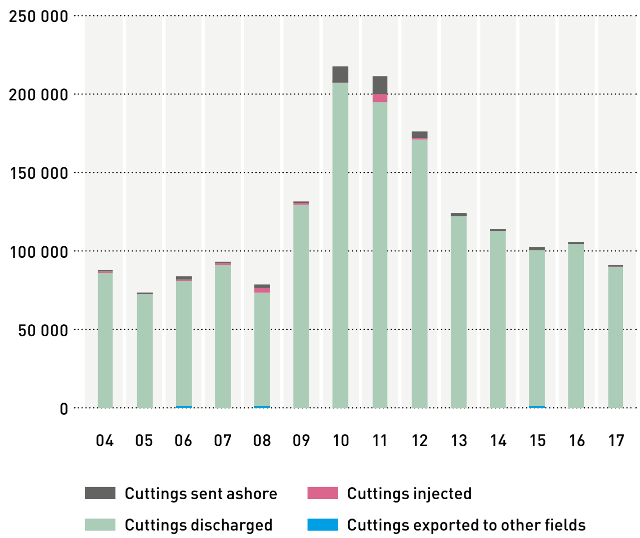



FIGURE 07 DISCHARGE OF DRILL CUTTINGS FROM WELLS DRILLED WITH WATER-BASED FLUID (TONNES)



# 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.**

**Produced water:** Accompanies the oil and gas up from the reservoir, and occurs naturally in the formations. A complex mix, it can contain several thousand separate compounds. The water is therefore subject to routine analyses. Where water is injected to improve recovery, it will mix with the formation water and may also contain various chemicals added, for example, to prevent bacterial growth, corrosion and emulsion formation.

Various treatment technologies are applied on the platform in order to help get the water's oil content as low as possible before discharge to the sea.

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.

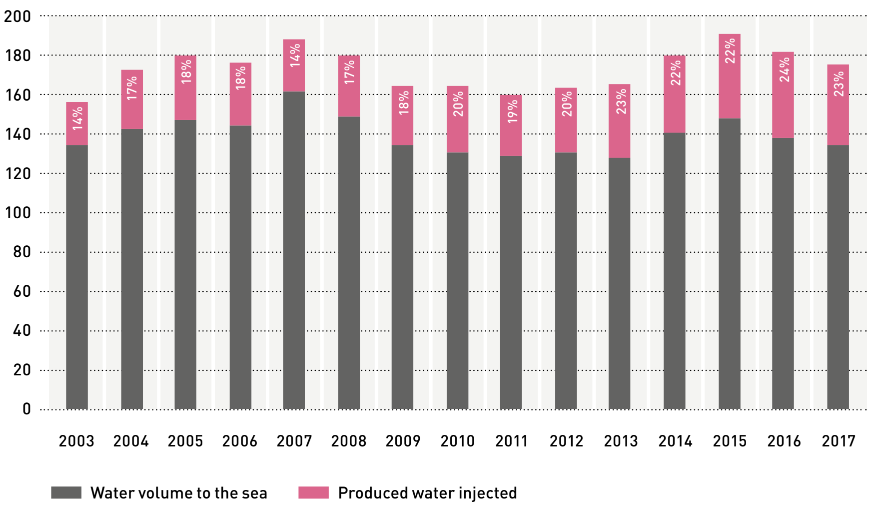
Oily water can also derive from cleaning process equipment, from accidents, or from the deposition of oil droplets released by flaring in connection with well testing and workovers.

### 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 declined substantially thereafter. Annual discharges rose to almost 150 million scm in 2012-15, but fell again in 2016 to just over 138 million scm. The downward trend persists, with discharges falling by just under three per cent in 2017 to 134 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. About 23 per cent, or a little over 40.9 million scm, was injected in 2017.

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



Produced water in new fields consists wholly 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. Despite this, discharges on the NCS are comparable with international figures.

The relative proportions of produced water and oil on the NCS have therefore shown a rising tendency. However, they declined somewhat in 2016 – probably because a number of new fields came on stream. This trend continued in 2017.

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. But it fell somewhat in 2016 and this decline continued in 2017. Displacement water accounts for just under 29 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 12.1 mg/l in 2017, compared with the official requirement of 30 mg/l. That was a slight decline of 1.7 per cent from 2016.

The quantity of oil in produced water discharged to the sea fell from just over 1 698 tonnes in 2016 to 1 621 (see figure 12). A total of 1 722 tonnes of oil was released with water from drainage, displacement, production and jetting in 2017, compared with 1 805 tonnes the year before.

**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)

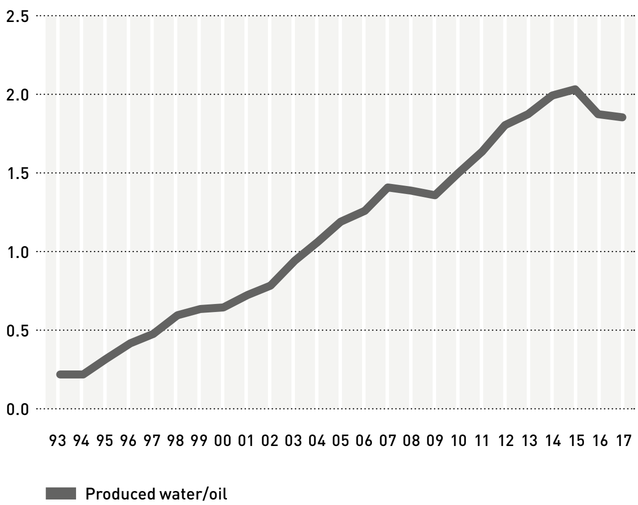



FIGURE 10 DISCHARGES TO THE SEA OF OTHER OILY WATER TYPES (MILL CU.M)

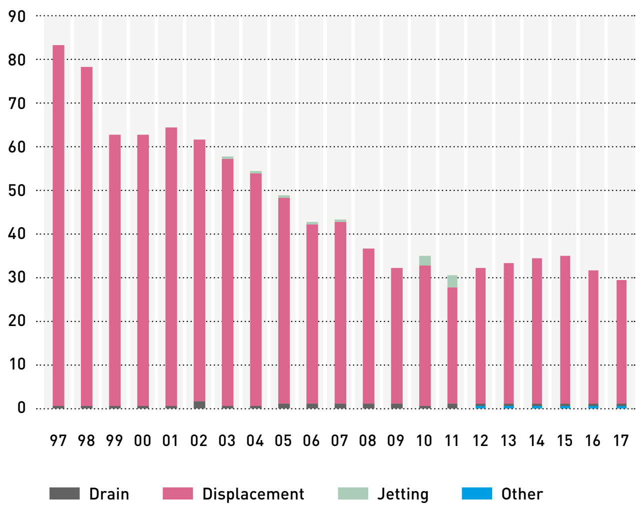


FIGURE 11 **OIL CONCENTRATION IN PRODUCED WATER DISCHARGED TO THE SEA** (MG/L)

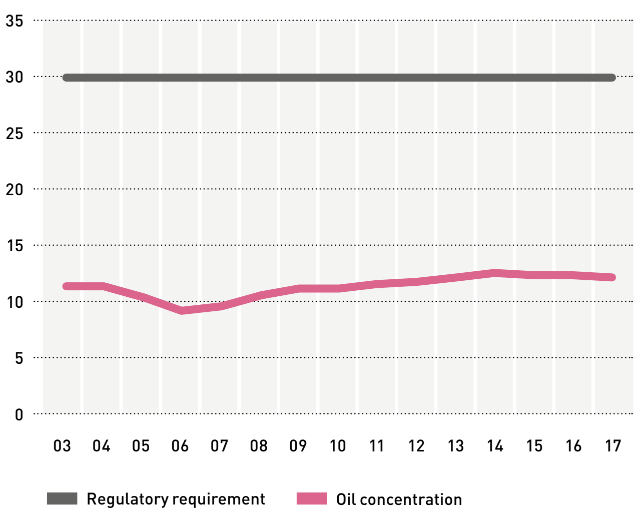
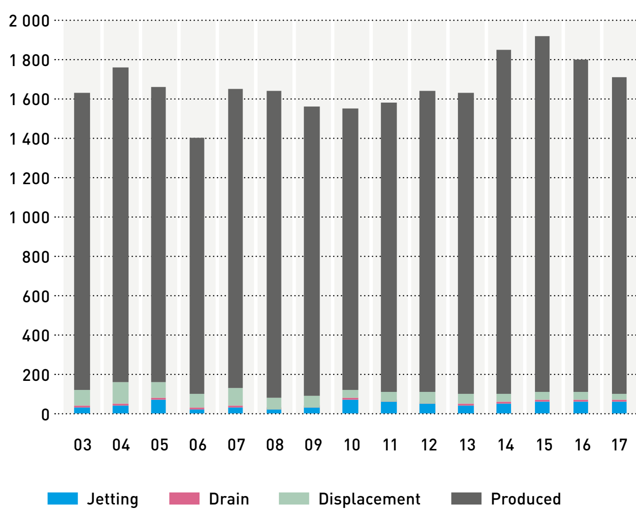



FIGURE 12 **OIL CONTENT IN WATER DISCHARGED ON THE NCS** (TONNES)



# 4.3 TREATMENT OF OILY WATER – EIF AND RBA

**The strategy of zero harmful discharges on the NCS is pursued with a risk-based approach, where risk assessments are used to ensure that measures will be 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.**

The potential environmental risk associated with produced-water discharges is assessed for the individual field through analyses and model calculation, and expressed as an environmental impact factor (EIF). These calculations show that dispersed oil in water forms a very small part of the risk picture associated with produced water discharges, while chemical additives may make a bigger contribution. The EIF is related to a facility, and is intended to provide the basis for substituting chemicals and assessing which components in the produced water contribute to risk. From 2010-17, the EIF for produced water has been updated through the Dream joint industry project (JIP) charter and work on Ospar's risk-based approach (RBA), which includes revised predicted no effect concentration (PNEC) values in line with marine environmental risk assessments (ECHA 2008). The EIF is not without problems as an indicator of environmental impacts. Its methodology has its limitations, which should be taken into account when assessing and possibly deciding on mitigating measures for the individual field and facility.

Research and EIF calculations show that certain chemical additives and natural components from the sub-surface, discharged together with produced water, have harmful effects on aquatic organisms. However, this is only possible with concentrations found close to the discharge point – within a few hundred metres up to about 1 000 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, which indicate that the organisms have been exposed but that no impact has been felt by groups of individuals, populations or the ecosystem.

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. Most fields have discharges far below the regulatory ceiling of 30 mg/l. However, problems are experienced on some for various reasons in achieving stable operation of injection facilities and treatment processes, and the level there is accordingly rather higher.

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.

Substantial investment has been made in treatment technology and investment to reduce oil discharged in produced water. Generally speaking, the concentration is far below the regulatory ceiling of 30 mg/l.

- 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.
- Treatment success 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 individual fields. 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.

Work on the RBA through Ospar also covers whole effluent testing (WET). This activity has involved acquiring produced-water samples from 25 offshore fields for chemical analysis and testing with bacteria (Microtox), phytoplankton (*Skeletonema costatum*) and crustaceans (*Acartia tonsa*). Similar activities have also been pursued on British, Dutch and Danish fields, among others. The work was due for completion in late 2018, but Ospar's oil industry committee (OIC) has postponed this to 2020.

# 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.

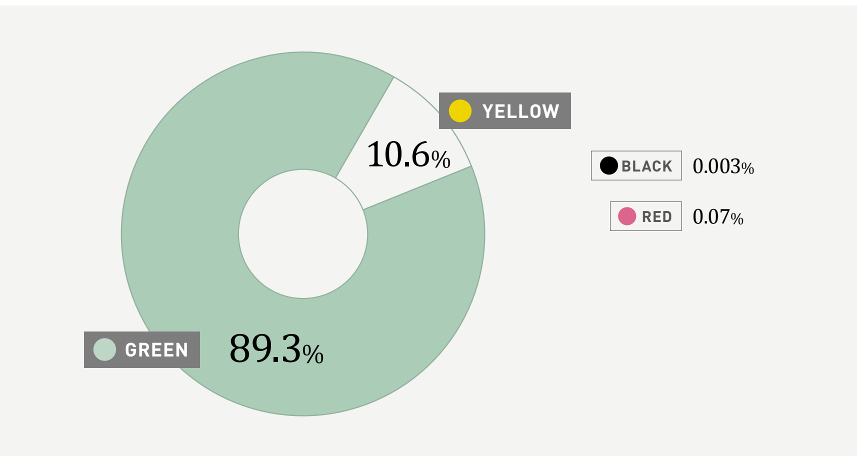
**4) BLACK** Chemicals which the government can permit to be discharged in special circumstance – where this is crucial for safety, for instance.

A more detailed description is provided in the NEA's M-107 guidelines on reporting from offshore petroleum operations (in Norwegian only).[1]

Discharges of chemical additives from Norwegian petroleum operations totalled just over 139 000 tonnes in 2017, down by almost 10 per cent from 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 amounted jointly to some 0.07 per cent of discharges. Yellow chemicals represented 10.6 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 releases of the most environmentally harmful substances to a fraction of their level only 10 years ago.

FIGURE 13 BREAKDOWN OF DISCHARGES OF CHEMICAL ADDITIVES FROM THE NCS BY THE NEA'S CATEGORIES (2017)




Alternative types of fire-extinguishing foams with less environmentally harmful properties came on the market from 2011. The NEA therefore incorporated foams in the substitution obligation, which meant that operators had to report discharges in connection with testing and exercises. This is the most important reason for the marked rise in black chemical discharges. It will take several years before all fire-extinguishing foams have been replaced across the whole NCS.

The trend since 2014 has been a substantial reduction in discharges of black chemicals. These came to 4.7 tonnes in 2017, a slight increase from 3.6 tonnes the year before. Where red chemicals are concerned, a steady rise occurred in 2013-16. Discharges fell slightly in 2017 to about 96 tonnes.

Complex factors underlie the variations for red and black chemicals in recent years, but changed requirements for both reporting and substitution work are the most important. The most significant 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 a satisfactory extinguishing performance (see the HSE regulations). Alternatives with less environmentally harmful properties are now available. These are 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 foam for a number of years to come. The new alternatives still contain components categorised as red, which make a substantial contribution to the marked increase in discharges for this category of chemicals. Reclassifying certain chemicals from yellow to red categories has also contributed.

[1] http://www.miljodirektoratet.no/Documents/publikasjoner/M107/M107.pdf.

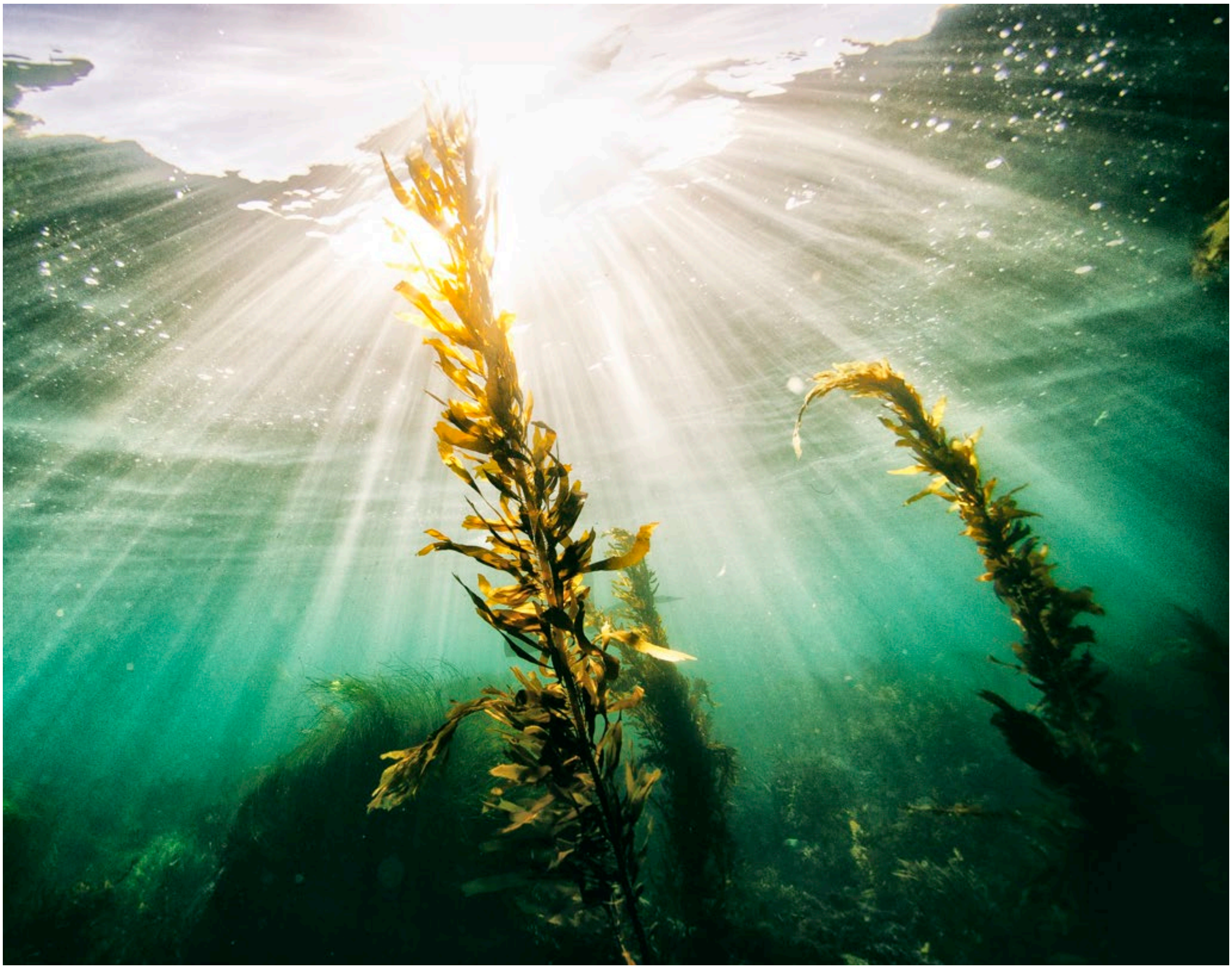
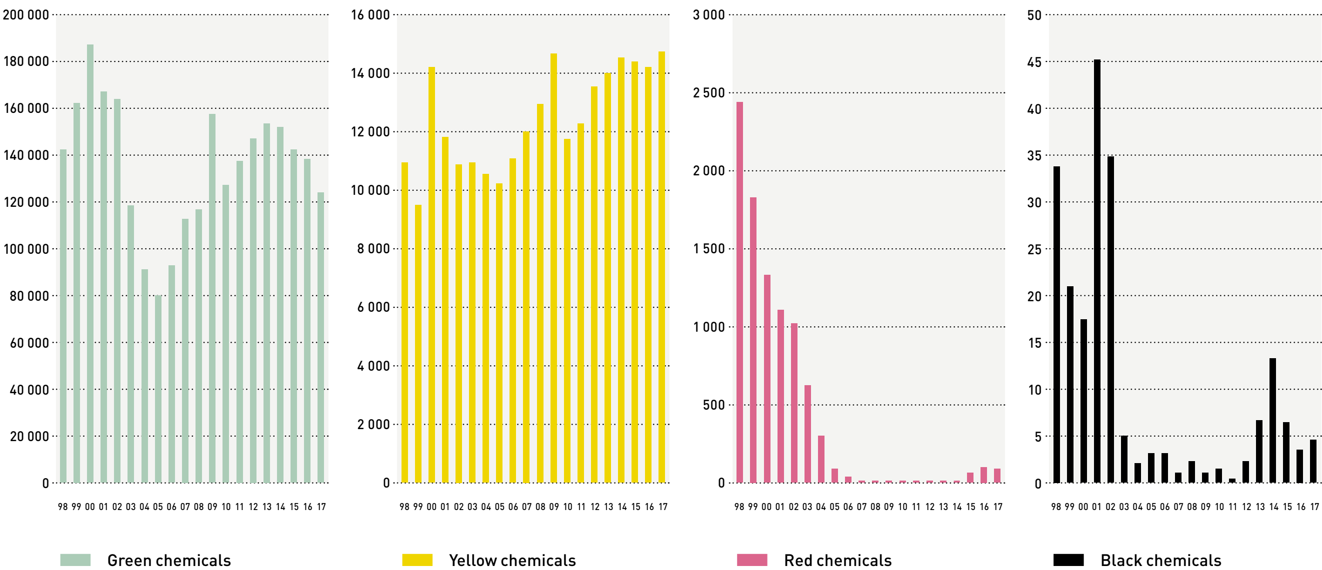


FIGURE 14

## 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. Giving a high priority to preventive measures over many years has yielded a downward trend in the number of acute emissions/spills. The total volume in 2017 was 12 cubic metres.**

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 smaller than 50 litres but correspondingly increased unintentional releases of chemicals. Forty-six incidents involving spillage of oil occurred in 2017, compared with 39 the year before. Spills larger than 50 litres have become steadily less frequent since 1997, but they increased slightly in 2017 to 18. That compared with nine the year before.

A similar declining trend can be observed for crude oil spills alone over almost 20 years, with numbers varying somewhat from 2013. There were 21 such discharges in 2017, including 11 smaller than 50 litres, eight 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 2017 was 12 cubic metres, down from the year before.

### UNINTENTIONAL CHEMICAL SPILLS

No similar declining trend can be seen for unintentional chemical spills, but a marked reduction has occurred over the past three years. Incidents have generally lain around 150-160 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 as chemicals. Just over 140 spills occurred in 2017, down from 160 the year before.

Unintentional chemical spills had an overall volume of 951 cubic metres in 2017, including 860 tonnes of green chemicals, 46 tonnes of yellow, six tonnes of red and just under a tonne 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 2017 was just under 490 tonnes, with green chemicals accounting for just over 489 tonnes.

FIGURE 15 UNINTENTIONAL OIL SPILLS TO THE SEA ON THE NCS

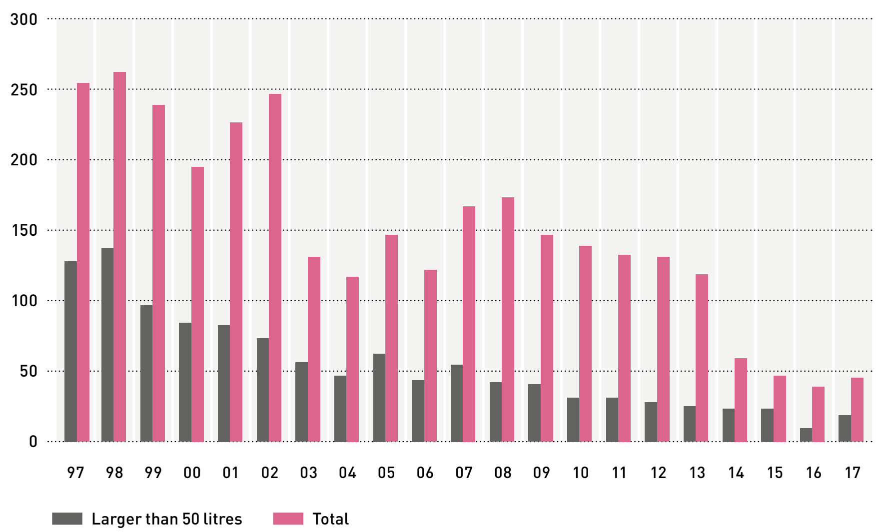


FIGURE 16 UNINTENTIONAL CRUDE OIL SPILLS TO THE SEA ON THE NCS

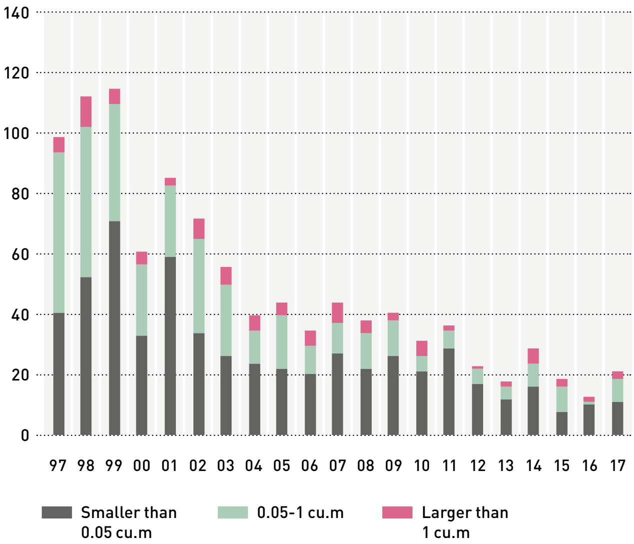



FIGURE 17 VOLUME OF UNINTENTIONAL OIL SPILLS ON THE NCS (CU.M)

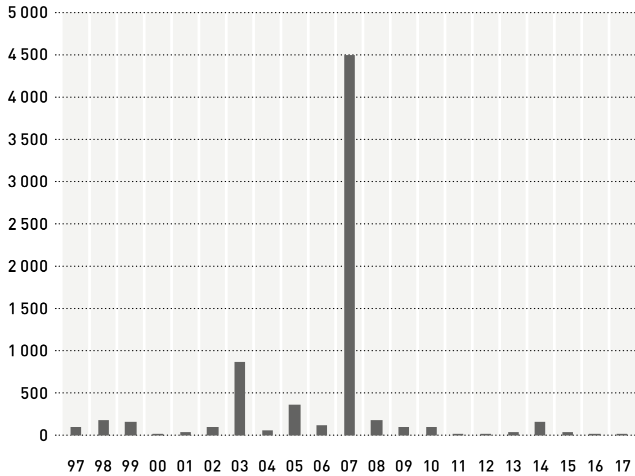



FIGURE 18 UNINTENTIONAL CHEMICAL SPILLS ON THE NCS BY THREE SIZES OF SPILL

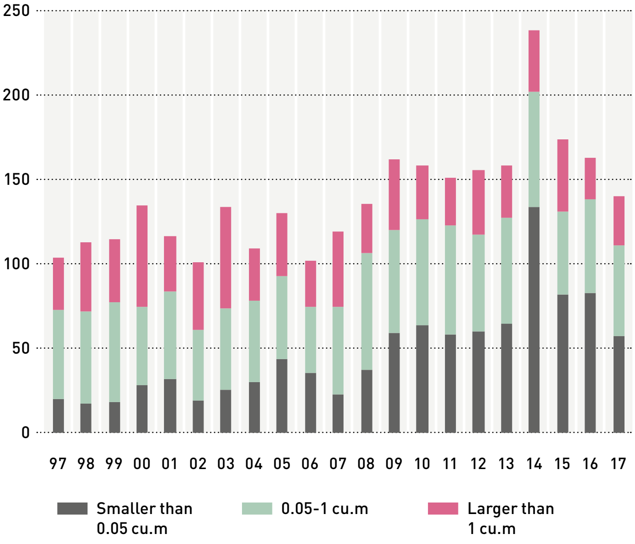
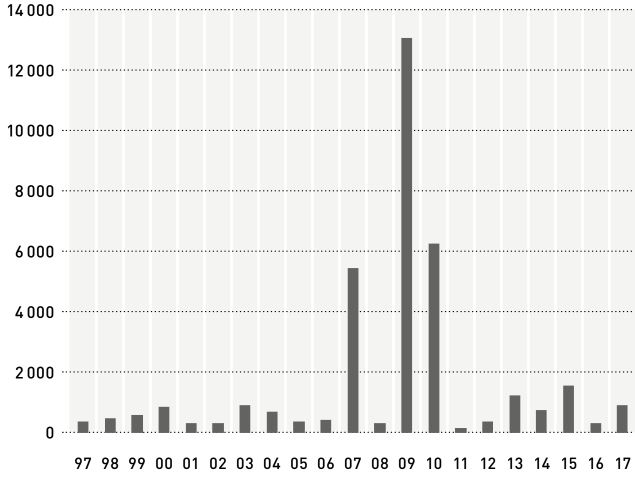
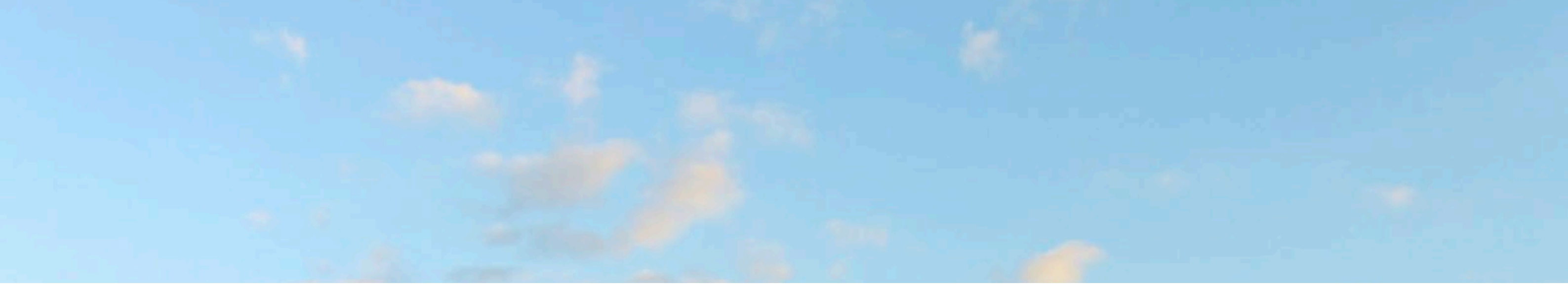



FIGURE 19 TOTAL VOLUME OF UNINTENTIONAL CHEMICAL SPILLS (CU.M)





# 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 INCIDENTS WHICH LEAD TO ACUTE (UNINTENTIONAL) 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 chemical substitutions (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 as well as benthic sediments and fauna, and 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.

The NEA has revised its M-300 guidelines on water-column monitoring. 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. A major survey was conducted in 2017, involving water-column monitoring with five work packages based on caged mussels, catching wild fish and zooplankton, and research and methodological development in such areas as DNA adducts in fish. The work was conducted through a collaboration between the International Research Institute of Stavanger (Iris), the Norwegian Institute for Water Research (Niva), the Norwegian Institute of Marine Research and Sintef. Results will be available during 2018, and are due to be presented at the Forum for Offshore Environmental Monitoring in October.

#### 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 accordingly exists in applying this material to the government's administrative work, along with data from the big Mareano mapping programme. A project was accordingly pursued in 2015-17 to assess the comparability of the two data sets, since two different grab sizes – 0.1 and 0.25 square metres respectively – have been used. The findings of this study include:

- in shallower waters (< 500 metres), Mareano should use the Norwegian standard (0.1-square-metre Van Veen grab)
- geological and chemical results from Mareano's grab can probably be used, but not faunal data.

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 in order to observe developments on the field after all discharges have ceased.

The Ekofisk area, Statfjord area and Barents Sea regions were investigated in 2017. Visual monitoring was also conducted alongside investigations

‹ The Edvard Grieg platform in place in the North Sea.

in the Barents Sea. Results from the environmental monitoring will be presented to the Forum for Offshore Environmental Monitoring in October. 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 has now been completed. Its information can also be exchanged with the Norwegian Marine Data Centre (NMDC), which has a large number of partners (www.nmdc.no).

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 Sea and Shore (Proof/Proofny) programme 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. [2, 3] From 2015, Marinforsk has taken over as one of the relevant programmes for the effects of pollution from petroleum operations. It also addresses pollution and other ecosystem impacts from environmental toxins and waste, the minerals industry, aquaculture, other influences and overall effects.

Proofny concludes 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 away. 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 (facility) on currents and thereby on changes to particle size in the sediment.

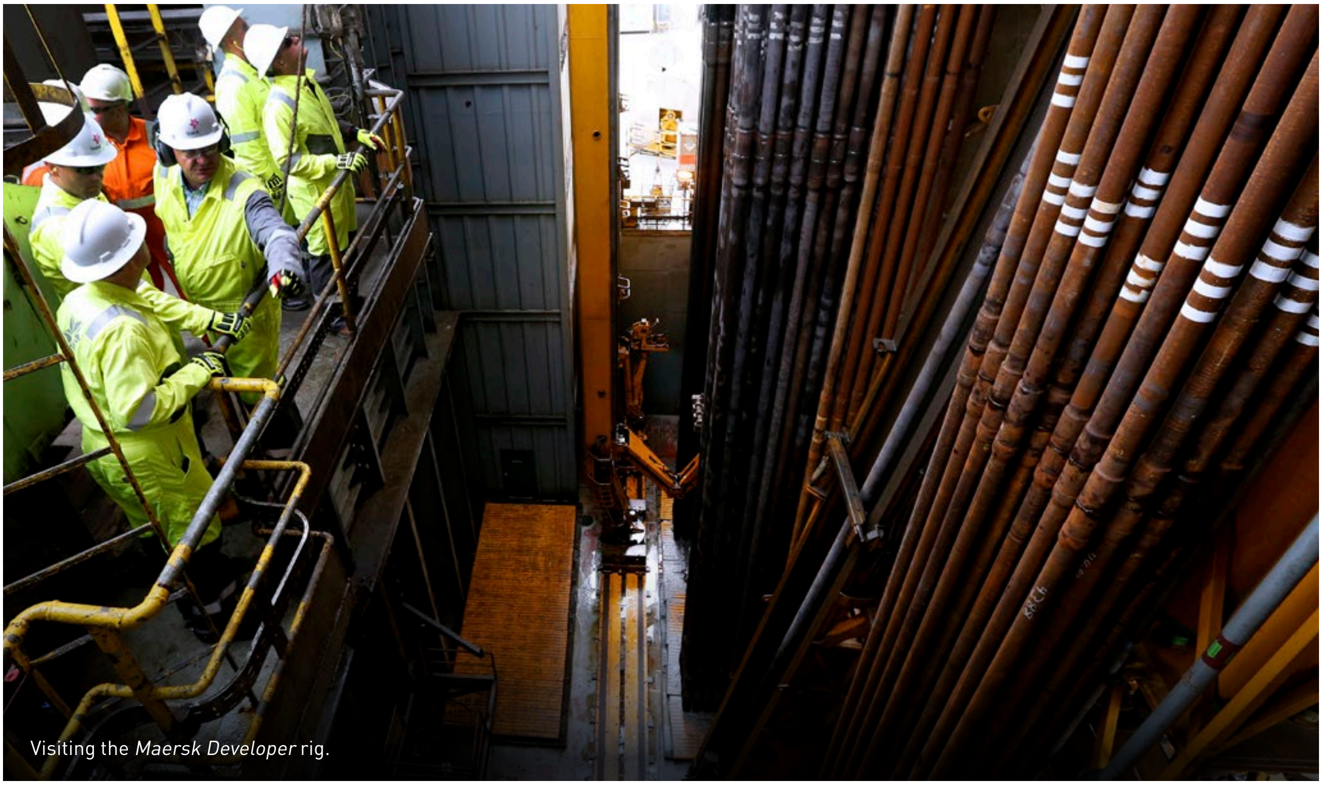
Since these publications appeared, the Barents Sea drill cuttings research initiative has begun. Initiated by Eni Norge, this project has a five-year time frame. It aims to provide information about the extent of effects from drill-cutting discharges over time through studies of seabed biology and ecology, geology and oceanography. The project is a collaboration between the University of Tromsø, Akvaplan-Niva and the Northern Research Institute (Norut). Wells drilled from 1989 to 2015 have been 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 only taken at distances above 250 metres.

Preliminary conclusions are that drilling operations which involve discharging drill cuttings cause local effects, such as reduced oxygen levels and a smaller number of faunal species. However, the scale 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.

### VISUAL INSPECTIONS

Visual inspections are carried out before planned exploration drilling can begin in areas which may contain organisms regarded as particularly vulnerable to drilling discharges, on the basis of an assessment of serious or irreversible harm in line with the precautionary principle. This could apply, for example, to areas with extensive sponge communities and/or coral reefs. The industry has developed guidelines for such surveys where deepwater corals are present. These will be further developed and

[2] 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.
[3] 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).



Visiting the *Maersk Developer* rig.

updated to apply to seabed habits during 2018. The goal of such guidelines is to avoid physical damage to coral reefs, sponge communities and the like. The 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.

Regulations issued by the Norwegian Directorate of Fisheries apply to fishing. These specify that:

- the possibility of a collision with a vulnerable habitat – in other words, corals or sponges on the seabed – must be calculated for each fishing operation
- if more than 60 kilograms of living corals or 800 kilograms of living sponges are brought up, the vessel must report this to the fisheries directorate and move at least two nautical miles before fishing can resume
- no catches of corals or sponges have been reported since the notice from the director of fisheries established regulations for fishing with bottom-towed gear in July 2011.

DNV GL presented results from the 2016 visual investigations in the Barents Sea to the 2017 Environmental Monitoring Forum. These involved mapping 10 locations in the Barents Sea from Blåmann in the south-west to Korpfjell in the far north-east. Remotely operated vehicles (ROVs) were deployed and drop cameras used over a stretch of 25 kilometres in all. The depth varied from 246 to 454 metres. Sponge coverage was broken down on a scale of four intervals from less than one per cent (none to single sponges) to more than 10 (high coverage). Sponges occur on both soft and hard (stony) seabeds. Korpfjell to the north-east was identified as a new biotope compared with earlier surveys, with gravel and carbonate crusts in some areas. The fauna also differed from areas observed earlier, probably because of the cold Arctic water (average over 10 years of -1.58°C) compared with fields in the south-east (average over 10 years of 8.51°C).

An empirical modelling has also been produced by DNV GL in order to be able to identify typical sponge areas in four by four kilometre squares, based on various data sources (Gebco, Met.no/IMR, Hav 5 and Sintef).

Trawl-door tracks were also registered with the aid of ROVs. They were identified in four of 10 areas investigated, with a frequency of 0.2-0.6 per 100 metres.

# 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 caused significant environmental harm – whether from offshore activities, associated transport or related land-based plants.**

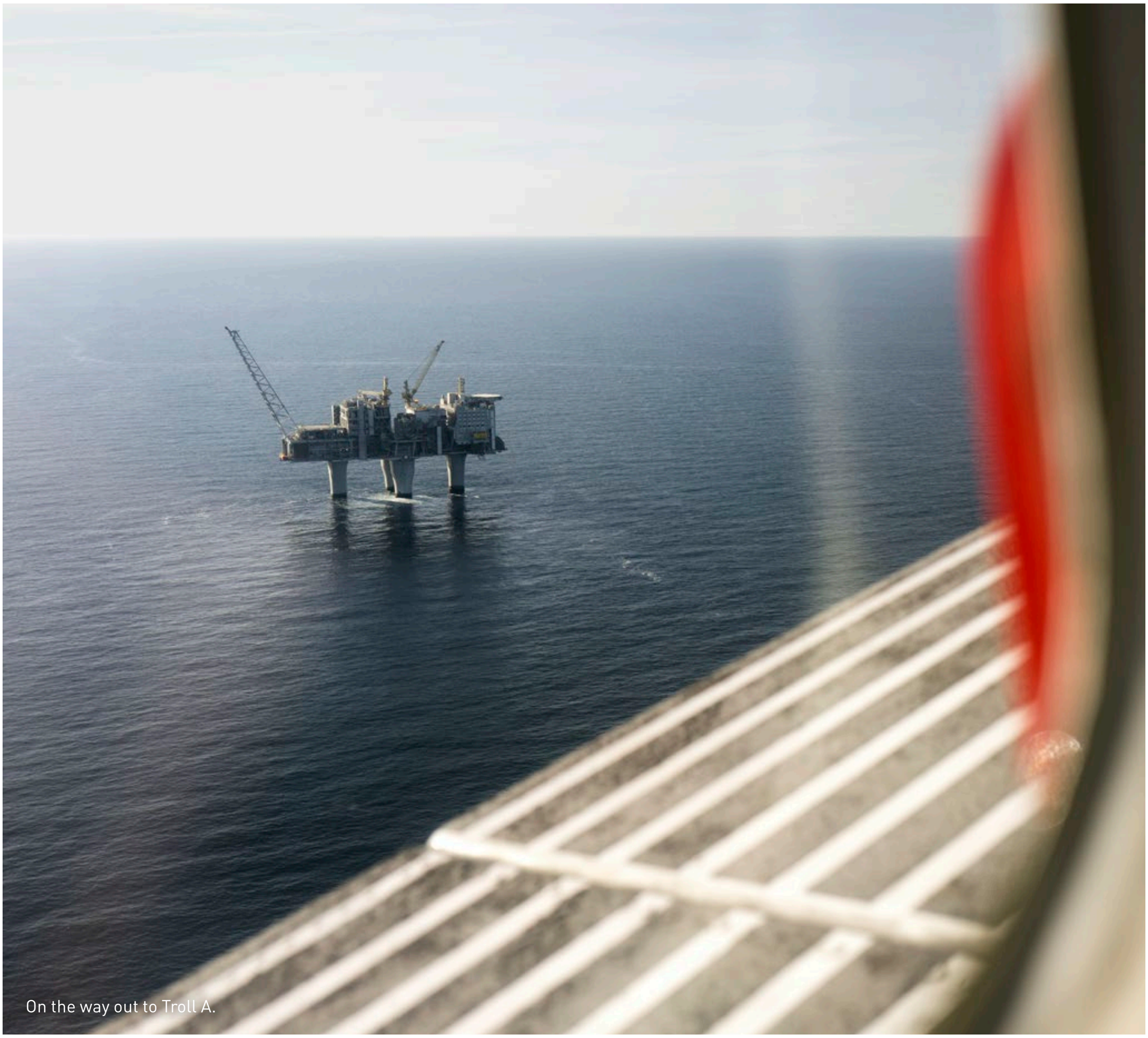
Choosing the right action to reduce environmental risk calls for good knowledge of which environmental components could be exposed and their vulnerability to the relevant stress (incident). That involves knowing when the environmental resources are at their most vulnerable, when they are present and which activity poses the highest environmental risk. A priority for the oil and gas industry has therefore been to contribute to learning more about the actual potential 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 discharges, a priority for the industry is to acquire a good understanding of their possible effects. 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, Equinor 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 about this issue has been one of the most important and fundamental areas of conflict over coexistence between the fishing and petroleum industries in Lofoten-Vesterålen. Involvement of 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. One goal has been to clarify the risk as a function of probability and consequence.

Symbioses is a tool which integrates recognised models for ecosystems (fish, fish eggs and larvae as well as plankton) and oil-spill dispersal. 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 area 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. Thirty-eight different combinations (scenarios) for spill rate, depth and duration as well as oil type were produced. These were simulated for all four threshold levels – a total of 152 oil spill simulations with both sea-surface and seabed blowouts. 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 in adult biomass 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). These results show that the consequences of a major oil spill could also be limited. Historical data about accidental spills on the NCS indicate that the probability is very low (blowout



On the way out to Troll A.

probability of less than $10^{-4}$). Even though the risk is extremely small, however, plans must be laid to deal with such a spill and ensure that irreparable damage cannot be caused to the environment. Risk is generally defined as a potential or possibility for undesirable incidents and the behaviour of such incidents. This can be expressed as risk = consequence x probability.

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. Follow-up activities are now planned to address possible effects on other fish species, including commercial varieties such as haddock, herring and capelin.

**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. Action must not be delayed until certain knowledge has been acquired.

In Norwegian environmental policy, the principle is described in such documents as the White Paper on environmental policy for sustainable development.[4] Section 9 of the Nature Diversity Act gives legal force to the principle. The preamble to the Act[5] 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.

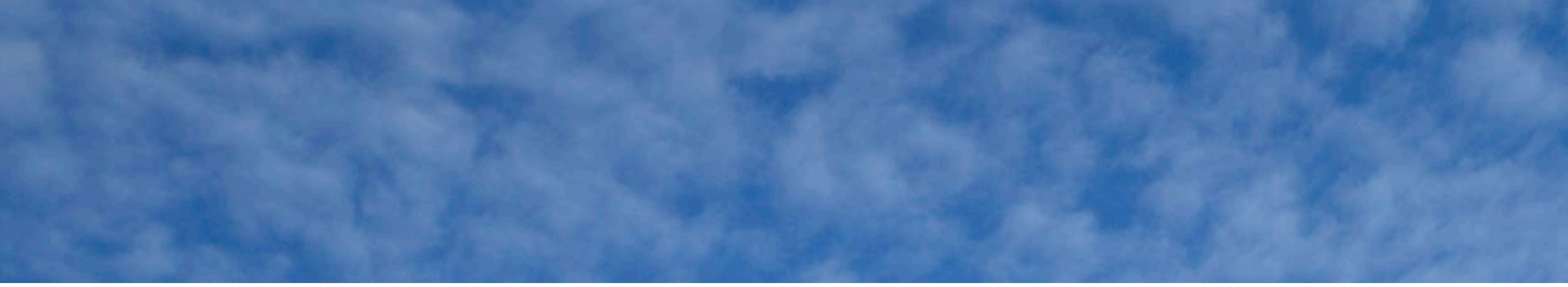
A precautionary approach is appropriate at a decision-making level in order to ensure that account is taken of uncertainties in an objective, fact-based and scientifically supported decision basis. It is inappropriate to involve the principle in the underlying scientific basis and present it to decision-makers 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 processes, 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. The Symbioses model system offers a good picture of this.

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

A precautionary approach is appropriate at a decision-making level. 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.



# 6 EMISSIONS TO THE AIR

**BOTH PRODUCTION AND EXPLORATION INCREASED IN 2017 COMPARED WITH THE YEAR BEFORE, BUT EMISSIONS TO THE AIR NEVERTHELESS FELL. THIS REPRESENTED A DECLINE IN EMISSIONS PER UNIT PRODUCED FOR THE FOURTH YEAR IN A ROW.**

# 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 figures provided 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.

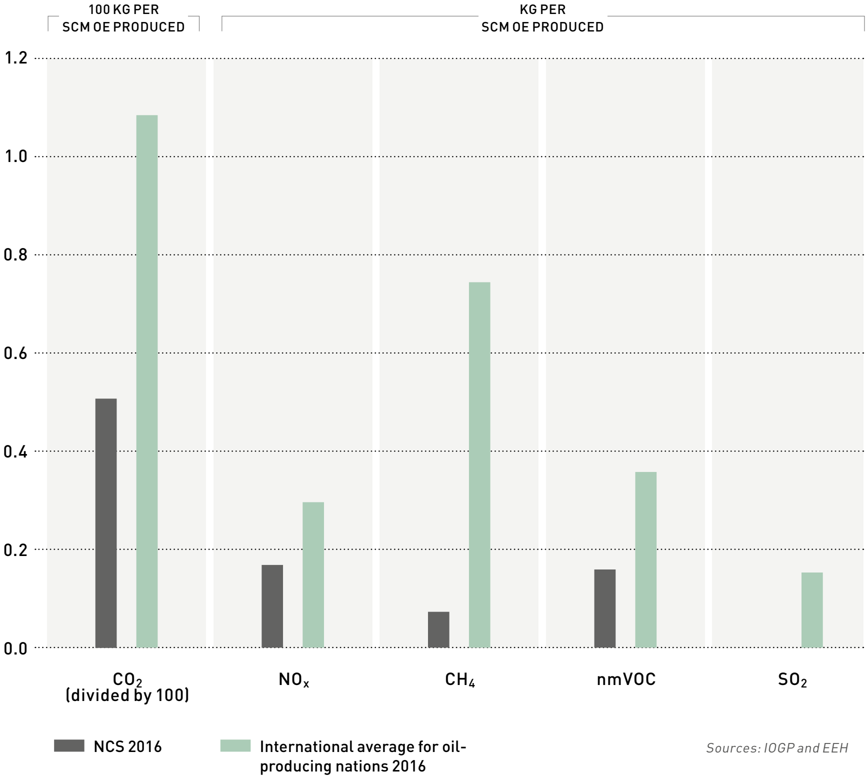
Power generation using natural gas and diesel oil as fuel is the main source of $CO_2$ and $NO_x$ emissions. Their levels depend mainly on energy consumption by the facilities and the energy efficiency of power generation. Gas flaring is the second largest source of these emission types. It only takes 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 2016 because international figures for 2017 are not available in May 2018.

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




Sources: IOGP and EEH

‹ The Valemon platform.

# 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 has 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 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. The most important instrument for 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 petroleum sector. 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.

Norway has adopted emission-reduction targets which correspond with those of the EU, and the government is working now to secure a bilateral agreement with the EU on joint fulfilment of their climate commitments by 2030.

## 6.2.1 CARBON CAPTURE AND STORAGE

CCS is crucial for achieving the ambitions set by the Paris agreement. Studies show that meeting the climate goals will be far more expensive without it. No other known possibility for significantly reducing emissions is currently available to such process industries as cement and steel. The Norwegian government's ambition is to realise a full-scale CCS facility by 2022.

Conceptual studies have been conducted for three possible plants – Norcem's cement factory in Brevik, Yara's ammonia plant in Porsgrunn and the Fortum Oslo Varme waste heat recovery facility. Equinor, Shell and Total are completing such studies for $CO_2$ transport to and storage beneath the NCS.

The government created uncertainty in the autumn of 2017 by failing to appropriate adequate funds in its budget for the front-end engineering and design (Feed) phase following the conceptual CCS studies. Instead, it referred to further assessments in the revised national budget in the spring of 2018.

In early 2018, Oslo Economics and Atkins presented a report on quality assurance for the demonstration of full-scale carbon capture, transport and storage. This report concluded that all the projects should receive funding for the next study phase in order to have a sufficiently good decision base for investment. Assuming that the Norwegian project will be one of a kind, that $CO_2$ prices remain low and the world thereby fails to achieve its climate goals, and that the commitment provides no industrial gains, it concluded that the

## GHG EMISSIONS FROM THE NCS

**A number of sources report figures for emissions to the air from Norwegian oil and gas production. However, both reported figures and development trends can vary considerably between the various sources from year to year. This reflects a number of factors, but by far the most important is different definitions of which activities are covered by 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. Deciding which emissions to include is 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.

- 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. 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 SSB also form the basis for the Miljøstatus.no website.

- The NEA has its own database for Norwegian emissions (norskeutslipp.no), 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. Totals for the industry will therefore be lower than those presented in the environmental report and by 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 will therefore vary not only in total but also from different sources.

project would not be socio-economically profitable.

In cooperation with the Zero and Bellona environmental organisations, the industry – represented by the Confederation of Norwegian Enterprise (NHO), the Norwegian Confederation of Trade Unions (LO), Norwegian Oil and Gas and the Federation of Norwegian Industries – has made it clear that the commitment to CCS in Norway has a big industrial potential.

A report from Sintef in the spring of 2018 on industrial opportunities and employment from CCS in Norway quantified how a commitment here could create and strengthen the competitiveness of jobs. It also estimated the potential value creation for Norway up to 2050.

In this report, Sintef points to value creation opportunities for the Norwegian process industry, hydrogen production from natural gas with carbon storage on the NCS, export opportunities for CCS technology and services, storage of $CO_2$ from industrial sources in Europe, and Norwegian shipyards and shipowners from transporting $CO_2$ by sea, as well as the jobs created by building the actual full-scale project planned in Norway.

Industry regards a Norwegian CCS commitment as an investment in infrastructure for future production in a low-emission society. As the first of its kind, however, implementation will depend on government-industry collaboration.

## 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 set as the new year for reaching the target.

A review of measures implemented by all operators was completed by Norwegian Oil and Gas during 2017 in relation to KonKraft's 2020 goal. This status review showed that the companies had already exceeded the target by 31 December 2016.

An important reason why the KonKraft goal has been met three years early is the increased attention paid in recent years to energy management through mapping, efficiency enhancement measures, knowledge-sharing between operators via seminars and workshops, and the development of tools and calculation methods.

## 6.2.3 ROADMAP FOR THE NCS

A roadmap for the NCS drawn up by the petroleum industry in 2016 set specific goals and ambitions for further cuts in emissions from oil and gas production. It was 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 LO.

The Norwegian petroleum sector 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 $CO_2$ 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. The goal is that maritime operations on the NCS will be conducted with low- or zero-emission technologies in the offshore fleet by 2030.

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 as well as efforts to identify and implement measures for reducing GHG emissions.

Since the industry has already met the KonKraft 2020 goal, reporting has begun on measures aimed at achieving the 2030 target.

# 6.3 GHG 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.**

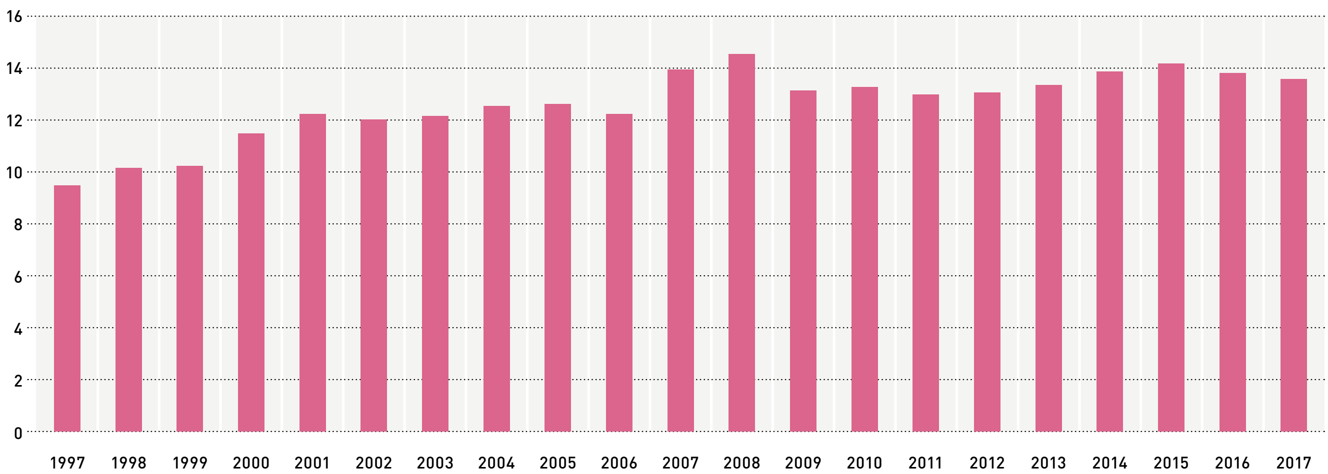
Figure 21 shows that total GHG emissions from the NCS and land-based facilities subject to the Petroleum Tax Act came to 13.6 million tonnes of $CO_2$ equivalent in 2017. That compares with 13.8 million the year before. The main reason why overall emissions have declined for two years in a row is a significant reduction in offshore flaring and lower emissions from engines. Methane emissions fell further in 2017 because of the transition to more realistic emission factors (see section 6.6). At the same time, total petroleum output rose because of increased gas exports to the rest of Europe. Specific emissions of $CO_2$ per unit produced ($CO_2$ intensity) therefore also declined.

Petroleum production in Norway leads the world for low GHG emissions. On average, these are less than half the global average per unit produced. The sector is subject to a number of instruments in this respect, including the $CO_2$ tax, the ETS, the $NO_x$ tax/fund, flaring restrictions in production licences, emission permits with energy management requirements, the obligation to use the BAT and the duty to assess and implement power from shore with new developments. These regulatory tools have produced and will continue to produce measures on the NCS.

Improved recovery measures will normally increase energy consumption per barrel produced. The fact that low emissions per unit produced have been maintained on the NCS while the recovery factor has risen substantially therefore represents a considerable achievement.

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). At the same time, certain other oil-producing countries 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 exploited 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 for only 20 per cent of production in 2014.

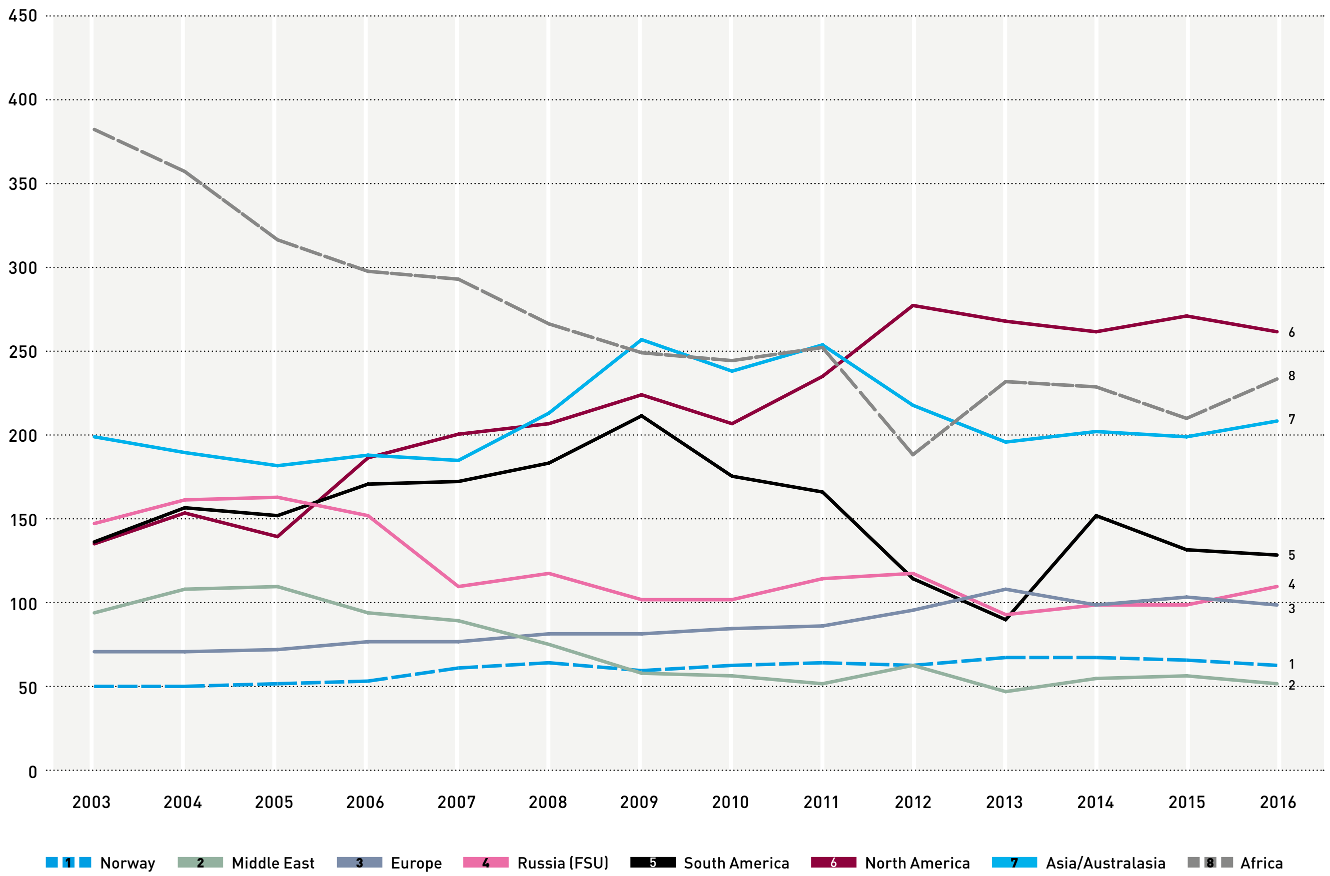
The data in figure 22 are taken from the annual report issued by the International Association of Oil & Gas Producers (IOGP), which presents the figures at regional rather than national level.

Norwegian Oil and Gas commissioned Rystad Energy in 2016 to provide a more detailed benchmarking of world oil production and associated emissions. This consultancy has a database covering global oil and gas output at field level, and has also developed a methodology for assessing emissions from each field which incorporates not only production but also refining and oil/gas consumption. On that basis, Rystad 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 emissions is the type of hydrocarbons in the reservoir. Technology and 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 comparison shows that the NCS is the best performer overall, with the lowest total emissions per unit produced when the whole chain from production and refining to consumption (by combustion) of oil and gas is taken into account.

FIGURE 22 **GHG EMISSIONS PER UNIT PRODUCED IN VARIOUS PETROLEUM PROVINCES 2003-16**
(KG OF $CO_2$ EQUIVALENT PER TONNE OF OE PRODUCED)

*Sources: IOGP and EEH*



While certain other countries benefit from large fields which are relatively simple to produce, as in Middle East, Norway has organised itself with large platforms serving several fields. This provides economies of scale and thereby reduces emissions. In addition, the country possesses a number of fields in global terms with power from shore and little flaring. Rystad's results show that, in terms of individual countries, Saudi Arabia and the United Arab Emirates have slightly lower emissions per unit produced than the NCS, but that higher emissions per unit produced in the Middle East as a region are more than 60 per cent above the Norway level – in part because of much flaring in Iraq and Iran.

Rystad's comparison confirms that $CO_2$ intensity on the NCS is 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.

> The most significant factor for emissions is the type of hydrocarbons in the reservoir. Others are technology, management, the extent of flaring and power from shore as well as the maturity of the continental shelf.

FIGURE 23

**$CO_2$ EMISSIONS ACROSS THE VALUE CHAIN FOR THE TOP 20 OIL/GAS PRODUCERS**
(KG OF $CO_2$ PER BARREL OF OE)

*Source: Rystad Energy*

# 6.4 DIRECT $CO_2$ EMISSIONS

**Total direct $CO_2$ emissions from operations on the NCS and land-based facilities subject to the Petroleum Tax Act amounted to 13.19 million tonnes in 2017, compared with 13.34 million the year before (figure 24).**

The main reason for the decline in the total amount of $CO_2$ released directly was reduced emissions from existing fields on the NCS following a significant drop in flaring and lower emissions from engines. At the same time, overall output from the NCS rose as a result of increased gas exports to the rest of Europe. Specific $CO_2$ emission per unit produced ($CO_2$ intensity) on the NCS therefore also declined.

Norway's oil and gas industry released 13.19 million tonnes of $CO_2$ in 2017.

Figure 25 presents the development of $CO_2$ emissions and the volume of gas flared in 2000-2017. A marked decline occurred from 2016 after a period with relatively stable quantities of flared gas.

Figure 26 shows the development of direct and indirect $CO_2$ emissions per volume of hydrocarbons delivered in 1990-2017. Specific $CO_2$ emissions in 2017 were 49.8 kilograms per scm oe produced.

That represents an improvement compared with the three previous years. 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 2017 (PER CENT)

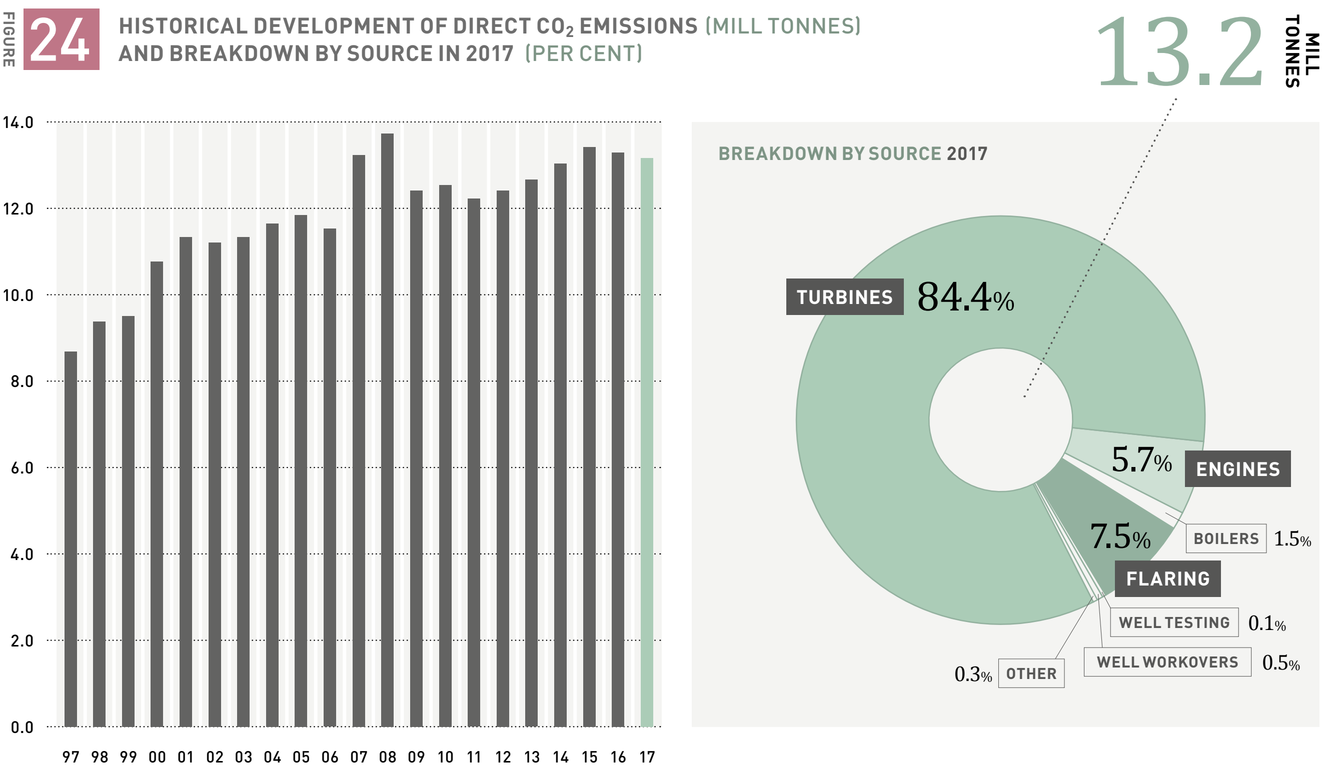


FIGURE 25
## HISTORICAL DEVELOPMENT OF FLARE GAS CONSUMPTION (SCM) AND ASSOCIATED CALCULATED $CO_2$ EMISSIONS (TONNES)

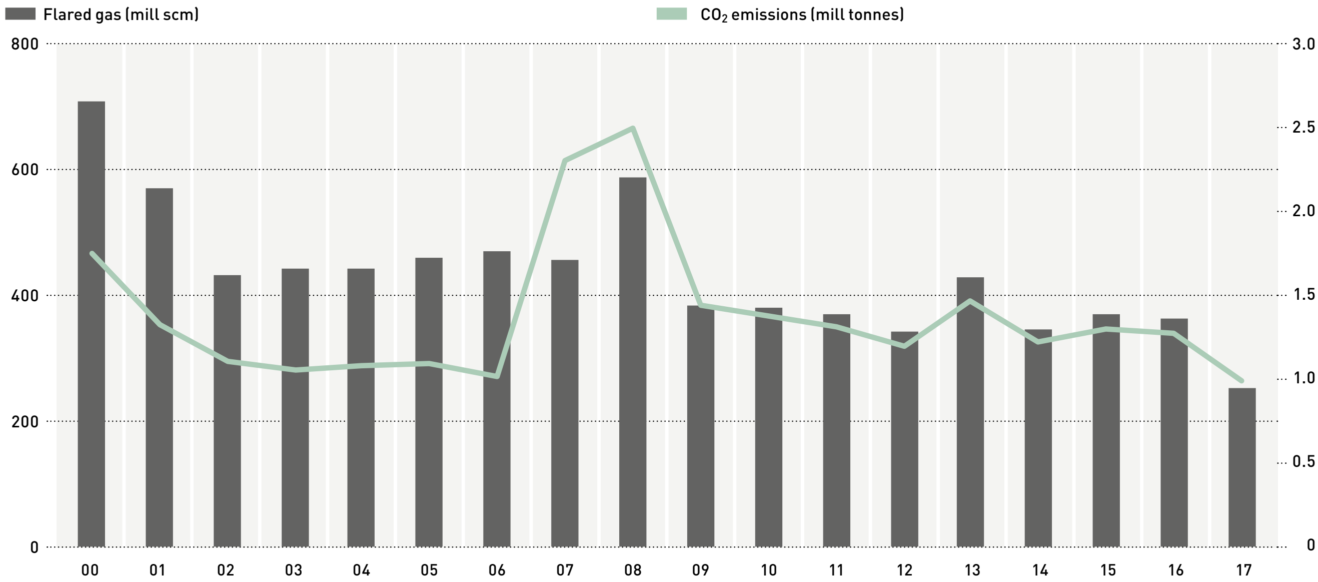
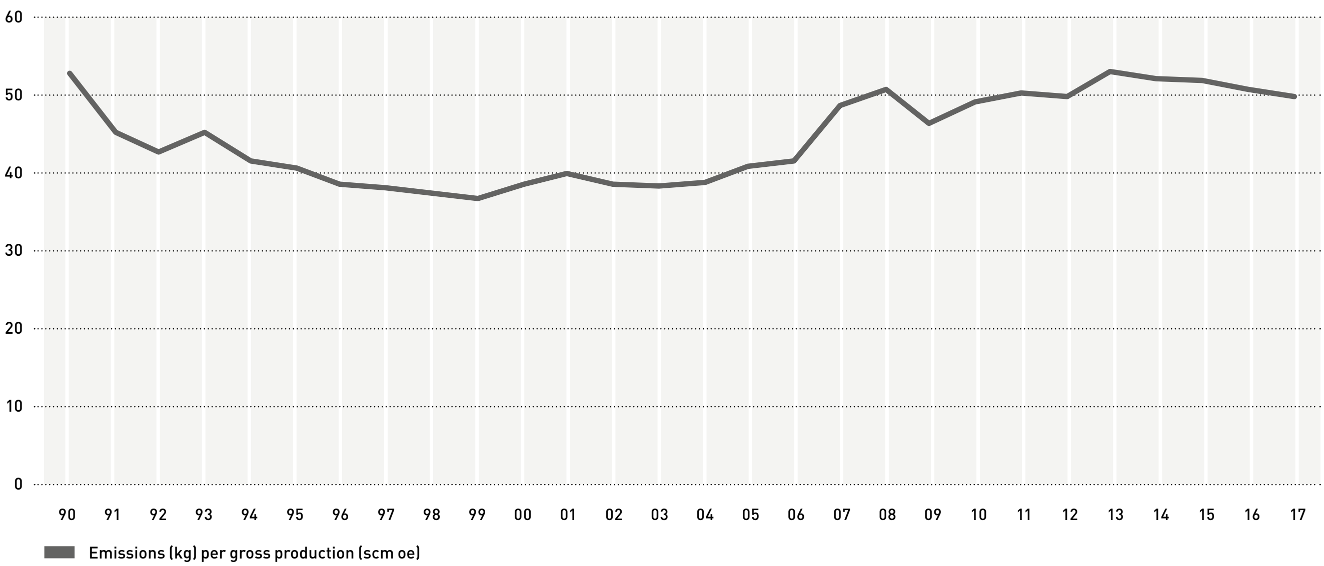



FIGURE 26
## SPECIFIC $CO_2$ EMISSIONS (KG/SCM OE)



# 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 achieve both climate and health benefits.**

$CH_4$ and nmVOC released from cold venting and fugitive emissions are the most important sources in the petroleum 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.


M-515 | 2016

Cold venting and fugitive emissions from Norwegian offshore oil and gas activities

Summary report

Prepared for the Norwegian Environment Agency

Geir Husdal
Lene Osenbroch
Özlem Yetkinoglu
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12 April 2016

## 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 largely of $CH_4$.

Since $CO_2$ emissions per unit of electricity generated from gas-fired power stations are only half of those released from coal-fired generating plant, switching from the latter to the former will be a good climate measure. This requires that methane emissions from production, the gas pipeline system and distribution to consumers are less than three per cent of the distributed volume.

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 for the whole gas value chain from the NCS are around 0.6 per cent. An Equinor 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.

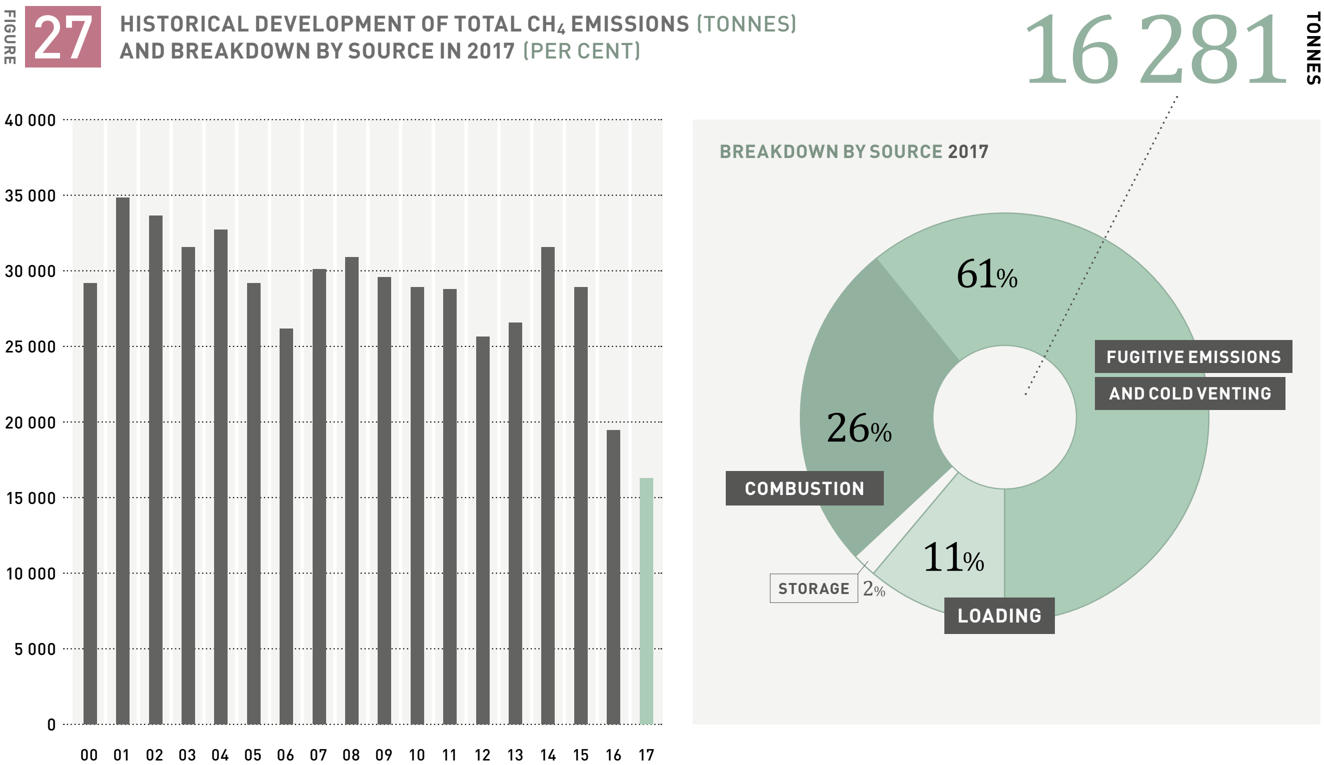
Efforts to avoid leaks have long been given priority on the NCS for both safety and environmental reasons. As a result, emissions related to upstream gas production from the NCS are only about 0.1 per cent of the volume produced.

# 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 2017, when a total of 16 281 tonnes was released – down by more than 40 per cent from 2015. This reflects, as mentioned above, the revision of emission factors carried out after the $CH_4$/nmVOC project with the NEA. Guidelines for reporting have been changed from the 2017 reporting year. However, Equinor 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 most important operational sources of $CH_4$ from the offshore oil and gas sector.

FIGURE 27 HISTORICAL DEVELOPMENT OF TOTAL $CH_4$ EMISSIONS (TONNES) AND BREAKDOWN BY SOURCE IN 2017 (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.**

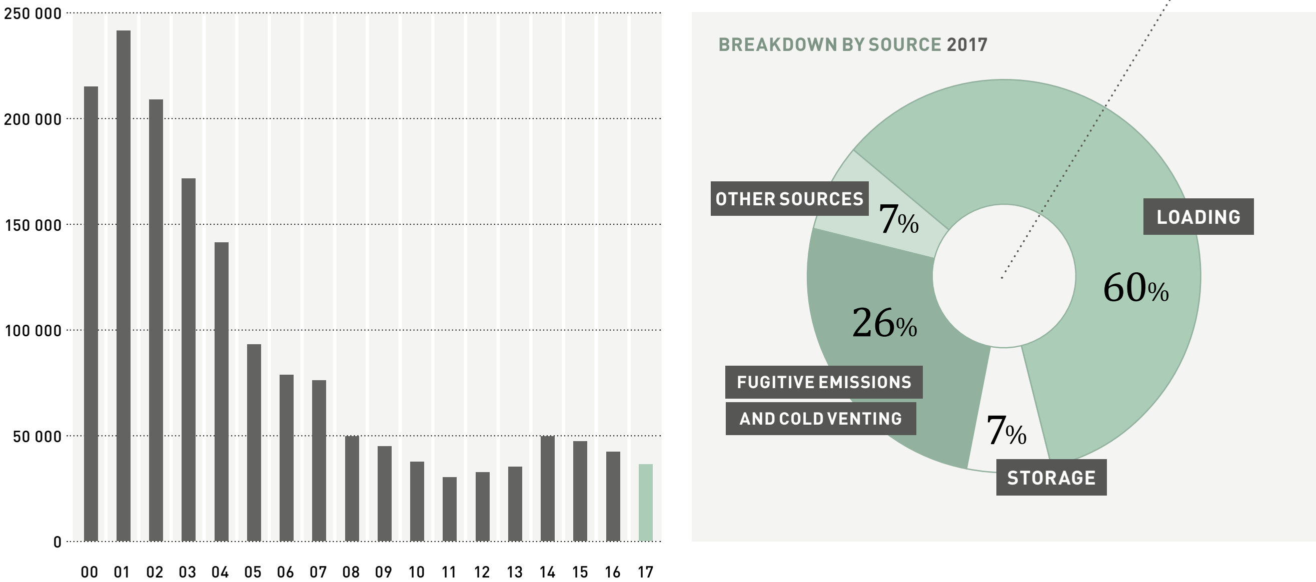
The total quantity of nmVOC emitted from the NCS declined from 42 503 tonnes in 2016 to 36 546 tonnes.

This reduction primarily reflected the joint project with the NEA described in section 6.6.

NmVOC emissions have shown a declining trend throughout the period since 2001.

FIGURE 28 **HISTORICAL DEVELOPMENT OF TOTAL nmVOC EMISSIONS** (TONNES) **AND BREAKDOWN BY SOURCE IN 2017** (PER CENT)

36 546 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.**

The business fund for $NO_x$ supports enterprises which implement measures to reduce their $NO_x$ emissions. Payments are made when the measure has been implemented and documented.

A new $NO_x$ agreement for 2018-25 was approved by the Efta Surveillance Authority (ESA) in February 2018, and is regarded as a stronger instrument for emission reductions than earlier environmental agreements. The commitment it imposes is an emission ceiling which reduces over time. Possible increases in activity in sectors covered by the agreement must be offset by further reductions.

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.

The Heimdal platform in the North Sea.

# 6.9 EMISSIONS OF $NO_X$

**Petroleum industry operations emitted a total of 42 900 tonnes of $NO_X$ in 2017, down from 44 717 tonnes the year before. Part of the decline reflected lower emissions from diesel engines following the implementation of emission-reducing measures on mobile units which have received support through the $NO_X$ fund.**

Figure 29 presents $NO_x$ emissions from operations on the NCS and how these broke down by source in 2017.

Specific $NO_x$ emissions for the year totalled 0.17 kilograms per scm oe delivered, down from 2016 (see figure 30). The primary reason for this fall was a decline in consumption of diesel oil as fuel following emission reductions on mobile rigs.

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

FIGURE 30 $NO_X$ EMISSIONS PER VOLUME OF HYDROCARBONS DELIVERED 1997-2017 (KG/SCM OE)

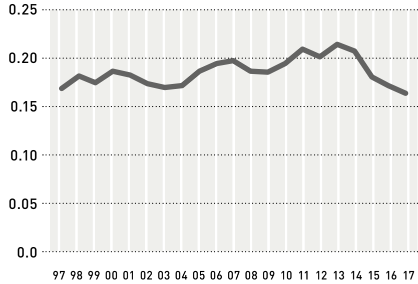
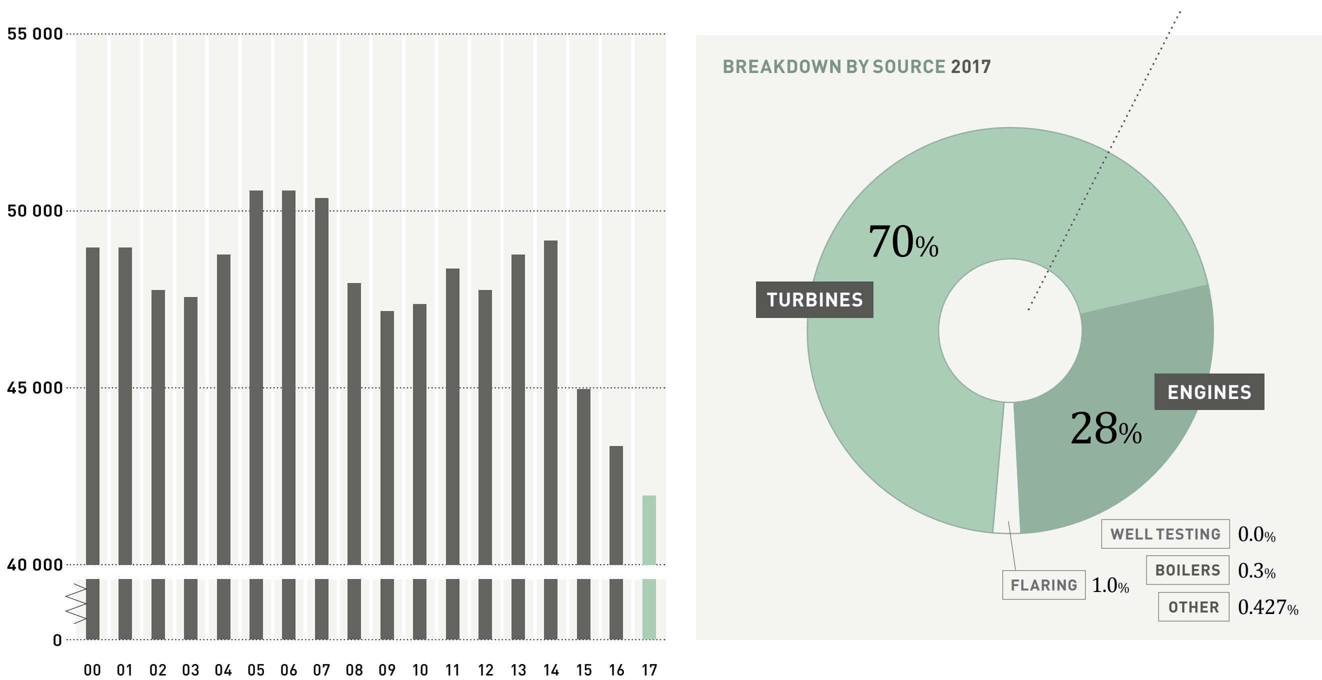



FIGURE 29 HISTORICAL DEVELOPMENT OF TOTAL $NO_X$ EMISSIONS (TONNES) AND BREAKDOWN BY SOURCE IN 2017 (PER CENT)

42 900 TONNES

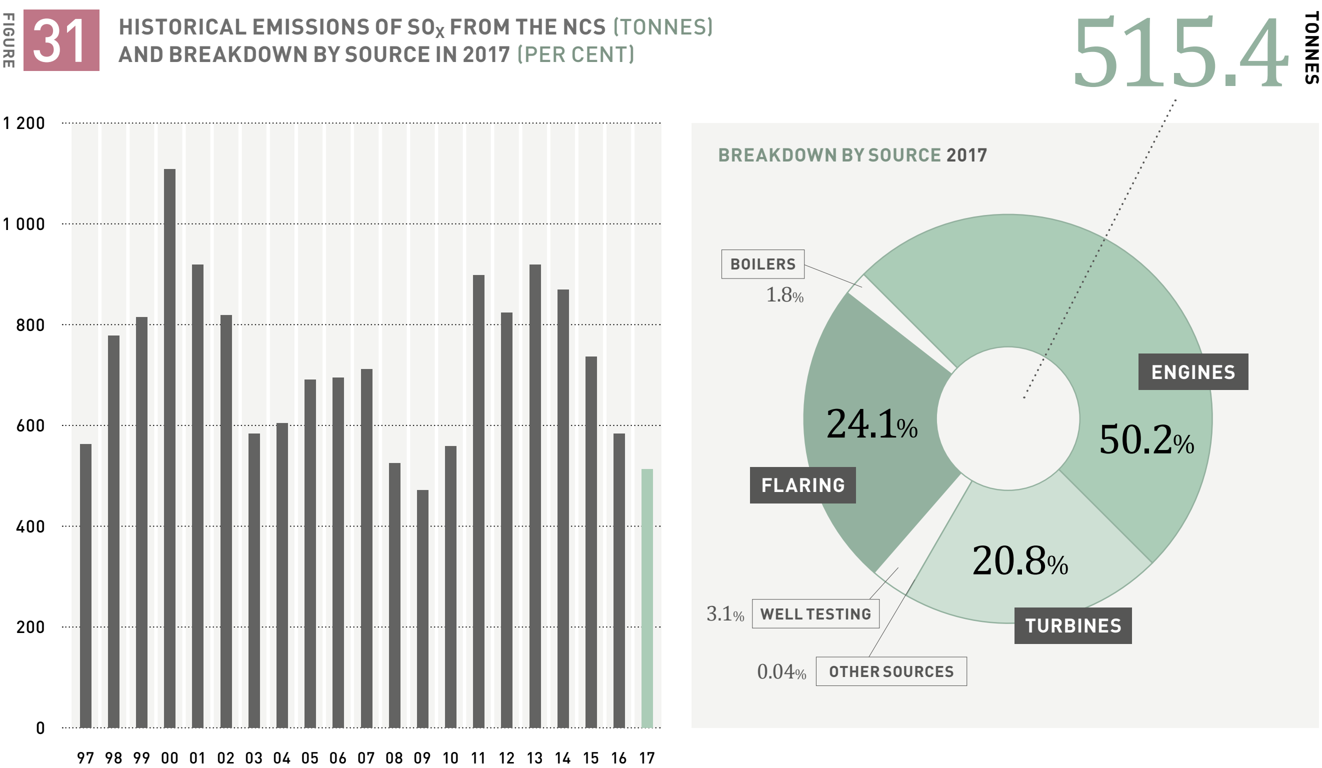


# 6.10 EMISSIONS OF $SO_X$

*Polar Pioneer* working in the Barents Sea.

Figure 31 shows $SO_x$ emissions from operations on the NCS and their breakdown by source in 2017. Total emissions in 2017 came to 515 tonnes, down from 584 tonnes the year before. This decline primarily reflected reduced consumption of diesel oil.

FIGURE 31 HISTORICAL EMISSIONS OF $SO_X$ FROM THE NCS (TONNES) AND BREAKDOWN BY SOURCE IN 2017 (PER CENT)



# 7 WASTE

**THE PETROLEUM INDUSTRY IS NORWAY'S BIGGEST WASTE GENERATOR. IT 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 the declaration and further treatment of the waste. All waste is sent ashore in accordance with the industry's guidelines.**

**NON-HAZARDOUS WASTE**

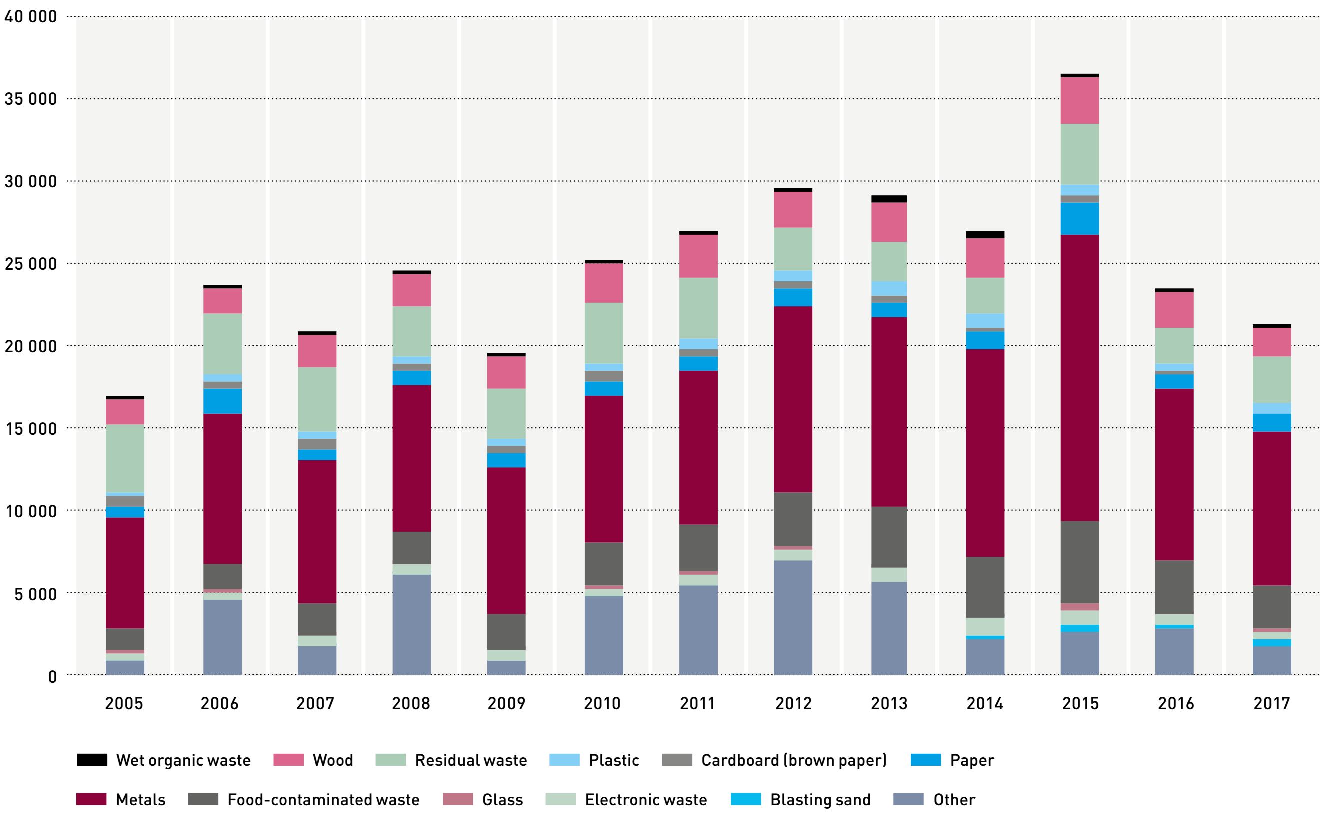
Non-hazardous waste totalled just over 21 000 tonnes in 2017, down by almost 10 per cent from the year before. The biggest change was reduced quantities of metal sent ashore.

**HAZARDOUS WASTE**

Just under 345 000 tonnes of hazardous waste were delivered for treatment on land in 2017, a marked reduction from just under 530 000 tonnes the year before.

The fraction with the biggest fall was drilling waste. Cuttings contaminated with oil-based fluid declined from 118 000 tonnes in 2016 to just under 88 000 tonnes. The quantity of oily water from drilling operations was also reduced.

FIGURE 32 **BREAKDOWN OF NON-HAZARDOUS WASTE FROM THE OFFSHORE INDUSTRY BY VARIOUS CATEGORIES IN 2017** (TONNES)

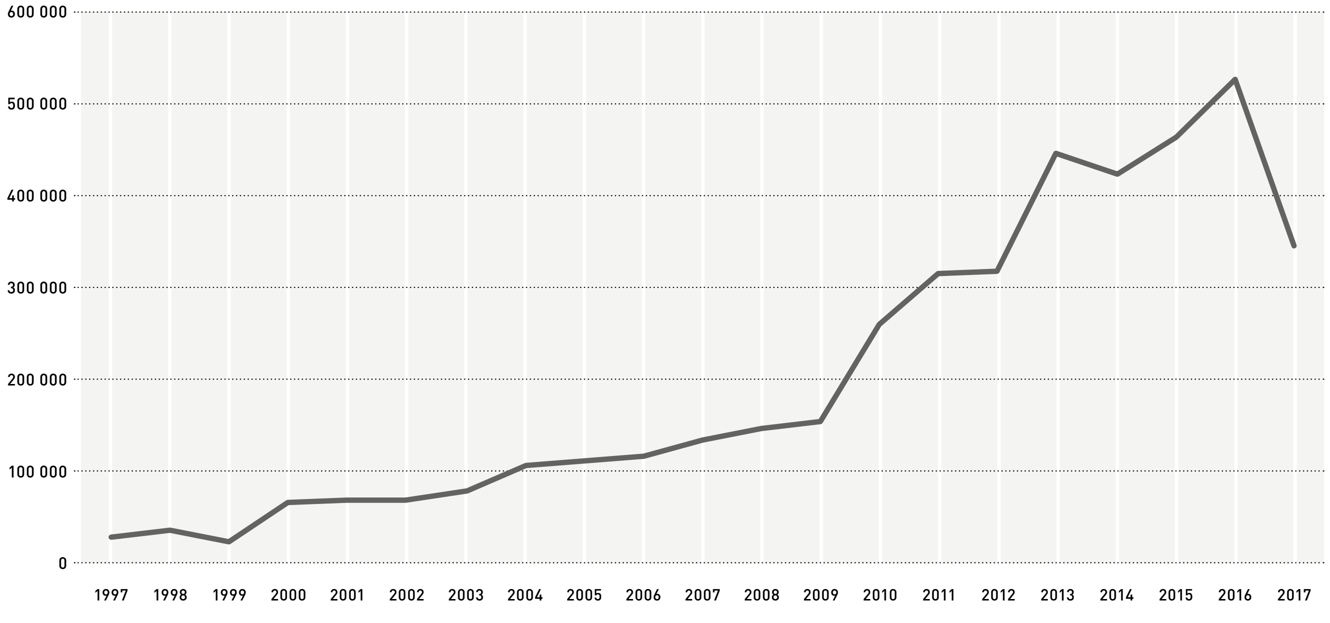


Growth in the quantity of oily waste since 2009 largely reflected earlier injection. Problems with leaks from injection wells were discovered on several fields up to 2009, and such injection ceased in 2009-10. Oily waste was sent ashore for treatment instead. Management of cuttings on these installations was designed for slurrification in order to make injection easier. 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 of new injection wells means that the quantity of injected oily waste is again rising slightly (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, the change makes it difficult to compare the various waste types with earlier statistics. A number of the categories

FIGURE 33 HAZARDOUS WASTE SENT ASHORE FROM THE OFFSHORE INDUSTRY IN 2017 (TONNES)



have been split into several sub-types, while others have been merged.

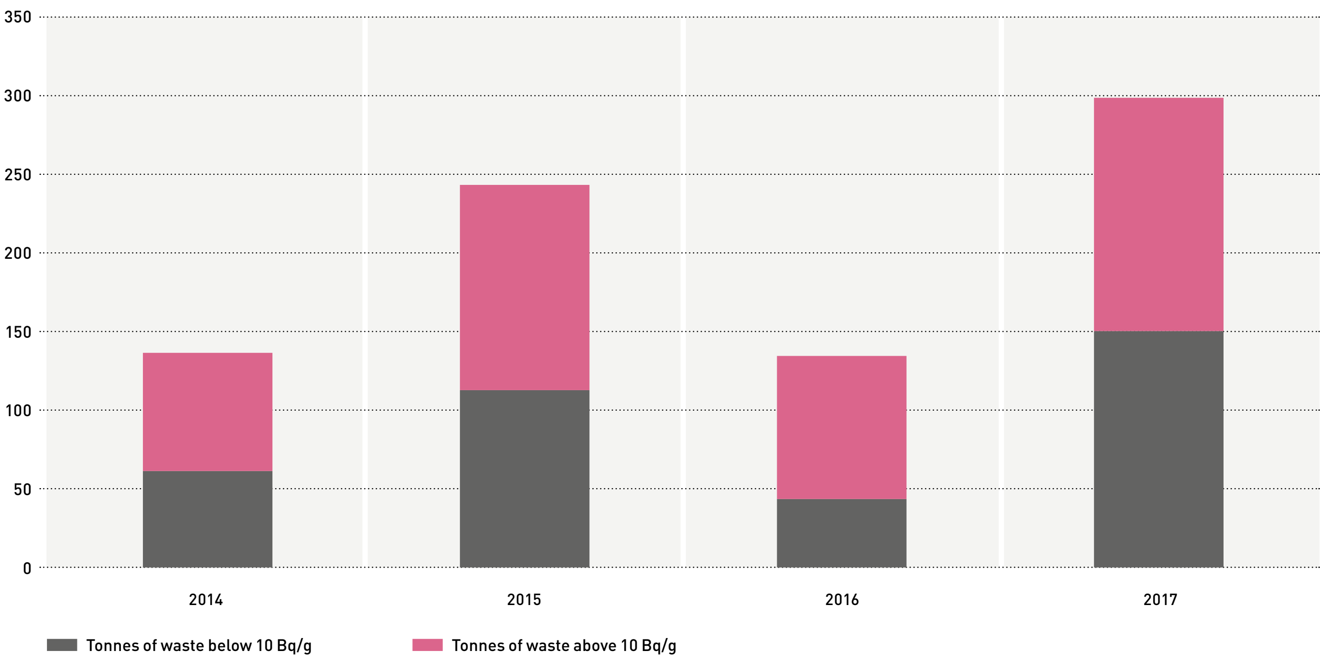
**LOW-LEVEL RADIOACTIVE WASTE**
Rocks beneath the seabed contain varying amounts of radium and other radioactive isotopes. These naturally occurring radioactive substances accompany oil, gas and – primarily – water to the surface during production. On some fields, sludge cleaned from oil-water separators 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.

Figure 34 presents the quantity of waste in tonnes delivered for final disposal in the two categories. The amount with activity below 10 Bq/g varies considerably because of changing reception capacity.

Just over 300 tonnes of low-level radioactive waste were dealt with in 2017.

FIGURE 34 LOW-LEVEL RADIOACTIVE WASTE DELIVERED FOR FINAL DISPOSAL (TONNES)



# 8

# SEISMIC SURVEYS

**MARINE SEISMIC SURVEYING IS THE MOST IMPORTANT TOOL AVAILABLE FOR MAPPING POSSIBLE OIL AND GAS DEPOSITS BENEATH THE SEABED.**

**Seismic surveys are also used to follow developments in the reservoirs, so that the maximum amount of oil and gas can be recovered from producing fields. In addition, they are important for assessing the properties of possible reservoirs before drilling wildcats to ensure that the most appropriate technology is used for this work. That reduces the risk related to operations in this phase.**

Seismic surveys are conducted by transmitting sound waves beneath the seabed, which reflect back from the different strata and are picked up by hydrophones. These signals can be used to form a picture of the sub-surface. The sound waves are generated by releasing compressed air at a pressure of roughly 200 bar, and differ significantly from those created with the aid of explosives. They therefore do not cause comparable injuries to fish.

Pressure changes generated in water are measured in Pascals, but acoustic strength is more usually expressed in decibels (dB), a logarithmic way of expressing the ratio between the measured pressure and a reference value. Since the latter differs between air and water, acoustic pressure cannot be compared directly in terms of the dB value. Close to the sound source, the pressure can reach about 220-200 dB. That would correspond to roughly 160-140 dB in air, where the reference value is different, and be comparable to the acoustic pressure from a hunting rifle. The acoustic pressure from the propeller of a large ship has been measured at 190-200 dB.

Sound can occur either as continuous signals – from ship's propellers and offshore wind turbines, for example – or as pulses. Signals used in seismic surveys today are short pulses repeated every eight to 10 seconds during operations, and can be classified as pulsating sound on the basis of their character and effect on marine life.

Research to identify possible damage to marine organisms from seismic surveys has been conducted both in Norway and internationally. Harmful effects on individual fish have almost exclusively been identified at early life stages, such as egg, larva and fry. While the impact on adults in the immediate vicinity of the acoustic source is confined by and large to temporary hearing loss, young fish less than five metres away have been killed. No harm has been found beyond that distance. The conclusion is that seismic sound waves will not have any negative significance for fish populations, even in the most intense breeding period.

The conclusion is that seismic sound waves will not have any negative significance for fish populations, even in the most intense breeding period.

‹ *Ramform Viking*. Source: PSG.

# 9 TABLES

TABLE 01

## HISTORICAL PRODUCTION DATA FOR THE NCS – SALEABLE (MILL SCM, EXCEPT GAS: BN SCM)

| Year | Oil | Gas | NGL | Condensate | Oil equivalent |
|---|---|---|---|---|---|
| 2008 | 122.66 | 100.11 | 16.94 | 3.92 | 243.64 |
| 2009 | 114.94 | 104.26 | 16.96 | 4.44 | 240.60 |
| 2010 | 104.39 | 107.00 | 15.55 | 4.17 | 231.11 |
| 2011 | 97.46 | 101.27 | 16.31 | 4.58 | 219.62 |
| 2012 | 89.20 | 114.72 | 17.80 | 4.57 | 226.29 |
| 2013 | 84.94 | 108.75 | 17.72 | 3.99 | 215.39 |
| 2014 | 87.75 | 108.82 | 18.95 | 2.91 | 218.44 |
| 2015 | 90.85 | 117.12 | 19.60 | 2.47 | 230.04 |
| 2016 | 93.96 | 116.65 | 20.18 | 1.93 | 232.73 |
| 2017 | 92.15 | 124.16 | 20.39 | 1.71 | 238.42 |

TABLE 02

## VOLUME OF GAS INJECTED AND CONSUMED (SCM)

| Year | Water | Gas | Gross fuel gas | Gross flare gas |
|---|---|---|---|---|
| 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 | 133 767 527 | 34 724 594 140 | 3 827 771 821 | 345 026 015 |
| 2015 | 143 329 249 | 35 323 271 891 | 4 047 965 041 | 372 726 858 |
| 2016 | 140 628 485 | 35 534 557 532 | 3 985 715 778 | 365 768 248 |
| 2017 | 147 091 676 | 30 938 793 047 | 4 127 007 536 | 254 166 656 |

‹ Hywind in Scotland, the first turbine on its way out.

TABLES

TABLE 03 DRILLING WITH OIL-BASED FLUIDS (TONNES)

| Year | Base fluids **Consumption** | Base fluids **Discharged** | Base fluids **Injected** | Base fluids **Transported to land** | Base fluids **Lost to formation** |
|---|---|---|---|---|---|
| 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 |
| 2017 | 127 693 | 0 | 23 290 | 55 310 | 49 094 |

TABLE 04 DRILLING WITH SYNTHETIC FLUIDS (TONNES)

| Year | Base fluids **Consumption** | Base fluids **Discharged** | Base fluids **Injected** | Base fluids **Transported to land** | Base fluids **Lost to formation** |
|---|---|---|---|---|---|
| 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 |
| 2017 | 0 | 0 | 0 | 0 | 0 |

TABLE 05 DRILLING WITH WATER-BASED FLUIDS (TONNES)

| Year | Base fluids **Consumption** | Base fluids **Discharged** | Base fluids **Injected** | Base fluids **Transported to land** | Base fluids **Lost to formation** |
|---|---|---|---|---|---|
| 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 |
| 2017 | 275 906 | 178 126 | 11 774 | 11 822 | 74 185 |

TABLE 06

## DISPOSAL OF CUTTINGS FROM DRILLING WITH OIL-BASED FLUIDS. CALCULATED FIGURES (TONNES)

| 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** |
|---|---|---|---|---|---|
| 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 |
| 2017 | 0 | 0 | 33 866 | 63 210 | 97 076 |

TABLE 07

## DISPOSAL OF CUTTINGS FROM DRILLING WITH WATER-BASED FLUIDS. CALCULATED FIGURES (TONNES)

| Year | Base cuttings **Exported to other fields** | Base cuttings **Discharged to sea** | Base cuttings **Volume injected** | Base cuttings **Transported to land** | **Total cuttings/ mud generated** |
|---|---|---|---|---|---|
| 2008 | 651 | 73 639 | 2 717 | 2 501 | 79 283 |
| 2009 | 0 | 129 674 | 1 624 | 104 | 131 683 |
| 2010 | 0 | 207 655 | 664 | 9 896 | 218 216 |
| 2011 | 0 | 195 062 | 5 741 | 10 885 | 211 666 |
| 2012 | 0 | 171 842 | 1 169 | 3 774 | 176 785 |
| 2013 | 0 | 123 005 | 50 | 2 210 | 125 265 |
| 2014 | 0 | 113 840 | 24 | 525 | 114 389 |
| 2015 | 1 239 | 99 424 | 0 | 2 405 | 103 068 |
| 2016 | 0 | 105 070 | 0 | 1 334 | 106 403 |
| 2017 | 0 | 90 831 | 305 | 131 | 91 266 |

TABLE 08

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

| Substance | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| BTEX | 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 | 2 106 254 |
| Phenols | 544 857 | 508 365 | 487 429 | 492 449 | 523 242 | 505 708 | 653 851 | 633 705 | 575 592 | 581 212 |
| Oil in water | 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 | 1 734 866 |
| Organic acids | 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 | 27 409 773 |
| PAH compounds | 129 468 | 153 177 | 142 408 | 157 778 | 168 160 | 157 896 | 169 764 | 131 426 | 125 702 | 128 849 |
| Heavy metals | 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 | 9 673 937 |

TABLE 09

## BTX COMPOUNDS DISCHARGED IN PRODUCED WATER (KG)

| Substance | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Benzene | 862 411 | 868 175 | 832 031 | 771 333 | 848 713 | 867 970 | 973 116 | 1 021 530 | 1 038 496 | 995 399 |
| Ethylbenzene | 34 675 | 46 135 | 41 758 | 37 913 | 43 761 | 45 992 | 53 131 | 52 764 | 51 915 | 49 749 |
| Toluene | 672 398 | 722 851 | 700 550 | 655 169 | 710 617 | 736 238 | 725 968 | 828 299 | 805 875 | 756 232 |
| Xylene | 234 513 | 265 764 | 243 835 | 210 644 | 251 946 | 272 427 | 157 481 | 365 941 | 324 955 | 304 874 |

TABLE 10

## HEAVY METALS DISCHARGED IN PRODUCED WATER (KG)

| Substance | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 614 | 483 | 895 | 656 | 604 | 622 | 645 | 746 | 642 | 708 |
| Barium | 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 | 8 988 989 |
| Lead | 386 | 290 | 239 | 428 | 309 | 70 | 191 | 84 | 91 | 115 |
| Iron | 1 058 121 | 797 369 | 825 822 | 959 698 | 863 198 | 653 691 | 833 664 | 780 463 | 695 635 | 680 518 |
| Cadmium | 41 | 28 | 22 | 32 | 18 | 7 | 11 | 5 | 6 | 10 |
| Copper | 102 | 102 | 89 | 162 | 143 | 109 | 249 | 128 | 155 | 176 |
| Chrome | 213 | 154 | 225 | 221 | 131 | 107 | 124 | 99 | 183 | 173 |
| Mercury | 11 | 9 | 9 | 15 | 13 | 8 | 8 | 9 | 8 | 9 |
| Nickel | 299 | 142 | 200 | 223 | 198 | 119 | 128 | 1 210 | 116 | 126 |
| Zinc | 16 651 | 7 100 | 6 948 | 10 108 | 5 418 | 3 608 | 9 303 | 1 523 | 1 436 | 3 113 |

TABLE 11

## PHENOLS
DISCHARGED IN PRODUCED WATER (KG)

| Stoff | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| C1-Alkylphenols | 207 855 | 203 376 | 199 007 | 186 923 | 190 276 | 182 387 | 266 814 | 242 415 | 232 258 | 222 264 |
| C2-Alkylphenols | 87 634 | 80 707 | 83 860 | 82 207 | 70 392 | 74 647 | 89 033 | 98 818 | 82 488 | 75 041 |
| C3-Alkylphenols | 29 137 | 26 108 | 27 350 | 29 194 | 39 995 | 40 560 | 43 232 | 43 471 | 35 436 | 32 448 |
| C4-Alkylphenols | 10 451 | 11 624 | 8 707 | 11 195 | 11 315 | 9 470 | 9 393 | 10 482 | 9 218 | 7 429 |
| C5-Alkylphenols | 2 022 | 1 325 | 1 551 | 3 165 | 4 577 | 3 742 | 3 453 | 3 455 | 2 694 | 1 996 |
| C6-Alkylphenols | 84 | 78 | 125 | 81 | 52 | 40 | 46 | 66 | 55 | 39 |
| C7-Alkylphenols | 61 | 22 | 55 | 61 | 53 | 96 | 120 | 88 | 62 | 63 |
| C8-Alkylphenols | 39 | 20 | 71 | 45 | 11 | 7 | 15 | 16 | 10 | 12 |
| C9-Alkylphenols | 13 | 64 | 44 | 31 | 8 | 4 | 50 | 7 | 7 | 9 |

TABLE 12

## ORGANIC ACIDS
DISCHARGED IN PRODUCED WATER (KG)

| Substance | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Butyric acid | 714 602 | 627 237 | 519 296 | 453 964 | 456 609 | 552 567 | 343 341 | 506 640 | 438 843 | 440 411 |
| Acetic acid | 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 | 23 728 815 |
| Formic acid | 314 221 | 563 669 | 493 913 | 450 016 | 341 274 | 1 294 782 | 517 012 | 495 495 | 408 644 | 353 922 |
| Naphthenic acid | 250 405 | 264 051 | 179 185 | 99 691 | 96 547 | 126 423 | 124 885 | 16 343 | 11 341 | 23 511 |
| Valeric acid | 341 590 | 338 214 | 241 354 | 159 998 | 165 674 | 175 702 | 167 286 | 176 567 | 163 812 | 175 891 |
| Propionic acid | 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 | 2 687 222 |

TABLE 13

## PAH COMPOUNDS
DISCHARGED IN PRODUCED WATER (KG)

| Compound | EPA PAH 16 | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Acenaphthene | Yes | 164 | 198 | 196 | 225 | 217 | 418 | 350 | 203 | 188 | 204 |
| Acenaphthylene | Yes | 174 | 93 | 83 | 94 | 93 | 127 | 158 | 381 | 196 | 132 |
| Anthracene | Yes | 60 | 10 | 7 | 9 | 8 | 36 | 49 | 75 | 46 | 45 |
| Benzo(a)anthracene | Yes | 18 | 9 | 8 | 8 | 9 | 15 | 23 | 16 | 13 | 15 |
| Benzo(a)pyrene | Yes | 5 | 4 | 3 | 3 | 3 | 7 | 13 | 4 | 4 | 5 |
| Benzo(b)fluoranthene | Yes | 16 | 9 | 9 | 10 | 10 | 8 | 14 | 16 | 14 | 16 |
| Benzo(g,h,i)perylene | Yes | 7 | 6 | 6 | 6 | 6 | 6 | 5 | 8 | 6 | 8 |
| Benzo(k)fluoranthene | Yes | 4 | 2 | 1 | 1 | 1 | 10 | 5 | 11 | 2 | 4 |
| C1-dibenzothiophene | No | 761 | 667 | 601 | 716 | 808 | 1 082 | 1 097 | 734 | 671 | 758 |
| C1-Phenanthrene | No | 1 589 | 2 438 | 2 222 | 2 873 | 2 957 | 2 860 | 3 086 | 2 767 | 2 424 | 2 521 |
| C1-naphthalene | No | 44 155 | 47 410 | 45 000 | 49 202 | 54 446 | 32 299 | 41 387 | 31 553 | 31 588 | 31 975 |
| C2-dibenzothiophene | No | 634 | 939 | 878 | 1 160 | 1 217 | 1 470 | 1 612 | 1 262 | 1 124 | 1 396 |
| C2-Phenanthrene | No | 1 976 | 2 706 | 2 598 | 3 747 | 3 748 | 4 040 | 4 247 | 3 668 | 3 389 | 4 081 |
| C2-naphthalen | No | 19 636 | 24 669 | 21 880 | 26 936 | 27 707 | 31 184 | 27 602 | 18 388 | 18 816 | 17 645 |
| C3-dibenzothiophene | No | 92 | 20 | 22 | 27 | 26 | 4 845 | 6 822 | 825 | 691 | 855 |
| C3-Phenanthrene | No | 306 | 662 | 694 | 1 157 | 1 111 | 1 604 | 1 743 | 1 557 | 1 351 | 1 361 |
| C3-naphthalene | No | 11 614 | 21 719 | 17 219 | 22 363 | 23 230 | 26 265 | 22 525 | 13 253 | 14 131 | 16 557 |
| Dibenz(a,h)anthracene | Yes | 4 | 3 | 2 | 3 | 2 | 2 | 2 | 3 | 2 | 3 |
| Dibenzothiophene | No | 394 | 435 | 407 | 465 | 518 | 492 | 517 | 465 | 411 | 453 |
| Phenanthrene | Yes | 1 565 | 1 712 | 1 576 | 1 775 | 1 781 | 1 674 | 2 008 | 1 981 | 1 815 | 1 959 |
| Fluoranthene | Yes | 28 | 25 | 27 | 45 | 37 | 35 | 43 | 52 | 43 | 44 |
| Fluorene | Yes | 1 166 | 1 175 | 1 126 | 1 384 | 1 327 | 1 473 | 1 599 | 1 696 | 1 404 | 1 384 |
| Indeno(1,2,3-c,d)pyrene | Yes | 3 | 2 | 1 | 1 | 2 | 2 | 1 | 17 | 1 | 4 |
| Chrysene | Yes | 61 | 42 | 30 | 41 | 38 | 77 | 122 | 97 | 74 | 83 |
| Naphthalene | Yes | 44 963 | 48 175 | 47 770 | 45 492 | 48 816 | 47 806 | 54 669 | 52 338 | 47 242 | 47 291 |
| Pyrene | Yes | 74 | 49 | 43 | 34 | 41 | 60 | 64 | 57 | 55 | 52 |

TABLE 14

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

| NEA colour category | | 2008 | 2009 | 2010* | 2011 | 2012** | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Green | Consumption | 351 815 | 382 892 | 374 541 | 351 387 | 368 849 | 451 433 | 420 988 | 409 276 | 388 767 | 327 461 |
| | Discharge | 116 614 | 158 201 | 127 249 | 138 019 | 147 773 | 153 671 | 152 255 | 142 807 | 138 882 | 123 859 |
| Yellow | Consumption | 95 348 | 91 886 | 103 061 | 80 141 | 82 881 | 100 990 | 95 101 | 104 137 | 110 981 | 99 694 |
| | Discharge | 12 957 | 14 649 | 11 727 | 12 305 | 13 533 | 14 019 | 14 546 | 14 418 | 14 232 | 14 756 |
| Red | Consumption | 4 323 | 3 206 | 2 894 | 1 842 | 2 088 | 3 004 | 3 172 | 3 464 | 3 047 | 2 817 |
| | Discharge | 15 | 21 | 16 | 8 | 8 | 8 | 14 | 67 | 103 | 96 |
| Black | Consumption | 60 | 16 | 1 259 | 1 140 | 746 | 531 | 691 | 401 | 609 | 355 |
| | Discharge | 2.5 | 1.2 | 1.4 | 0.6 | 2.4 | 6.7 | 13.3 | 6.6 | 3.6 | 4.7 |

* 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.

TABLE 15

## DISCHARGE OF OIL-CONTAMINATED WATER – ALL TYPES

| Water type | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|
| | | | | |
| | | | | |
| **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) | 10 | 6 | 8 | 8 |
| Discharges of water (cu.m) | 953 964 | 917 986 | 727 811 | 867 531 |
| Total water volume (cu.m) | 993 156 | 1 099 819 | 763 736 | 891 951 |
| Water injected (cu.m) | 36 298 | 184 247 | 19 875 | 16 740 |
| | | | | |
| | | | | |
| **DISPLACEMENT** | | | | |
| Discharges of dispersed oil (tonnes) | 58 | 55 | 47 | 51 |
| Discharges of water (cu.m) | 35 781 227 | 31 567 044 | 31 953 823 | 27 025 783 |
| Total water volume (cu.m) | 35 781 227 | 31 567 050 | 31 953 823 | 27 025 783 |
| Water injected (cu.m) | 0 | 0 | 0 | 0 |
| | | | | |
| | | | | |
| **PRODUCED** | | | | |
| Discharges of dispersed oil (tonnes) | 1 569 | 1 487 | 1 443 | 1 478 |
| Discharges of water (cu.m) | 149 241 700 | 134 770 215 | 130 842 793 | 128 550 571 |
| Total water volume (cu.m) | 173 375 110 | 158 559 726 | 157 890 256 | 160 758 982 |
| Water injected (cu.m) | 30 379 135 | 29 547 450 | 33 217 136 | 31 095 328 |
| | | | | |
| | | | | |
| **JETTING** | | | | |
| Discharges of dispersed oil (tonnes) | 13 | 24 | 65 | 53 |

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 |
| | 4 414 | 25 506 | 49 276 | 26 249 | 8 768 | 19 508 |
| | 4 414 | 27 101 | 49 871 | 40 073 | 9 293 | 20 837 |
| | 0 | 2 267 368 | 267 | 12 298 | 463 | 1 330 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | 8 | 8 | 11 | 8 | 8 | 8 |
| | 953 596 | 954 377 | 984 216 | 1 014 435 | 1 015 018 | 972 128 |
| | 979 802 | 991 618 | 1 065 755 | 1 124 895 | 1 100 171 | 1 108 276 |
| | 18 831 | 33 566 | 86 527 | 102 389 | 78 131 | 135 450 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | 58 | 56 | 43 | 40 | 38 | 32 |
| | 31 491 555 | 32 227 733 | 33 230 953 | 33 830 308 | 30 510 835 | 28 714 703 |
| | 31 491 555 | 32 227 733 | 33 230 953 | 33 830 308 | 30 510 835 | 28 714 703 |
| | 0 | 0 | 0 | 0 | 0 | 0 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | 1 535 | 1 541 | 1 761 | 1 819 | 1 698 | 1 621 |
| | 130 909 973 | 127 833 805 | 141 006 271 | 148 181 942 | 138 101 839 | 134 202 747 |
| | 162 958 696 | 161 188 862 | 176 840 378 | 186 681 015 | 178 111 199 | 173 109 836 |
| | 32 756 572 | 37 292 502 | 39 360 701 | 42 479 952 | 43 421 496 | 40 942 535 |
| | | | | | | |
| | | | | | | |
| | | | | | | |
| | 43 | 37 | 43 | 59 | 61 | 61 |

TABLE 16 TOTAL CONSUMPTION, DISCHARGE AND INJECTION OF CHEMICALS BY APPLICATION (TONNES)

| Application | | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|
| A - DRILLING AND WELL CHEMICALS | Consumed | 365 902 | 399 053 | 409 337 | 357 665 |
| | Injected | 88 506 | 65 682 | 44 204 | 37 685 |
| | Discharged | 93 190 | 135 589 | 104 966 | 111 839 |
| B - PRODUCTION CHEMICALS | Consumed | 31 278 | 27 720 | 26 816 | 28 564 |
| | Injected | 4 046 | 4 499 | 4 403 | 4 598 |
| | Discharged | 17 208 | 17 021 | 16 001 | 17 272 |
| C - INJECTION CHEMICALS | Consumed | 15 517 | 12 997 | 11 487 | 9 830 |
| | Injected | 1 486 | 1 485 | 1 367 | 1 492 |
| | Discharged | 235 | 200 | 188 | 212 |
| D - PIPELINE CHEMICALS | Consumed | 3 385 | 2 973 | 2 477 | 4 609 |
| | Injected | 0 | 146 | 599 | 936 |
| | Discharged | 516 | 917 | 1 308 | 3 245 |
| E - GAS TREATMENT CHEMICALS | Consumed | 22 257 | 21 381 | 17 905 | 21 061 |
| | Injected | 1 502 | 1 634 | 1 406 | 1 628 |
| | Discharged | 13 124 | 11 849 | 9 698 | 11 097 |
| F - AUXILIARY CHEMICALS | Consumed | 7 135 | 7 886 | 8 091 | 8 073 |
| | Injected | 810 | 501 | 420 | 377 |
| | Discharged | 4 031 | 4 795 | 4 244 | 4 489 |
| G - CHEMICALS ADDED TO THE EXPORT FLOW | Consumed | 5 443 | 5 085 | 5 094 | 4 665 |
| | Injected | 0 | 0 | 0 | 0 |
| | Discharged | 439 | 1 664 | 1 847 | 1 483 |
| H - CHEMICALS FROM OTHER PRODUCTION LOCATIONS | Consumed | 614 | 475 | 536 | 0 |
| | Injected | 210 | 25 | 117 | 114 |
| | Discharged | 847 | 753 | 753 | 692 |
| K - RESERVOIR MANAGEMENT | Consumed | 15 | 12 | 14 | 6 |
| | Injected | 0 | 0 | 0 | 0 |
| | Discharged | 0 | 9 | 5 | 2 |

TABLES

| | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| | | | | | | |
| | 373 746 | 470 793 | 429 087 | 425 201 | 411 370 | 331 094 |
| | 36 627 | 59 664 | 54 161 | 62 018 | 58 125 | 40 535 |
| | 113 521 | 119 005 | 117 402 | 107 797 | 104 873 | 89 500 |
| | | | | | | |
| | 29 018 | 31 815 | 31 802 | 32 953 | 37 325 | 40 034 |
| | 4 082 | 4 867 | 4 020 | 4 973 | 8 880 | 8 339 |
| | 19 577 | 21 968 | 21 852 | 20 365 | 20 801 | 23 119 |
| | | | | | | |
| | 9 155 | 9 340 | 10 011 | 10 451 | 9 686 | 8 885 |
| | 2 945 | 1 115 | 1 334 | 8 076 | 7 717 | 6 895 |
| | 176 | 1 173 | 1 356 | 1 040 | 518 | 474 |
| | | | | | | |
| | 7 138 | 3 490 | 7 161 | 6 610 | 6 092 | 5 088 |
| | 494 | 917 | 1 282 | 1 558 | 575 | 329 |
| | 4 153 | 2 361 | 3 217 | 4 015 | 3 099 | 1 581 |
| | | | | | | |
| | 22 563 | 25 535 | 26 342 | 25 123 | 23 429 | 19 999 |
| | 4 133 | 668 | 5 390 | 5 330 | 3 541 | 2 010 |
| | 16 079 | 16 133 | 16 697 | 17 302 | 17 169 | 16 045 |
| | | | | | | |
| | 7 671 | 9 095 | 9 407 | 9 645 | 8 767 | 9 561 |
| | 190 | 394 | 334 | 589 | 1 920 | 1 534 |
| | 4 903 | 5 451 | 5 236 | 4 223 | 4 383 | 5 354 |
| | | | | | | |
| | 5 269 | 5 875 | 6 121 | 7 281 | 6 728 | 15 664 |
| | 0 | 0 | 0 | 0 | 0 | 0 |
| | 1 951 | 615 | 383 | 1 781 | 1 585 | 1 529 |
| | | | | | | |
| | 0 | 0 | 0 | 0 | 0 | 0 |
| | 150 | 100 | 895 | 2 690 | 1 618 | 983 |
| | 952 | 986 | 677 | 773 | 792 | 1 112 |
| | | | | | | |
| | 4 | 16 | 25 | 14 | 7 | 2 |
| | 0 | 0 | 2 | 5 | 6 | 0 |
| | 3 | 12 | 9 | 4 | 1 | 1 |

TABLE 17 **CONSUMPTION AND DISCHARGE OF CHEMICALS BY ENVIRONMENTAL PROPERTIES** (KG)

| NEA category description | NEA colour category | Category | | 2008 | 2009 | 2010 |
|---|---|---|---|---|---|---|
| Substances on the Plonor list | Green | 201 | Consumption | 259 361 | 287 182 | 286 277 |
| | | | Discharge | 76 539 | 109 905 | 90 612 |
| Water | Green | 200 | Consumption | 92 454 | 95 710 | 88 264 |
| | | | Discharge | 40 075 | 48 296 | 36 638 |
| Other chemicals | Yellow | 100 | Consumption | 95 348 | 91 886 | 103 061 |
| | | | Discharge | 12 957 | 14 649 | 11 727 |
| Biodegradability < 20% | Red | 8 | Consumption | 3 141 | 2 145 | 2 387 |
| | | | Discharge | 11 | 16 | 14 |
| Two out of three categories: biodegradability < 60%, log Pow ≥ 3, $EC_{50}$ or $LC_{50}$ ≤ 10 mg/l | Red | 6 | Consumption | 1 182 | 1 061 | 507 |
| | | | Discharge | 5 | 5 | 2 |
| Inorganic and $EC_{50}$ or $LC_{50}$ ≤ 1 mg/l | Red | 7 | Consumption | | 0 | 0 |
| | | | Discharge | | 0 | 0 |
| Biodegradability < 20% and toxicity $EC_{50}$ or $LC_{50}$ ≤ 10 mg/l | Black | 4 | Consumption | 1 | 1 | 21 |
| | | | Discharge | 0 | 0 | 0 |
| Biodegradability < 20% and log Pow ≥ 5 | Black | 3 | Consumption | 1 | 1 | 1 238 |
| | | | Discharge | 1 | 1 | 1 |
| Hormone-disrupting substances | Black | 1 | Consumption | 20 | 14 | 0 |
| | | | Discharge | 1 | 0 | 0 |
| List of priority chemicals included in result target 1 (priority list), White Paper no 25 (2002-2003) | Black | 2 | Consumption | 0 | 0 | 0 |
| | | | Discharge | 0 | 0 | 0 |
| Substances thought to be, or which are, hazardous to genes or reproduction | Black | 1.1 | Consumption | 38 | | |
| | | | Discharge | 0 | | |

| | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|
| | | | | | | | |
| | 273 274 | 282 848 | 347 659 | 322 308 | 311 326 | 284 080 | 236 999 |
| | 99 503 | 104 496 | 114 955 | 107 671 | 93 929 | 89 952 | 79 231 |
| | | | | | | | |
| | 78 114 | 86 001 | 103 774 | 98 679 | 97 414 | 104 162 | 89 061 |
| | 38 515 | 43 277 | 38 716 | 44 584 | 48 735 | 48 775 | 44 007 |
| | | | | | | | |
| | 80 141 | 68 454 | 83 779 | 77 067 | 85 617 | 88 471 | 84 066 |
| | 12 305 | 7 575 | 8 088 | 8 803 | 8 904 | 9 152 | 9 184 |
| | | | | | | | |
| | 1 493 | 1 287 | 1 664 | 1 821 | 2 004 | 1 871 | 1 996 |
| | 6 | 4 | 4 | 5 | 8 | 17 | 17 |
| | | | | | | | |
| | 349 | 801 | 1 340 | 1 351 | 1 411 | 1 040 | 719 |
| | 2 | 4 | 3 | 9 | 16 | 11 | 16 |
| | | | | | | | |
| | 0 | 0 | 0 | 0 | 50 | 135 | 102 |
| | 0 | 0 | 0 | 0 | 44 | 75 | 63 |
| | | | | | | | |
| | 12 | 11 | 5 | 14 | 4 | 2 | 1 |
| | 0 | 1 | 0 | 4 | 3 | 2 | 1 |
| | | | | | | | |
| | 1 128 | 694 | 476 | 631 | 322 | 517 | 320 |
| | 0 | 0 | 3 | 4 | 4 | 2 | 3 |
| | | | | | | | |
| | 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 |

TABLE

# 17 CONSUMPTION AND DISCHARGE OF CHEMICALS BY ENVIRONMENTAL PROPERTIES (KG)

| NEA category description | NEA colour category | Category | | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|
| Reach annex IV | Green | 204 | Consumption | | | | 261 | 227 | 224 |
| | | | Discharge | | | | 137 | 132 | 85 |
| Reach annex V | Green | 205 | Consumption | | | | 275 | 298 | 1 176 |
| | | | Discharge | | | | 6 | 24 | 536 |
| Yellow in sub-category 1. Expected to biodegrade fully | Yellow | 101 | Consumption | 7 336 | 8 124 | 7 755 | 6 902 | 6 800 | 6 612 |
| | | | Discharge | 3 709 | 3 843 | 3 673 | 3 257 | 3 199 | 3 169 |
| 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 | 5 259 |
| | | | Discharge | 1 768 | 1 714 | 1 702 | 1 507 | 1 533 | 2 084 |
| Yellow in sub-category 3. Expected to biodegrade to substances which could be environmentally hazardous | Yellow | 103 | Consumption | 1 | 6 | 1 | 1 | 0 | 0 |
| | | | Discharge | 0 | 1 | 0 | 1 | 0 | 0 |
| Calcium hydroxide, sodium hydroxide, hydrochloric acid, sulphuric acid, nitric acid and phosphoric acid | Yellow | 104 | Consumption | | | | | 5 419 | 3 756 |
| | | | Discharge | | | | | 347 | 318 |
| 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 | | | | | 0 | |
| Additive packages which are exempted from test requirements and not tested | Black | 0.1 | Consumption | | | | | 6 | 8 |
| | | | Discharge | | | | | 0 | 0 |
| Test data lacking | Black | 0 | Consumption | 40 | 50 | 46 | 74 | 84 | 27 |
| | | | Discharge | 1 | 4 | 5 | 0 | 0 | 1 |

TABLE 18

## DISCHARGE OF CONTAMINANTS IN CHEMICALS (TONNES)

| Substance | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.19 | 0.20 | 0.15 | 0.18 | 0.51 | 0.48 | 0.23 | 0.21 | 0.28 | 0.24 |
| Lead | 1.51 | 2.52 | 1.47 | 1.48 | 3.51 | 3.86 | 2.80 | 2.44 | 3.29 | 2.78 |
| Cadmium | 0.01 | 0.02 | 0.01 | 0.01 | 0.06 | 0.03 | 0.06 | 0.02 | 0.03 | 0.08 |
| Copper | 2.22 | 3.88 | 3.13 | 1.67 | - | - | - | - | - | - |
| Chrome | 0.55 | 0.81 | 0.73 | 0.77 | 0.88 | 1.01 | 0.85 | 0.61 | 0.59 | 0.39 |
| Mercury | 0.00 | 0.01 | 0.00 | 0.01 | 0.01 | 0.02 | 0.02 | 0.02 | 0.02 | 0.01 |
| Organohalogens | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 | 0.01 | 0.00 | 0.00 | 0.00 |

TABLE 19

## ACUTE DISCHARGES TO THE SEA

| Discharge type | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| **CHEMICALS** | | | | | | | | | | |
| Number, volume < 0.05 cu.m | 37 | 59 | 64 | 58 | 60 | 65 | 134 | 82 | 83 | 57 |
| Number, volume 0.05-1 cu.m | 69 | 61 | 62 | 65 | 57 | 62 | 68 | 49 | 55 | 54 |
| Number, volume > 1 cu.m | 30 | 42 | 32 | 28 | 39 | 31 | 36 | 42 | 25 | 29 |
| Volume < 0.05 cu.m (cu.m) | 0.4 | 0.6 | 0.6 | 0.6 | 0.7 | 0.6 | 1.1 | 0.6 | 0.9 | 0.5 |
| Volume 0.05-1 cu.m (cu.m) | 19.6 | 22.9 | 20.0 | 24.5 | 16.5 | 17.9 | 21.2 | 15.6 | 17.9 | 15.5 |
| Volume > 1 cu.m (cu.m) | 347.0 | 13 028.6 | 6 244.9 | 175.6 | 388.3 | 1 267.2 | 736.8 | 1 562.0 | 313.5 | 898.7 |
| Total number | 136 | 162 | 158 | 151 | 156 | 158 | 238 | 173 | 163 | 140 |
| Total volume (cu.m) | 366.9 | 13 052.1 | 6 265.5 | 200.7 | 405.5 | 1 285.7 | 759.2 | 1 578.2 | 332.3 | 914.6 |
| | | | | | | | | | | |
| **OIL** | | | | | | | | | | |
| Number, volume < 0.05 cu.m | 130 | 106 | 109 | 102 | 103 | 94 | 36 | 24 | 30 | 28 |
| Number, volume 0.05-1 cu.m | 34 | 37 | 24 | 29 | 24 | 19 | 15 | 17 | 6 | 15 |
| Number, volume > 1 cu.m | 9 | 4 | 7 | 2 | 4 | 6 | 8 | 6 | 3 | 3 |
| Volume < 0.05 cu.m (cu.m) | 1.0 | 0.6 | 0.6 | 0.6 | 0.7 | 0.6 | 0.3 | 0.2 | 0.2 | 0.2 |
| Volume 0.05-1 cu.m (cu.m) | 7.9 | 9.3 | 4.9 | 8.8 | 6.5 | 5.6 | 4.3 | 6.0 | 1.4 | 5.0 |
| Volume > 1 cu.m (cu.m) | 185.8 | 104.0 | 105.0 | 15.0 | 9.3 | 40.8 | 157.7 | 33.8 | 15.1 | 7.1 |
| Total number | 173 | 147 | 140 | 133 | 131 | 119 | 59 | 47 | 39 | 46 |
| Total volume (cu.m) | 194.7 | 113.9 | 110.5 | 24.3 | 16.5 | 47.1 | 162.3 | 40.0 | 16.7 | 12.2 |

TABLE 20 **EMISSIONS TO THE AIR, ALL SOURCES** (TONNES)

| Year | Emissions $CO_2$ (tonnes) | Emissions $NO_x$ (tonnes) | Emissions $CH_4$ (tonnes) | Emissions nmVOC (tonnes) | Emissions $SO_x$ (tonnes) | Emissions PCB (g) | Emissions PAH (g) | Emissions dioxins (mg) | Consumed fuel gas (scm) | Consumed diesel oil (tonnes) | Consumed oil (tonnes) | Discharges to the sea, fall-out from well tests (tonnes) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2008 | 13 776 426 | 50 870 | 30 923 | 50 444 | 526 | 1.3 | 47 | 61 | 5 361 668 937 | 279 529 | 7 517 | 1.4 |
| 2009 | 12 444 220 | 49 804 | 29 627 | 45 503 | 473 | 1.8 | 62 | 80 | 4 824 405 725 | 312 627 | 6 920 | 1.0 |
| 2010 | 12 581 242 | 50 048 | 28 966 | 38 201 | 557 | 1.7 | 94 | 78 | 4 800 873 166 | 316 645 | 25 039 | 2.8 |
| 2011 | 12 283 631 | 51 475 | 28 937 | 31 068 | 899 | 1.7 | 1 593 | 79 | 4 725 836 624 | 377 017 | 10 105 | 3.4 |
| 2012 | 12 448 717 | 50 648 | 25 658 | 33 036 | 825 | 2.3 | 168 | 84 | 4 797 865 506 | 394 669 | 10 891 | 3.4 |
| 2013 | 12 722 253 | 52 057 | 26 688 | 35 253 | 921 | 0.9 | 47 | 40 | 4 702 505 527 | 436 831 | 4 827 | 1.4 |
| 2014 | 13 096 391 | 52 375 | 31 601 | 49 755 | 868 | 2.4 | 132 | 110 | 5 031 178 493 | 424 027 | 11 313 | 5.5 |
| 2015 | 13 484 751 | 46 789 | 29 050 | 47 344 | 736 | 1.1 | 58 | 49 | 5 291 070 354 | 356 844 | 4 854 | 2.4 |
| 2016 | 13 348 063 | 44 719 | 19 471 | 42 503 | 584 | 0.9 | 49 | 32 | 5 281 158 770 | 335 339 | 4 081 | 2.0 |
| 2017 | 13 190 854 | 42 900 | 16 372 | 36 543 | 516 | 1.4 | 78 | 66 | 5 233 277 326 | 285 885 | 6 480 | 2.5 |

TABLE

# 21 EMISSIONS TO THE AIR BY SOURCE (TONNES)

| Source | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| **OTHER SOURCES** | | | | | | | | | | |
| Emissions nmVOC | 809 | 685 | 1 363 | 1 137 | 49 | 24 | 32 | 36 | 6 | 0,5 |
| Emissions $CH_4$ | 581 | 537 | 1 635 | 2 559 | 185 | 90 | 122 | 134 | 10 | 0,5 |
| Emissions $SO_x$ | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0,1 |
| Emissions $NO_x$ | 0 | 151 | 63 | 15 | 0 | 2 | 2 | 1 | 2 | 5,9 |
| Emissions $CO_2$ | 106 978 | 91 028 | 113 691 | 100 019 | 62 058 | 35 031 | 44 910 | 42 228 | 12 539 | 7 412 |
| | | | | | | | | | | |
| **WELL WORKOVERS** | | | | | | | | | | |
| Emissions nmVOC | | | | | | | | | 5 | 11 |
| Emissions $CH_4$ | | | | | | | | | 2 | 3 |
| Emissions $SO_x$ | | | | | | | | | 0 | 0 |
| Emissions $NO_x$ | | | | | | | | | 85 | 177 |
| Emissions $CO_2$ | | | | | | | | | 29 084 | 61 259 |
| | | | | | | | | | | |
| **WELL TESTING** | | | | | | | | | | |
| Emissions nmVOC | 13 | 20 | 85 | 30 | 25 | 18 | 38 | 16 | 10 | 11 |
| Emissions $CH_4$ | 1 | 3 | 8 | 3 | 9 | 0 | 5 | 0 | 1 | 0 |
| Emissions $SO_x$ | 4 | 12 | 47 | 60 | 13 | 21 | 19 | 5 | 0 | 16 |
| Emissions $NO_x$ | 69 | 160 | 470 | 168 | 146 | 32 | 98 | 40 | 50 | 18 |
| Emissions $CO_2$ | 23 197 | 46 011 | 152 940 | 55 619 | 59 745 | 18 481 | 52 586 | 20 027 | 17 478 | 11 942 |
| | | | | | | | | | | |
| **FLARING** | | | | | | | | | | |
| Emissions nmVOC | 236 | 92 | 73 | 76 | 75 | 126 | 75 | 23 | 55 | 133 |
| Emissions $CH_4$ | 827 | 321 | 263 | 278 | 267 | 264 | 238 | 90 | 200 | 325 |
| Emissions $SO_x$ | 3 | 3 | 3 | 224 | 215 | 200 | 201 | 172 | 169 | 124 |
| Emissions $NO_x$ | 979 | 607 | 606 | 589 | 556 | 650 | 553 | 574 | 572 | 431 |
| Emissions $CO_2$ | 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 | 994 659 |
| | | | | | | | | | | |
| **BOILERS** | | | | | | | | | | |
| Emissions nmVOC | 11 | 17 | 21 | 37 | 33 | 21 | 26 | 38 | 36 | 23 |
| Emissions $CH_4$ | 79 | 22 | 37 | 32 | 31 | 30 | 19 | 59 | 48 | 18 |
| Emissions $SO_x$ | 10 | 26 | 12 | 23 | 27 | 16 | 26 | 20 | 14 | 9 |
| Emissions $NO_x$ | 250 | 78 | 95 | 194 | 155 | 170 | 176 | 206 | 169 | 118 |
| Emissions $CO_2$ | 196 580 | 152 171 | 156 106 | 152 706 | 242 413 | 235 646 | 235 658 | 230 476 | 218 121 | 201 634 |
| | | | | | | | | | | |
| **ENGINES** | | | | | | | | | | |
| Emissions nmVOC | 1 072 | 1 217 | 1 283 | 1 554 | 1 502 | 1 713 | 1 721 | 1 415 | 1 318 | 1 187 |
| Emissions $CH_4$ | 30 | 19 | 16 | 14 | 15 | 16 | 15 | 18 | 6 | 0 |
| Emissions $SO_x$ | 402 | 320 | 387 | 488 | 415 | 494 | 486 | 411 | 287 | 259 |
| Emissions $NO_x$ | 14 982 | 16 302 | 16 822 | 19 980 | 19 703 | 21 546 | 21 065 | 14 419 | 13 240 | 12 064 |
| Emissions $CO_2$ | 778 988 | 823 882 | 856 490 | 1 025 526 | 998 860 | 1 132 633 | 1 138 908 | 955 720 | 853 505 | 753 240 |
| | | | | | | | | | | |
| **TURBINES** | | | | | | | | | | |
| Emissions nmVOC | 898 | 883 | 890 | 867 | 883 | 864 | 933 | 990 | 982 | 1 013 |
| Emissions $CH_4$ | 3 418 | 3 354 | 3 692 | 3 563 | 3 653 | 3 538 | 3 874 | 4 118 | 3 744 | 3 866 |
| Emissions $SO_x$ | 106 | 112 | 108 | 105 | 156 | 190 | 136 | 129 | 114 | 107 |
| Emissions $NO_x$ | 34 590 | 32 506 | 31 993 | 30 528 | 30 088 | 29 658 | 30 480 | 31 549 | 30 601 | 30 085 |
| Emissions $CO_2$ | 10 156 180 | 9 892 780 | 9 922 026 | 9 630 473 | 9 885 826 | 9 829 452 | 10 406 423 | 10 929 706 | 10 938 903 | 11 160 707 |

TABLES

TABLE **22** EMISSIONS OF $CH_4$ AND nmVOC FROM FUGITIVE SOURCES AND COLD VENTING (TONNES)

| Year | nmVOC emissions | $CH_4$ emissions |
|---|---|---|
| 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 |
| 2017 | 9 176 | 9 838 |

TABLE **23** COMBUSTED HYDROCARBONS IN WELL TESTS

| Year | Combusted diesel (tonnes) | Combusted gas (cu.m) | Combusted oil (tonnes) |
|---|---|---|---|
| 2008 | 0 | 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 | 0 | 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 |
| 2017 | 28 | 435 717 | 3 402 |

TABLE **24** EMISSIONS OF $CH_4$ AND nmVOC FROM STORAGE AND LOADING (TONNES)

| Type | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | |
| **STORAGE** | | | | | | | | | | |
| Emissions nmVOC | 3 578 | 6 397 | 4 655 | 4 041 | 2 978 | 7 160 | 5 170 | 3 724 | 3 244 | 2 706 |
| Emissions $CH_4$ | 332 | 998 | 1 107 | 596 | 337 | 1 114 | 703 | 355 | 321 | 352 |
| | | | | | | | | | | |
| **LOADING** | | | | | | | | | | |
| Emissions nmVOC | 34 714 | 27 032 | 22 646 | 15 072 | 17 409 | 16 144 | 28 205 | 27 747 | 26 623 | 21 985 |
| Emissions $CH_4$ | 6 631 | 5 890 | 4 141 | 2 711 | 2 894 | 1 783 | 1 703 | 1 801 | 2 002 | 1 879 |

TABLE 25

## SEPARATED WASTE BY SOURCE TRANSPORTED TO LAND (TONNES)

| Type | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Other | 6 094 | 951 | 4 747 | 5 425 | 7 043 | 5 700 | 2 279 | 2 570 | 2 766 | 1 701 |
| Blasting sand | 3 | 0 | 1 | 3 | 0 | 0 | 161 | 482 | 296 | 537 |
| EE waste | 631 | 530 | 590 | 773 | 692 | 775 | 986 | 725 | 645 | 478 |
| Glass | 86 | 98 | 94 | 115 | 115 | 104 | 114 | 116 | 118 | 97 |
| Food-contaminated waste | 2 042 | 2 198 | 2 622 | 2 781 | 3 390 | 3 694 | 3 667 | 3 550 | 3 085 | 2 685 |
| Metals | 8 856 | 8 945 | 9 059 | 9 432 | 11 180 | 11 538 | 12 637 | 12 680 | 10 480 | 9 460 |
| Paper | 810 | 828 | 926 | 980 | 1 100 | 1 005 | 1 119 | 1 127 | 983 | 906 |
| Cardboard (brown paper) | 442 | 414 | 440 | 483 | 457 | 465 | 326 | 215 | 127 | 130 |
| Plastic | 427 | 490 | 597 | 635 | 676 | 736 | 748 | 671 | 600 | 658 |
| Residual waste | 3 211 | 3 079 | 3 718 | 3 750 | 2 586 | 2 503 | 2 183 | 2 176 | 2 155 | 2 701 |
| Wood | 1 916 | 1 855 | 2 385 | 2 604 | 2 338 | 2 441 | 2 461 | 2 432 | 2 044 | 1 809 |
| Wet organic waste | 143 | 120 | 107 | 89 | 115 | 270 | 361 | 213 | 214 | 263 |

TABLE 26

## HAZARDOUS WASTE TRANSPORTED TO LAND (TONNES)

| Norog category | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|---|---|---|---|
| Other waste | 2 | 0 | 5 | 7 | 12 | 28 | 90 | 95 | 107 | 122 |
| Batteries | 99 | 79 | 73 | 143 | 111 | 140 | 200 | 126 | 109 | 116 |
| Blasting sand | 148 | 238 | 146 | 454 | 479 | 465 | 684 | 710 | 742 | 421 |
| Drilling-related waste | 143 326 | 148 719 | 257 968 | 303 500 | 311 541 | 386 309 | 360 142 | 394 412 | 461 522 | 294 063 |
| Well-related waste | | | | | | 14 626 | 7 781 | 6 747 | 3 154 | 2 696 |
| Spent catalysts | | | | 2 | | | | 10 | | |
| Chemicals | 73 | 101 | 89 | 162 | 152 | 1 003 | 3 086 | 2 199 | 1 671 | 3 599 |
| Fluorescent tubes | 26 | 23 | 26 | 28 | 27 | 35 | 33 | 29 | 33 | 33 |
| Solvents | 245 | 89 | 39 | 777 | 273 | 457 | 699 | 307 | 9 382 | 803 |
| Paint, all types | | | | | 0 | 80 | 108 | 236 | 197 | 190 |
| Oily waste | 2 544 | 2 447 | 2 031 | 6 810 | 2 288 | 6 438 | 8 499 | 8 855 | 18 610 | 11 964 |
| Process-related waste | | | | | | 72 | 517 | 558 | 417 | 479 |
| Cement | | | | | | | 11 | 22 | 32 | 38 |
| Spray cans | 18 | 18 | 19 | 20 | 20 | 22 | 25 | 19 | 18 | 16 |
| Tank washing waste | 395 | 1 834 | 378 | 3 870 | 2 314 | 37 598 | 41 747 | 35 549 | 32 241 | 31 113 |

# 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

**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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