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Hejre to South Arne Development Project
SELECT Phase

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Hejre tie-back to South Arne – ESPOO Report

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1 Introduction

1.1 Reading guide

This report comprises the Espoo documentation of Denmark elaborated under the Hejre to South Arne Development Project. It contains a description of the project-related transboundary environmental impacts, which are caused by project impacts generated in Denmark and potentially affecting the marine territories (EEZ and/or territorial waters) of neighbouring countries.

Chapters 2 and 3 provide relevant background information on the Hejre to South Arne Development Project. This includes a description of the legal framework and the mechanisms of the Espoo process and a project description. Chapter 4 describes the impact assessment methodology applied. The central part of this report in chapter 5 including the screening of potential transboundary impacts and chapter 6 dealing with the assessment of transboundary impacts. The assessment chapters are organized by environmental receptors that are likely to be affected by various project pressures. For each receptor the assessment results are presented, with information on the expected transboundary impacts. A separate chapter deals with the assessments made on Natura 2000 areas and applicable legislation. The results of the assessment are summarized in the conclusion of chapter 7. References are listed in chapter 8.

The Espoo report and procedure are an integrated part of the EIA procedures and approval processes.

1.2 Abbreviations

The following abbreviations are used in the document:

Abbreviation	**Explanation**
BAT	Best Available Technique
BBL	Barrel
BEP	Best Environmental Practice
BLP	Bridge Linked Platform
BOP	Blow-Out Preventer
BOPD	Barrels of Oil Per Day
BPD	Barrels Per Day
BRL	Background Reference Level
CH_4	Methane
CO_2	Carbon diOxide
DCE	Danish Centre for Environment and Energy
DEA	Danish Energy Agency
DEPA	Danish Environmental Protection Agency

DSV	Diving Support Vessel
DUC	Danish Underground Consortium
DW	Dry Weight
EC	European Council
EIA	Environmental Impact Assessment
EnS-Index	A quantification of environmental status based on descriptors in the Marine Strategy Framework Directive
ES	Environmental Status
ERL	Effect Range Low
ETS	Emission Trading System
EU	European Union
FPSO	Floating Production Storage and Offloading
GBS	Gravity Based Structure (the oil storage tank at South Arne)
GES	Good Environmental Status
GOR	Gas Oil Ratio
HELCOM	Helsinki Commission
HLV	Heavy Lift Vessel
HOCNF	Harmonised Offshore Chemical Notification Form
HPHT	High-Pressure High-Temperature
HUC	Hook-Up and Commissioning
IBTS	International Bottom Trawl Survey
ICES	International Council for the Exploration of the Seas
IMO	International Maritime Organization
JNCC	Joint Nature Conservation Committee
MMSCFD	Million Standard Cubic Feet per Day
MPU	Mobile Production Unit
MSFD	Marine Strategy Framework Directive
mT	Metric Tonnes
NGL	Natural Gas Liquids
NH^{4+}	Ammonia

nmVOC	Non-Methane Volatile Organic Compounds
NORM	Naturally Occurring Radioactive Materials
NOx	Nitrogen Oxides
NPD	Naphthalene, C1-Naphtalene, C2-Naphtalene, C3-Naphtalene, C1-Phenantrene, C2-Phenantrene, C3-Phenantrene, Dibenzothiophene, C1-Dibenzotiophene, C2-Dibenzotiophene, C3-Dibenzotiophene
OCP	Organo Chlorine Pesticides
OSCAR	Oil Spill Contingency and Response
OSPAR	OSlo PARis convention
OSRL	Oil Spill Response Limited
P&A	Plugging and abandonment (the process for decommissioning of wells)
PAH	Polycyclic Aromatic Hydrocarbons
PBDE	Poly Brominated Diphenyl Ethers
PCB	Poly Chlorinated Biphenyls
PEC	Predicted Environmental Concentration
PLONOR	Pose Little Or NO Risk
PNEC	Predicted No-Effect Concentration
POB	Persons On Board
PPB	Parts Per Billion
PPM	Parts Per Million
PTS	Permanent Threshold Shift
PUQ	Process, Utility and (living) Quarter
RBA	Risk Based Approach (method of assessment of discharges of produced water according to OSPAR)
ROV	Remotely Operated underwater Vehicle
SA	South Arne
SAC	Special Areas of Conservation (under the EU Habitats Directive)
SAL	Single Anchor Loading
SCANS	Small Cetacean Abundance in the North Sea
SEL	Sound Exposure Levels
SINTEF	Stiftelsen for INdustriell og TEknisk Forskning

SO_X	Sulphur Oxides
SPA	Special Protection Area (under the EU Birds Directive)
SPL	Sound Pressure Level
TA	Temporary Abandonment
TD	Total Depth
TEL	Target Effect Level - a low range for potential toxicological effect
THC	Total Hydrocarbons
TL	Transmission Losses
TTS	Temporary Threshold Shift
VOC	Volatile Organic Compounds
WHP	Well Head Platform
WHPE	(South Arne) Well Head Platform East
WHPN	(South Arne) Well Head Platform North

1.3 Project background

INEOS E&P A/S is investigating the possibility to re-develop and subsequently operate the Hejre field in the Danish Sector of the North Sea. The Hejre field was previously operated by DONG E&P A/S. The intended re-development entails a development solution with a Hejre tie-back to South Arne using the existing Hejre facilities.

The partners in the Hejre licence (5/98) are:

- INEOS E&P A/S (operator) 60 %
- INEOS E&P (Norge) Petroleum DK AS 25 %
- INEOS E&P (Petroleum Denmark) ApS 15 %

INEOS E&P A/S has commissioned COWI to carry out an environmental impact assessment (EIA) for the re-development, operation and decommissioning of the Hejre field. The present report documents the EIA process, findings and conclusions. The EIA has been carried out in compliance with the Danish EIA regulation (Consolidation Act No. 4 of 03/01/2023).

The original Hejre concept ('Hejre Legacy') was approved by the Danish Energy Agency (DEA) after the completion of an EIA process (DONG E&P A/S 2011). The platform steel jacket and pre-drilling wellhead deck was installed in 2014. The topside fabrication contract was however terminated in 2016 due to tech-nical difficulties and significant delays. Drilling continued as per original scope and was completed in 2016. A total of 5 HPHT wells were drilled of which 3 are suitable for being part of the Hejre field re-development. The 3 wells are ready for production following production liner perforation and well clean-up.

As the Hejre field re-development via tie-back to South Arne extends outside the previously approved project scope, an updated EIA report is required according to Act No. 4 of 03/01/2023 on environmental as-sessment of plans, programs and specific projects (EIA). The re-development project is covered by Annex 1, point 29) Any change or extension of projects listed in this Annex, provided that such change or extension itself meets the threshold values, if any, set out in this Annex.

1.4 The Hejre field

The Hejre field is located within licenses 5/98 and 1/06 on the Danish continental shelf approximately 300 km west of the Danish west coast.

The field is a High Pressure High Temperature (HPHT) oil field including natural gas liquids (NGL). The Hejre jacket is located at the position 6.234.174,9 mN, 559.510,8 mE (reference UTM zone 31 on ED50 Datum) at approximately 68 m water depth.

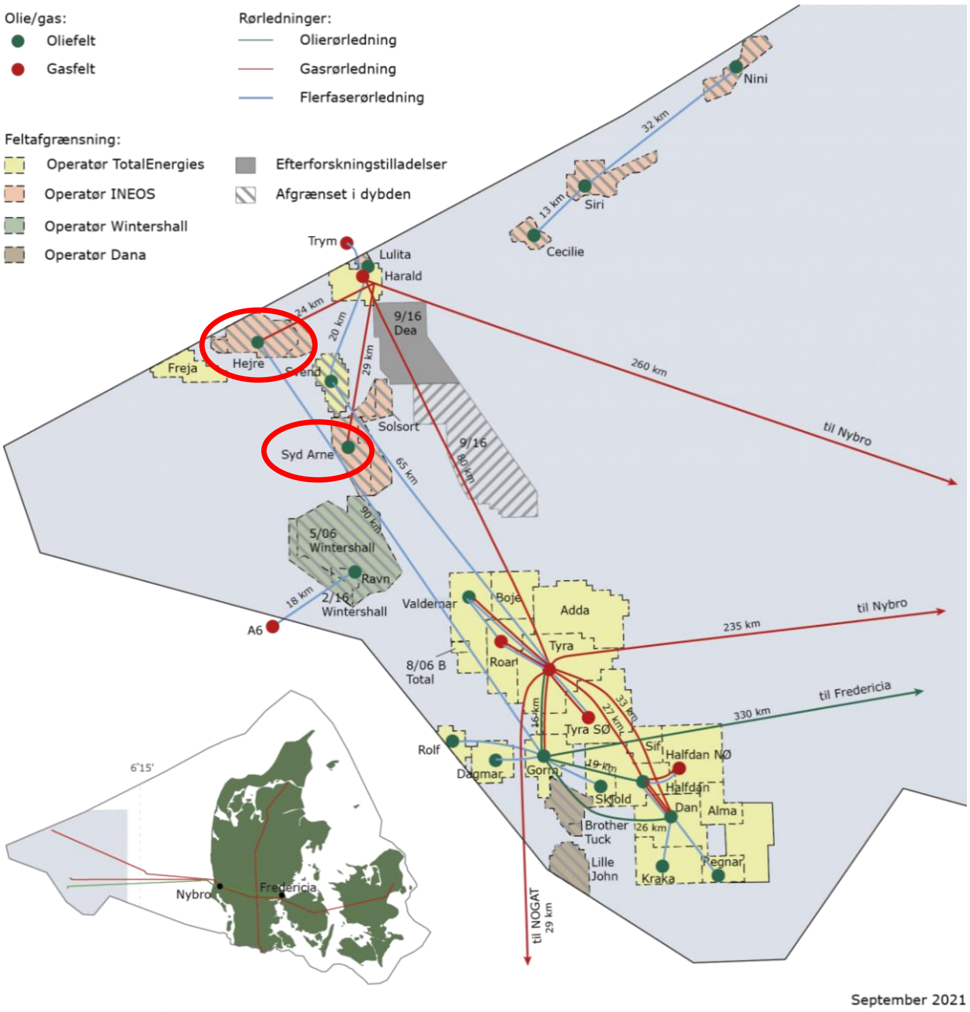

Figure 1-1 Location of the Hejre Field, the Syd (South) Arne platform and other oil and gas installations in the Danish sector of the North Sea.

1.4.1 The Hejre tie-back to South Arne concept

The selected Hejre tie-back to South Arne re-development concept comprises of an unmanned topsides at Hejre that will be remotely controlled from South Arne. A new 30 km insulated multiphase pipeline will be installed between Hejre and South Arne, where well fluids from Hejre will be processed. The concept is based on using existing infrastructure and available capacity at South Arne. The Hejre oil will be produced to the South Arne Gravity Based Structure (GBS) storage tank where it will be temporarily stored before being exported by shuttle tanker via the existing South Arne oil offloading system. The gas will be exported through the existing South Arne to Nybro pipeline. To ensure that the export gas from South Arne can comply with the specifications required by the Nybro Gas Facility, the heavy gas components, the so-called Natural Gas Liquids (NGLs), from Hejre will be injected into the South Arne reservoir and will remain there.

Figure 1-2 below shows an overview of the concept.

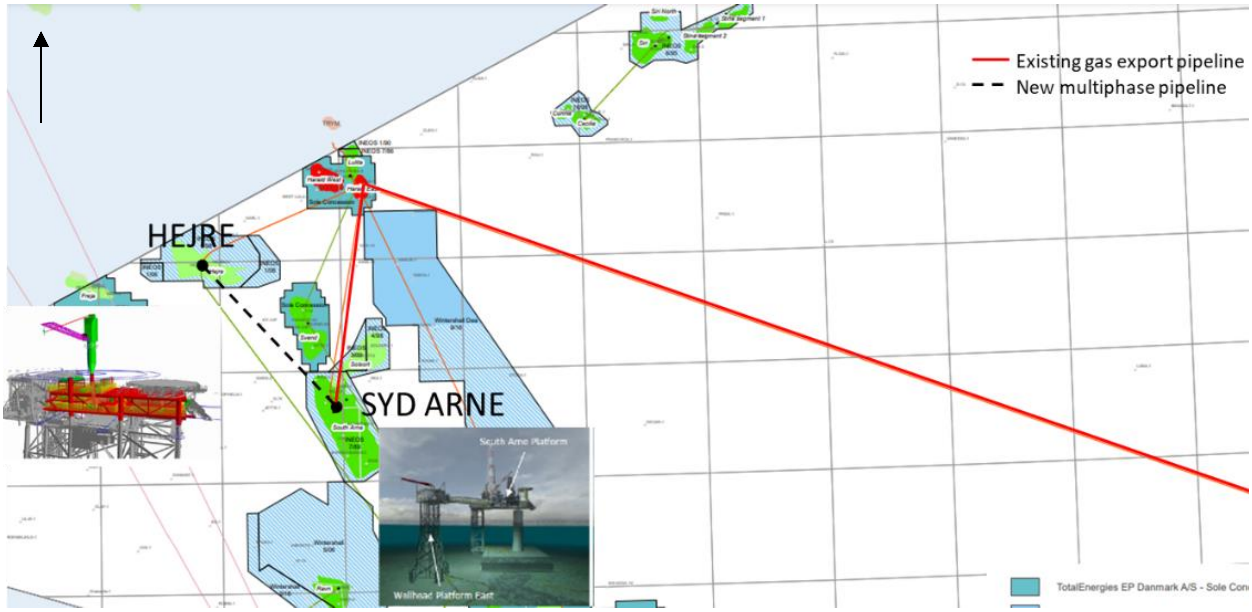

Figure 1-2 Overview of the concept for the Hejre tie-back to Syd (South) Arne development project.

The activities related to the redevelopment are described in detail in chapter 3.

1.5 Time schedule

The proposed time schedule for the Hejre field re-development up until EXECUTE (Construction) is illustrated below in Figure 1-3. The subsequent Operations phase (approx. 20 years) and the future Decommissioning phases are not shown in the schedule.

Offshore pipeline installation work is expected to start in Q2 2026, and pipeline hook-up, installation of the new Hejre topsides, modifications at South Arne and perforation and clean-up of the Hejre wells is expected to take place in Q2 and Q3 2027. First oil is expected in Q4 2027.

The timing for the potential drilling of the Lunde well is also not shown in the schedule but will take place after work on the existing Hejre wells is completed – either directly after or in a later campaign.

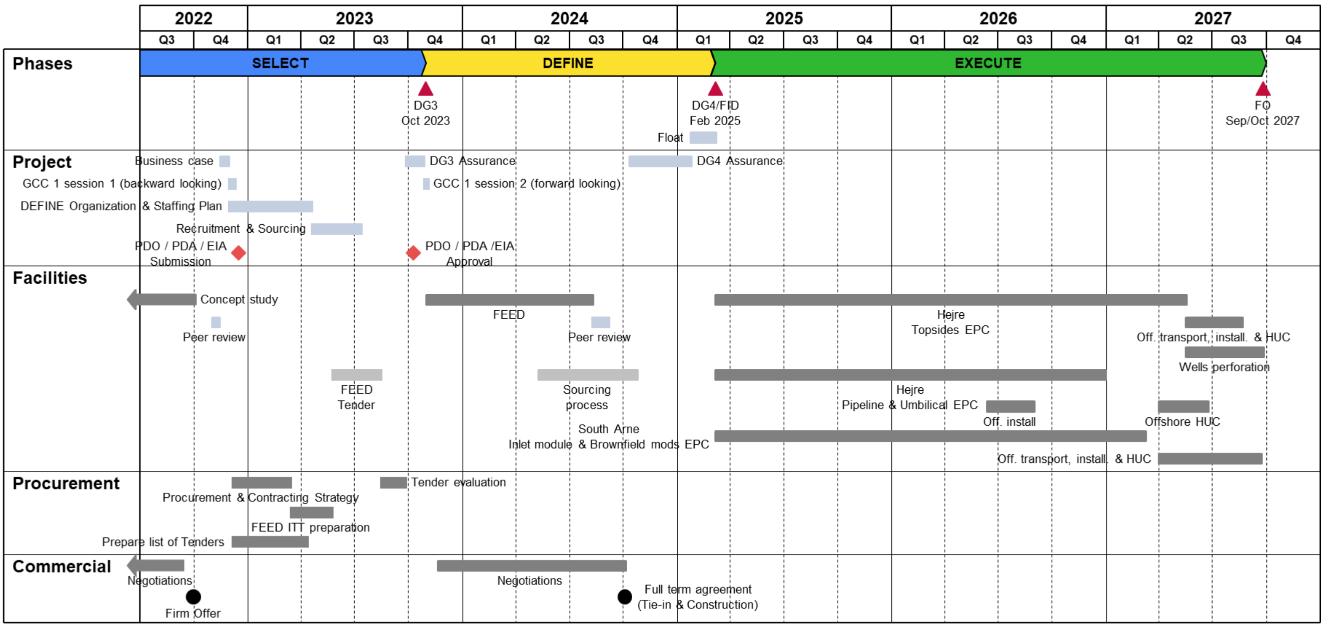

Figure 1-3 High-level time schedule for the Hejre field re-development.

2 Legal framework and Espoo consultation process

A development project such as the Hejre to South Arne Development Project must comply with numerous international conventions as well as directives and laws on the EU and national levels. This chapter provides an overview of the legal framework and national approval processes, which apply to the Hejre to South Arne Development Project, and which also contains the procedures to be followed under the Espoo Convention.

2.1 The Espoo Convention and Espoo consultation process

2.1.1 The Espoo Convention

The “Convention on Environmental Impact Assessment in a transboundary context of 25th of February 1991” (Espoo Convention) sets out the obligations of the contracting Parties to assess the environmental impact of certain activities at an early stage of project planning. It also lays down the general obligation of States to notify and consult one another on all major projects under consideration that are likely to have a significant adverse environmental impact across boundaries.

According to the Espoo Convention a transboundary impact is “any non-global impact within the jurisdiction of the Party due to the planned activities, the physical cause of which is wholly or partially located on the area under the jurisdiction of the other Party.”

The Party of Origin (PoO) is the Contracting Party or Parties to the Convention, under whose jurisdiction the planned operation is to take place, which in this case is Denmark only.

The Affected Party (AP) is a Contracting Party or Parties to the Convention that may be exposed to a transboundary impact of the planned activities. In relation to the Hejre Development Project Denmark is both AP and PoO, while Norway, Sweden, Germany, the Netherlands and UK are APs.

The convention states that the PoO shall, consistent with the provisions of the convention, ensure that APs are notified of a proposed activity: Offshore hydrocarbon production. Extraction of petroleum and natural gas for commercial purposes where the amount extracted exceeds 500 metric tons/day in the case of petroleum and 500 000 cubic metres/day in the case of gas (#15 - Appendix 1 of the Convention) that is likely to cause a significant adverse transboundary impact.

2.1.2 The Espoo consultation process

The consultation process foreseen under the Espoo Convention’s Articles 3-6 is coordinated by the Espoo Focal Point in the PoO. The consultation process consists of the following major steps:

- Notification in accordance with Article 3: For a proposed activity listed in Appendix I that is likely to cause a significant adverse transboundary impact, the Party of Origin shall, for the purposes of ensuring adequate and effective consultations under Article 5, notify any Party which it considers may be an Affected Party as early as possible and no later than when informing its own public about that proposed activity.

- Preparation of the environmental impact assessment documentation (Espoo report) pursuant to Article 4: The Party of Origin shall furnish the Affected Party, as appropriate through a joint body where one exists, with the environmental impact assessment documentation. The concerned Parties shall arrange for distribution of the documentation to the authorities and the public of the Affected Party in the areas likely to be Affected and for the submission of comments to the competent authority of the Party of Origin, either directly to this authority or, where appropriate, through the Party of Origin within a reasonable time before the final decision is taken on the proposed activity.

- Consultation pursuant to Article 5: The Party of Origin shall, after completion of the environmental impact assessment documentation, without undue delay enter into consultations with the Affected Party concerning, inter alia, the potential transboundary impact of the proposed activity and measures to reduce or eliminate its impact. Consultations may relate to:

    a) Possible alternatives to the proposed activity, including the no-action alternative and possible measures to mitigate significant adverse transboundary impact and to monitor the effects of such measures at the expense of the Party of Origin;

    b) Other forms of possible mutual assistance in reducing any significant adverse transboundary impact of the proposed activity; and

    c) Any other appropriate matters relating to the proposed activity.

  The Parties shall agree, at the commencement of such consultations, on a reasonable timeframe for the duration of the consultation period. Any such consultations may be conducted through an appropriate joint body, where one exists.

- Final Decision pursuant to Article 6: The Parties shall ensure that, in the final decision on the proposed activity, due account is taken of the outcome of the environmental impact assessment, including the environmental impact assessment documentation, as well as the comments thereon received pursuant to Article 3 and 4, and the outcome of the consultations as referred to in Article 5. The Party of Origin shall provide to the Affected Party the final decision on the proposed activity along with the reasons and considerations on which it was based. If additional information on the significant transboundary impact of a proposed activity, which was not available at the time a decision was made with respect to that activity and which could have materially affected the decision, becomes available to a concerned Party before work on that activity commences, that Party shall immediately inform the other concerned Party or Parties. If one of the concerned Parties so requests, consultations shall be held as to whether the decision needs to be revised.

The consultation process and content of the environmental impact assessment documentation for the Hejre to South Arne Development project is considering recommendations given from the Economic Commission for Europe (UNECE, 1996) and the European Commission (European Commission, 2013).

The consultation process started 21 February 2023, when the Danish EPA as Espoo focal point distributed a letter of notification together with an Espoo Scoping report to the APs.

The following countries have requested to be part of the Espoo process: Germany and Sweden.

2.2 Further national and international legal requirements

2.2.1 Protection of the marine environment

The Marine Environment Act (Consolidation act no. 1165 of 25/11/2019) regulates discharges and emissions from platforms.

Discharges to sea

The associated regulation on discharges to the sea of compounds and materials from certain marine facilities (Executive order no. 394 of 17/7/1984) defines the information needed to obtain a permission for discharges.

The discharge permit regulates discharge of oil and chemicals to the sea and, among others, define requirements on:

- Maximum oil concentration in discharged produced water.
- Limitations for total amount of oil to be discharged.
- Monitoring programme for oil concentration in discharge water.
- Continuous control of total oil discharge.
- Classification of offshore chemicals.
- Use and discharge of offshore chemicals depending on classification (explained below).
- Regular reporting on discharge of oil and chemicals.

Classification of offshore chemicals

Chemicals are classified according to the DEPA colour coding system, which follows the OSPAR classification (substitution, ranking and PLONOR) and relates to the environmental hazard of offshore chemicals. The codes are:

Black chemicals are the most critical and not acceptable to be used offshore.

Red chemicals are environmentally hazardous to such an extent that they should generally be avoided and be substituted where possible. Substances that are inorganic and highly toxic (EC/LC < 1 mg/l) and/or have a very low biodegradation (< 20% in 28 days) are classified as red. Substances that meet more than one of three criteria of low biodegradation (< 60% in 28 days), high bioaccumulation (log Pow ≥ 3 and MW < 700) or toxicity (EC_{50}/LC_{50} < 10 mg/l) are also classified as red.

Yellow chemicals exhibit some degree of environmental hazard, which in case of significant discharges can give rise to concern. Substances that meet one of three criteria of low biodegradation (< 60% in 28 days), high bioaccumulation (log Pow ≥ 3 and MW < 700) or toxicity (EC_{50}/LC_{50} < 10 mg/l) are classified as yellow.

Green chemicals are considered not to be of environmental concern (so-called PLONOR-substances that "Pose Little Or NO Risk" to the environment) and also includes organic substances with EC_{50}/LC_{50} > 1 mg/l, acids and bases categorized as green chemicals.

Regulation of non-indigenous species

Regulation to prevent introduction of non-indigenous species through ballast water regulated through Executive order no. 1000 of 18/09/2019 about handling of ballast water and sediments from ship ballast tanks. In addition, introduction of non-indigenous species though ballast water is regulated through the following international conventions and declarations:

- IMO's Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (known as the London Convention 1972) including the 1996 Protocol which became effective in 2006.

Emissions

Air emissions from platforms, drilling rigs and ships are regulated in the in the regulation on prevention of air pollution from ships (Notification no. 9840 of 12/04/2007) and by The Marine Environment Act (Consolidation act no. 1165 of 25/11/2019).

In addition, air emissions from platforms are regulated in the regulation on certain air polluting emissions from combustion installations on offshore platforms (Executive order no. 1449 of 20/12/2012) and in the regulation on prevention of air pollution from ships (Notification no. 9840 of 12/04/2007).

Order of solid and liquid content of sulphur in fuels (Order no 228 of 06/02/2022) regulates the amount of sulphur allowed in ship fuel and thus indirectly impact the emission from ships.

2.2.2 Natura 2000 areas

Natura 2000 is a network of nature protection areas established under the EU Habitats[1] and Birds[2] Directive. The network consists of Special Areas of Conservation (SACs) designated by the member states under the Habitats Directive. The network also consists of Special Protection Areas (SPAs) designated under the Bird Directive. The aim of the network is to assure the long-term survival of Europe's most valuable and threatened species and habitats.

The directives are implemented in Danish legislation through:

› The Environmental Goal Act[3]

› The Subsoil Act[4]

› The regulation on EIA[5]

› The Offshore Appropriate Assessment Order[6]

› The Habitats Order[7]

Prior to any decision on projects with potential impact on a Natura 2000 area, documentation has to be presented that the activity will not lead to negative effects on the favourable conservation status of species or habitats that are part of the selection basis or affects the integrity of the area negatively.

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[1] Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora.
[2] Council Directive 79/409/EEC of 2 April 1979 on the conservation of wild birds. Amended in 2009 it became the Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds.
[3] Consolidated Act no. 119 of 26/01/2017 on Environmental Goals for International Nature Protection Sites (bekendtgørelse af lov om miljømål m.v. for internationale naturbeskyttelsesområder (Miljømålsloven).
[4] Consolidation Act no. 1533 of 16/12/2019 on the Use of the Danish Subsoil
[5] Consolidated Act no. 4 of 03/01/2023 on Environmental Assessment of Plans and Programmes and of Specific Projects
[6] Administrative Order no. 1050 of 27/06/2022 on Impact Assessment of International Nature Protection Sites and Protection of Certain Species at Preliminary Studies, Investigation and Extraction of Hydrocarbon, Storage in the Underground, Pipelines, etc. off-shore (bekendtgørelse om konsekvensvurdering vedrørende internationale naturbeskyttelsesområder og beskyttelse af visse arter ved forundersøgelser, efterforskning og indvinding af kulbrinter, lagring I undergrunden, rørledninger, m.v. offshore).
[7] Administrative Order no. 2091 of 12/11/2021 on appointment and administration of international nature protection sites and protection of certain species (bekendtgørelse om udpegning og administration af internationale naturbeskyttelsesområder samt beskyttelse af visse arter).

2.2.3 The OSPAR Convention

The Convention for the Protection of the Marine Environment of the North-East Atlantic or OSPAR Convention is the main legislative instrument regulating international cooperation regarding the marine environment in the North Sea. The convention regulates international cooperation in the North-East Atlantic and sets European standards for the offshore oil and gas industry, marine biodiversity and baseline monitoring of environmental conditions. The focus of the convention is on BAT, BEP and clean technologies.

The OSPAR Convention has implemented several strategies on environmental issues such as hazardous substances, biodiversity and radioactive compounds. The strategies include prohibition of the discharge of oil-based mud (OBM), how drill cuttings are managed in the construction phase. In addition, hazardous substances are regulated after principles of substitution, where less hazardous substances or preferably non-hazardous substances substitute these substances if possible. The convention requires a HOCNF (Harmonised Offshore Chemical Notification Format) and a pre-screening of substances in relation to their toxicity, persistence and biodegradability. Compounds that cannot be substituted must be ranked if not listed on the PLONOR (Pose Little Or No Risk) list, which contains the substances with no or little environmental effect.

The OSPAR commission recommends an elimination of discharges of produced water, so that in 2020 the discharge of produced water will not result in unwanted effects in the marine environment. Discharged produced water should not contain more than 30 mg dissolved oil per litre. The commission is establishing a risk-based approach (RBA) to assess the discharge of produced water. The RBA recommendation 2012/5 and the associated RBA guideline 2012-07 were adopted in 2012, and all contracting parties finalised their implementation plans in 2013 which is followed by full implementation in 2020.

OSPAR agreement 2017-02 recommends procedures for monitoring of environmental impacts of discharges from offshore installations including monitoring of sediment and water column characteristics. The monitoring programmes should comprise both baseline surveys prior to any petroleum development and follow-up surveys during exploration, production and decommissioning.

In OSPAR decision 98/3 on the disposal of disused offshore installations, OSPAR sets up the rules for leaving disused installations offshore. A disused offshore installation is defined as an offshore installation that no longer serves the purpose it was originally placed in the area for, or not serving another legitim purpose. Offshore pipelines are not covered by the decision.

The general rule is that offshore installations are not allowed to be left in a maritime area. Derogation from decision 98/3 may be considered for parts of an installation if certain conditions are met.

2.2.4 Marine Strategy Framework Directive

The Marine Strategy Framework Directive[8] (MSFD) aims at achieving Good Environmental Status (GES) of the marine waters of the EU by 2020 and to protect the resource base upon which marine-related economic and social activities depend. The Commission also produced a set of detailed criteria and methodological standards[9] to help Member States implement the MSFD. To achieve GES by 2020, each Member State is required to develop a strategy for its marine waters (Marine Strategy).

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[8] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive).

[9] Commission Decision (EU) 2017/848 of 17 May 2017 laying down criteria and methodological standards on good environmental status of marine waters and specifications and standardised methods for monitoring and assessment and repealing Decision 2010/477/EU.

The MSFD is implemented in Danish legislation through the Consolidated Act on Marine Strategy[10]. The purpose of the act is to establish the framework for achieving GES in Danish waters. The main instrument in achieving this is the Marine Strategy, which covers all Danish marine waters, including the Danish waters of the North Sea.

The Danish Ministry of Environment defines what is regarded as 'Good Environmental Status' of the marine environment using 11 different descriptors. For each descriptor a set of qualitative environmental targets and preliminary indicators are set. In the table below, all 11 descriptors are listed together with relevant environmental targets.

	Descriptors	Relevant environmental targets
D1	Biodiversity (birds)	Populations and habitats for birds are conserved and protected in accordance with objectives under the Birds Directive
D1	Biodiversity (mammals)	Harbour porpoise, harbour seal and grey seal achieve favourable conservation status in accordance with the timeline laid down in the Habitats Directive
D1	Biodiversity (pelagic habitats)	The abundance of plankton follows the long-term average.
D2	Non-indigenous species	The number of new non-indigenous species introduced through ballast water, ship fouling and other relevant human activities is decreasing
D3	Commercially exploited fish stocks	Within the framework of the Common Fisheries Policy, spawning biomass exceeds the level that can ensure a maximum sustainable yield.
D4	Marine food webs	The relevant environmental targets under descriptor 1 (biodiversity) and descriptor 3 (commercial exploited fish stocks)
D5	Eutrophication	Danish part of discharges of nitrate and phosphorous (TN, P) follows the maximal acceptable discharges set in HELCOM.
D6	Sea floor integrity (losses and physical impacts)	In connection with licensing offshore activities requiring an environmental impact assessment (EIA), the approval authority encourages assessment and reporting to the Danish Environmental Protection Agency (monitoring programme) of the extent of physical losses and physical disturbances of benthic broad habitat types.
D6	Sea floor integrity (habitat types on the sea floor)	The marine habitat types under the Habitats Directive achieve favourable conservation status in accordance with the timeline laid down in the Habitats Directive
D7	Alteration of hydrographical conditions	In connection with licensing offshore activities requiring an environmental impact assessment (EIA), the approval authority is encouraging reporting to the Danish Environmental Protection Agency (monitoring programme) of hydrographical changes and the adverse effects of these.

10 Consolidated Act no. 1161 of 25/11/2019 on Marine Strategy (bekendtgørelse af lov om havstrategi).

D8	Contaminants (concentrations and species health)	Discharges of contaminants in the water, sediment and living organisms do not lead to exceeding of the environmental quality standards applied in current legislation.
D8	Contaminants (acute pollution events)	The spatial extent and duration of acute pollution events is gradually reduced as much as possible through prevention, monitoring and risk-based scaling of contingency and response facilities Adverse effects on marine mammals and birds from acute pollution events are prevented and minimised as much as possible. For example, this may be secured by means of floating booms as well as through contingency plans for marine mammals and birds injured in oil spills.
D9	Contaminants in fish and other seafood for human consumption.	Emissions of contaminants generally do not lead to exceeding of the maximum residue levels applicable in the food legislation for seafood. The trend in total Danish dioxin emissions into the air is not increasing.
D10	Marine litter	The amount of marine litter is reduced significantly in order to achieve the UN goal that marine litter is prevented and significantly reduced by 2025.
D11	Underwater noise	As far as possible, marine animals under the Habitats Directive are not exposed to impulse sound which leads to permanent hearing loss (PTS). The limit value for PTS is currently assessed as 200 and 190 dB re.1 uPa2s SEL for seals and harbour porpoise, respectively. The best knowledge currently available is on these species.

It should be noted that the environmental status has not been mapped for all descriptors and thresholds are only defined for a few descriptors (contaminants and underwater noise).

OSPAR is currently working on a common framework of indicators and assessment values to be used in the Northeast Atlantic. In this EIA, a draft version of the list of indicators has been used to assess the impact of the project on the objectives of the Marine Strategy.

Eight areas in the North Sea have been appointed as marine protected areas according to the Marine Strategy Framework Directive. Activities within these areas are strictly regulated, however neither Hejre nor South Arne are located within one of these areas.

2.2.5 Maritime spatial plan

Maritime spatial planning is regulated through the Danish legislation in the Act on Maritime spatial planning[11].

The Danish Maritime Authority is responsible for establishing Denmark’s first maritime spatial plan. The maritime spatial plan is to form the basis of the coordination of the many uses of Denmark's sea area in a manner that can support the conditions for sustainable growth in Blue Denmark. The maritime spatial plan is to establish which sea areas in Danish waters can be used for inter alia, offshore energy extraction, shipping, fishing, aquaculture, seabed mining and environmental protection towards 2030.

[11] Consolidation act no. 400 of 06/04/2020

The maritime spatial plan 2.0 is currently through the process of public hearing and awaits final adoption. The areas of spatial planning at sea of relevance are primarily the zones for offshore energy exploration, see Figure 2-1.

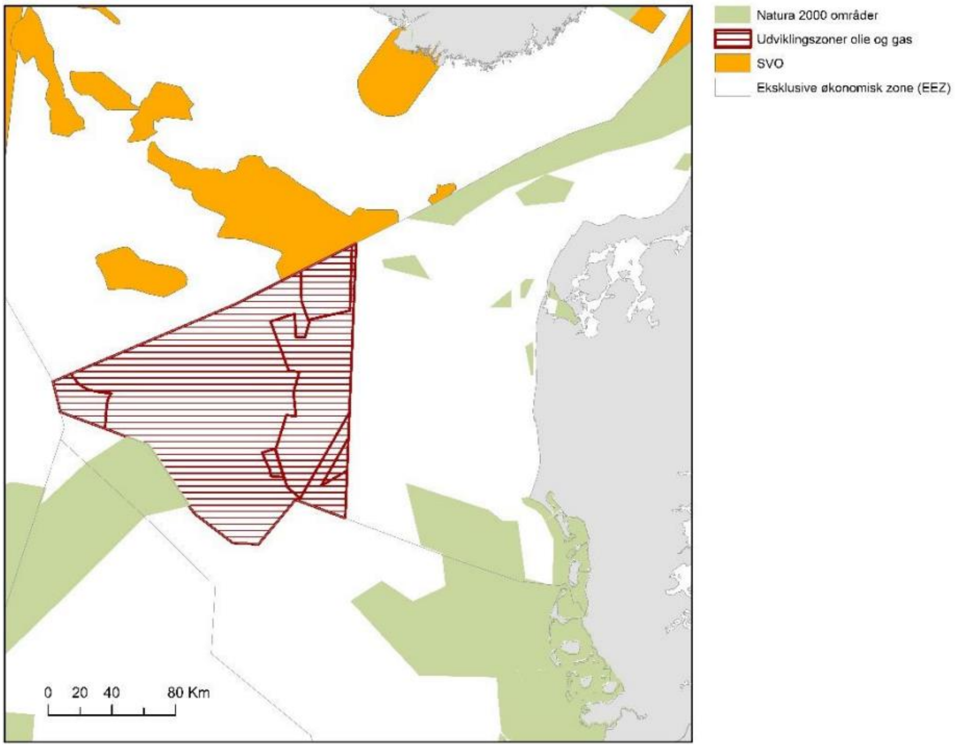


Figure 2-1 *Development zone for oil and gas exploration in relation to Norway SVO-areas (especially valuable areas) and Natura 2000 areas in German and Danish sector (COWI, 2021).*

2.2.6 Regulation of decommissioning

Decommissioning is regulated through Danish legislation in the Subsoil Act[4] and the Marine Environment Act**Error! Bookmark not defined.**.

According to the subsoil act decommissioning plans for offshore oil and gas installations shall be prepared, submitted and approved by the DEA before the installations can be removed. DEA has prepared a guideline for these decommissioning plans "Guideline on decommissioning plans for offshore oil and gas facilities or installations" dated August 2018. The guideline explains the legal framework and the required contents of the plans.

In addition, decommissioning is regulated through the following international conventions and declarations:

› IMO's Convention on the Prevention of Marine Pollution by Dumping of Wastes and other Matter (known as the London Convention 1972) including the 1996 Protocol which became effective in 2006.

› The London Convention is a global convention that aims at protecting the marine environment from human activities by promoting control of sources of marine pollution and by taking steps to prevent pollution of the ocean. Under the convention all dumping of waste is prohibited except certain types of waste listed on the convention's 'reverse list'.

› Ministerial Declaration of the Ninth Trilateral Governmental Conference on the Protection of the Wadden Sea (known as the Esbjerg Declaration 2001).

- OSPAR Commission's OSPAR Convention (1992 and 1998), Annex III on Prevention and elimination of pollution from offshore sources, Decision 98/3 on Disposal of disused offshore installations, and recommendation 77/1 on Disposal of pipes, metal shavings and other material resulting from offshore petroleum hydrocarbon exploration and exploration operations.

- Regarding decommissioning, the Esbjerg Declaration states that more environmentally acceptable and controllable land-based solutions are preferred, and that decommissioned offshore installations therefore shall either be reused or be disposed on land.

The OSPAR Commission establishes the framework for decommissioning including guidelines and procedures. Recommendation 77/1 states that dumping of bulky waste such as pipes and containers is prohibited without special permission excluding inter-field pipelines. All dumping or leaving wholly or partly in place of offshore installations in the North Sea is prohibited according to Decision 98/3. However, derogation from this regulation is possible when there are significant reasons why an alternative disposal is preferred. Decision 98/3 does not include decommissioning of pipelines.

2.3 National approval procedure in Denmark

2.3.1 Environmental Impact assessment (EIA)

An Environmental Impact Assessment (EIA) is required in order to obtain an approval for offshore exploration and production of oil and gas. This requirement is set forth in Directive on the assessment of the effects of certain public and private projects on the environment (EIA Directive[12]). The directive is implemented in Danish legislation through the:

- Consolidated Act on Environmental Assessment of Plans and Programmes and of Specific Projects (see footnote 5)

- Subsoil Act (see footnote 4)

- Regulation on EIA, impact assessment regarding international nature conservation areas and protection of certain species during offshore exploration and production of hydrocarbons, subsoil storage, pipelines, etc. (see footnote 6).

The EIA document on which this Espoo report is based is compliant with the above-mentioned legislation.

The public hearing process for offshore projects is as follows:

The project owners' application, the environmental impact assessment report and a draft permit from the authority will be available on the website of the Danish Energy Agency, and the public will have the opportunity to comment on the EIA through an eight-week public hearing phase. After the hearing period the DEA will decide if a permit for the project will be granted.

[12] Directive 2011/92/EU of the European Parliament and of the Council of 13 December 2011 on the assessment of the effects of certain public and private projects on the environment. Amended in 2014 it became Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment.

Decisions regarding the project and the EIA will be published on the DEA website, and any party with relevant and individual interests in the decision may file a written complaint on environmental issues to the Energy Board of Appeal within four weeks of the publication.

3 Technical description of project

3.1 Field description

The Hejre field is located within licence 5/98 on the Danish continental shelf approximately 300 km west of the Danish west coast. The field is a High-Pressure High-Temperature (HPHT) oil field with associated gas.

The Hejre jacket is located at the position 6.234.174,9 mN, 559.510,8 mE (reference UTM zone 31 on ED50 Datum) at approximately 68 m water depth.

The Hejre field, located in the southern part of the Central Graben, is dominated by extensive Late Jurassic rifting and subsequent Late Cretaceous inversion. The Gertrud Graben is bounded by the Mona fault and Piggvar Terrace towards the north, the Gerd Ridge towards the southwest and the Heno Plateau towards the south. The Gertrud Graben itself continues towards the northwest and merges with the Feda Graben. Below shows the extent of the interpretation used as input to the structural project.

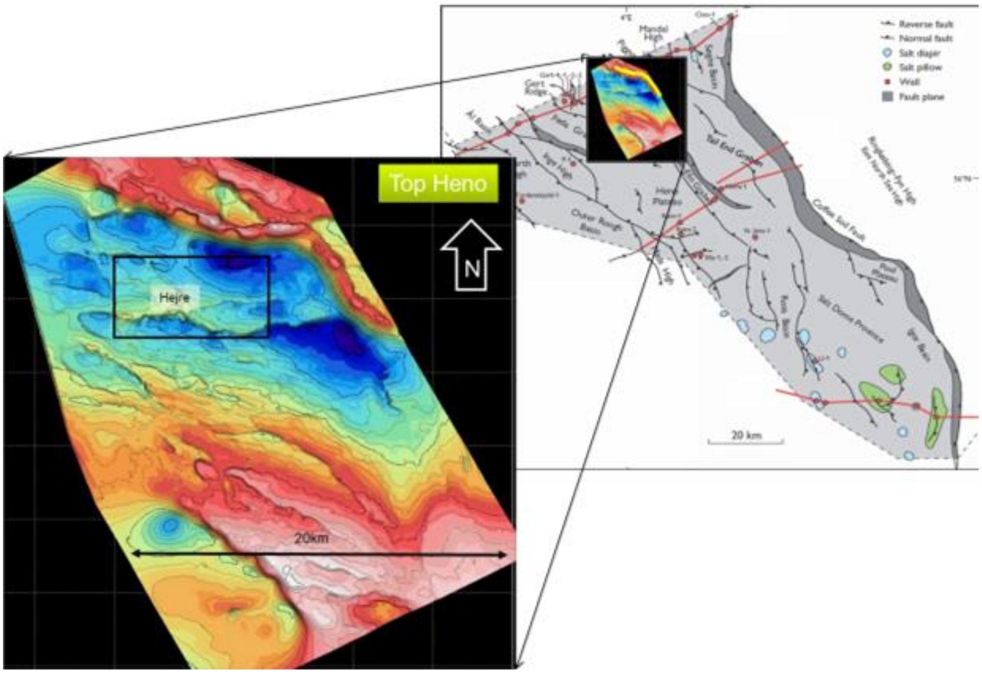


Figure 3-1 The Hejre area interpretation.

The Hejre field comprises several large segments, which are bounded by faults. Within the main Hejre field three of the main segments have been penetrated by exploration/appraisal and development wells and are considered as proven recoverable resources.

To date, 7 wells (including discovery well, Hejre-1 and appraisal well, Hejre-2) and 2 side-tracks (HA-1A and HA-3A) have been drilled on the Hejre field encountering the Gert reservoir in seven penetrations. Cores from 4 wells have been retrieved and provide crucial information to reservoir characteristics, interpretation of facies and depositional environment. Extensive sampling and analytical programming have been performed to characterise the sediment and diagenetical history. An overview of the drilled wells is shown on Figure 3-2.

Production is planned to take place from three of the existing Hejre wells HA-1A, HA-2 and HA-4, one in each segment of the Hejre field. The characteristics of the Hejre reservoir are provided in Table 3-1.

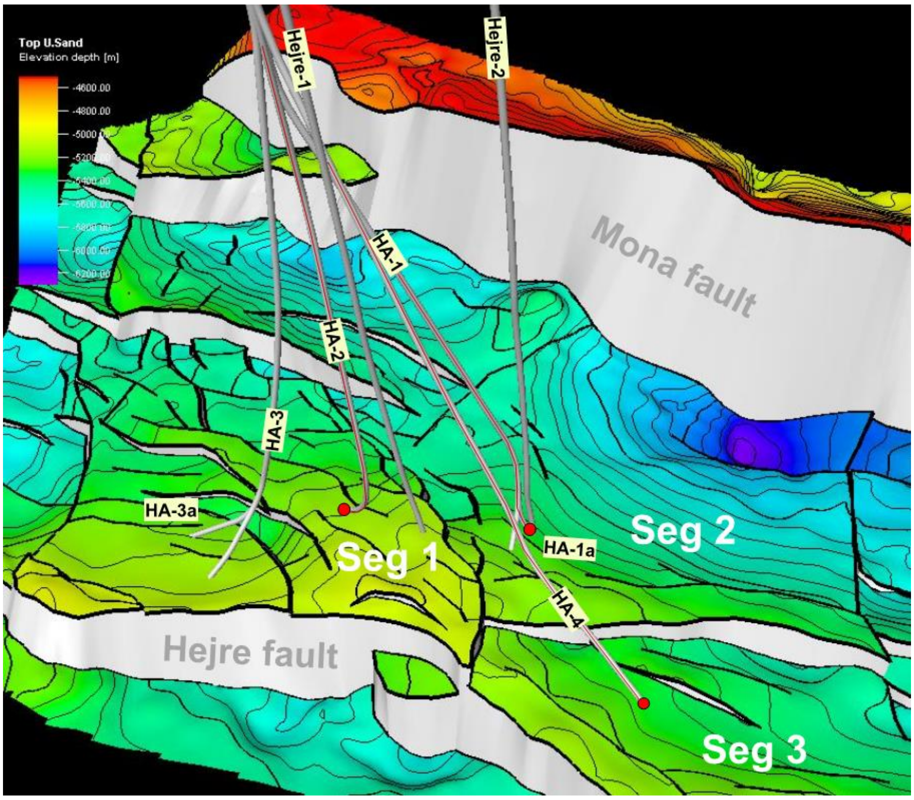


Figure 3-2 Overview of the 7 wells and 2 side-tracks drilled on the Hejre field.

Table 3-1 Hejre reservoir and fluid characteristics.

Parameter (unit)	Value
Reservoir depth (m)	5000-5500
Reservoir pressure (bar)	1000
Stratigraphy/Sedimentology	Jurassic shallow marine sands
Reservoir temperature (°C)	160
Reservoir thickness (m)	1-70
Oil density (API)	44
GOR (SCF/STB)	1300-2250

3.2 Project overview

The Hejre tie-back to South Arne development concept comprises a remotely controlled unmanned topside at Hejre and multiphase tie-back to the host South Arne where well fluids are processed. The multiphase production from Hejre will be exported to South Arne through a new 30 km multiphase pipeline (wet insulated or pipe-in-pipe).

The Hejre oil will be processed at South Arne main platform and produced to the South Arne Gravity Based Structure (GBS) for storage and exported by shuttle tanker like the South Arne oil, i.e., utilizing the existing South Arne oil export facilities. The gas will be exported through the existing South Arne to Nybro pipeline. NGL's will be injected at the host platform, South Arne, into the South Arne reservoir and will remain there.

The Hejre tie-back to South Arne project includes:

- Construction and installation
  - Construction and installation of a new unmanned topsides at Hejre
  - New fortified riser will be installed at Hejre
  - Perforation, clean-up and well test of 3 existing Hejre wells. Barrier repair of well HA-5
  - Drilling of a new well; Lunde (optional)
  - Modifications at Hejre jacket to remove the temporary items left over from the original installation in 2014.
  - Hook-up between the Hejre pre-drilling wellhead module installed in 2014 and the new topside.
  - Modification at the South Arne WHPE – a new tie-in module with a slug catcher, multiphase pig receiver, NGL pumps and new caisson with riser and power cable to be installed
  - Tie-in scope at South Arne Main – removal of obsolete degasser unit and new NGL injection booster pumps to be installed
- Laying and commissioning of pipeline and power cable
  - 30 km 10” or 12” multiphase pipeline from Hejre to South Arne
  - Installation of power cable with fibre optic from South Arne to Hejre with power and control from host
- Production
  - Processing of Hejre and Lunde well fluids at South Arne for 20 years
  - Operation and maintenance of multiphase pipeline and power cable
  - Operation and maintenance of Hejre platform and wells
- Decommissioning
  - Close-in, plug and abandonment of Hejre and Lunde wells
  - Flushing and dismantling of platform and subsea structures
  - Empty Hejre-South Arne pipeline and prepare for *in situ* disposal below seabed if permitted by Authorities

3.3 Existing installations

3.3.1 Hejre jacket and wellhead module

The existing Hejre structure comprises of an 8-legged steel jacket and a pre-drilled wellhead deck which were installed in 2014. Figure 3-3 shows the Hejre jacket present day (pictures taken in year 2019 during a maintenance campaign):

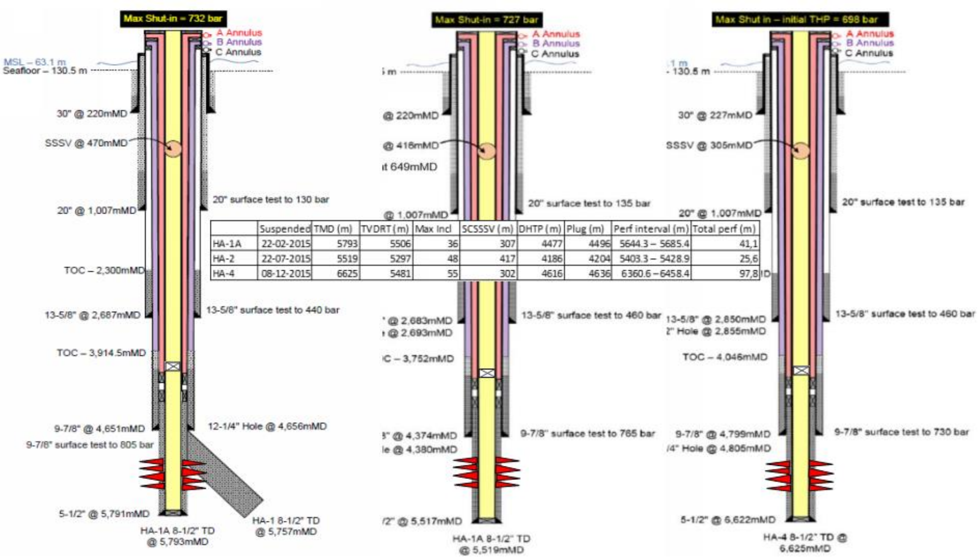
Figure 3-3 The Hejre Jacket

3.3.2 Hejre wells

Five HPHT wells have been drilled from the Hejre platform including two side-tracks. Drilling was completed in 2016 as part of Hejre Legacy,

Three of the wells (HA-1A, HA-2 and HA-4) have been drilled and completed with a 5-1/2” cemented liner across the reservoir and 5-1/2” production tubing to surface and Xmas Tree installed. The wells are ready for production pending pulling of deep-set plugs, perforation and clean-up. The wells are temporarily abandoned with seawater treated with corrosion inhibitor for protection of the wells.

The design of the 3 production wells can be seen on the figure below.



	Suspended	TMD (m)	TVDRT (m)	Max Incl	SCSSSV (m)	DHTP (m)	Plug (m)	Perf interval (m)	Total perf (m)
HA-1A	22-02-2015	5793	5506	36	307	4477	4496	5644.3 – 5685.4	41,1
HA-2	22-07-2015	5519	5297	48	417	4186	4204	5403.3 – 5428.9	25,6
HA-4	08-12-2015	6625	5481	55	302	4616	4636	6360.6 – 6458.4	97,8

Figure 3-4 Illustration of the design of the 3 HPHT production wells (from left: HA-1A, HA-2 & HA-4).

Two wells, HA-3A and HA-5, were decided to be plugged back and suspended at the 13-5/8" casing. These wells can be side-tracked at this point for future activities. A barrier repair of HA-5 is required.

3.3.3 South Arne host platform

The facilities at South Arne main consist of a combined wellhead, processing and accommodation platform, connected by a bridge to a wellhead platform, SA WHPE, and an unmanned satellite platform, South Arne Well Head Platform North (SA WHPN), see Figure 3-5. SA WHPE is placed about 80 m east of the existing South Arne platform and connected to the platform by a combined foot and pipe bridge while SA WHPN is an unmanned platform with a helideck about 2.5 km north of the existing South Arne main platform. A bundle pipeline has been established between SA WHPN and SA WHPE, which incorporates a production pipeline, lift gas and water-injection pipelines and power supply cables. South Arne main has accommodation facilities for 75 persons.

The processing facilities at South Arne consist of a plant that separates the hydrocarbons produced and an 87,000 m^3 oil storage tank on the seabed from which the oil is exported to shore by tanker. The treated gas is exported by a pipeline to Nybro. All the produced water is processed and treated, after which as much as possible is reinjected and the rest is discharged to sea.

Figure 3-5 South Arne and well head platform East.

The amounts of oil, gas and water produced at South Arne in 2020 are listed in Table 3-2.

Table 3-2 Key activity figures from South Arne 2020 (South Arne OSPAR report 2021).

Activity	Unit	Value
Oil production	thousand Sm³	479
Gas production*	million Sm³	82
Produced water, discharged	thousand Sm³	290
Displacement water discharged	thousand Sm³	481
Injected water	thousand Sm³	2,218

* Including for flaring and used locally as fuel

3.4 Drilling, construction and installation

3.4.1 Hejre Legacy wells

The scope for the present EIA related to the Hejre Legacy wells covers perforation and clean-up of HA-1A, HA-2 and HA-4 and barrier repair of HA-5. These activities are described further below.

Well perforation and clean-up of HA-1A, HA-2 and HA-4

A rig is required to re-enter the wells. The rig activities for completion of the wells will consist of:

- Move rig to location
- Rig up coil tubing
- Perforate, clean up and test wells
- Move rig away.

It is expected that a three-legged jack-up rig will be used for all well activities. The jack-up rig will be towed to and positioned alongside the Hejre platform. When the rig is in position, the rig's legs with spud cans will be lowered into the seabed to ensure that the rig will stay stabilized during drilling operations. A spud can is a flat conical shaped foot attached to the leg of the rig, which ensures that the rig will not sink too deep into the seabed.

The spud cans will typically penetrate 0.5-3 m into the seabed, depending on the underlying sediment. If necessary, the spud cans can be supported by rock dumps. Each spud will have a size of 201 m^2, which is 603 m^2 in total. The substructure of the leg will be an open construction with 3 rig legs each having a size of around 671 m^2, which results in 2013 m^2 (0.002 km^2) in total.

The drilling derrick will then be positioned over the platform so that the wells can be accessed or drilled through the selected slots on the platform.

Once the rig is in place and all interfaces established and verified, coiled tubing equipment will be rigged up on the completed wells. Coiled tubing will be used for pulling of the deep-set plugs and perforation of the wells. On each of the wells, a survey tool will be run on coiled tubing to verify and correlate depth and intervals for later perforation. After accurate well correlation, the perforating assemblies will be run in hole in each well and the wells perforated at correct depth and orientation.

Table 3-3 provides an overview of the estimated amounts of completion chemicals to be used for the Hejre Legacy wells. Possible amounts for contingencies are included in the figures.

Table 3-3 Estimated usage of completion and clean-up chemicals for the Hejre Legacy wells. All the usage figures include 100% for contingencies.

Completion chemicals	Planned use [tons]	Planned discharge [tons]	Colour code
Lubricant	0.2	0	R
Viscosifier	1	0.2	G
Brine	1203	0.1	G
Hydrate removal	12	0	G
MEG	533	0	G
Brine	300	0	G
Manage Clays	900	0	G
Well cleanup	127	0	Y
Viscosifier	15	0	Y
Corrosion Protection	3	0	Y
Brine	2400	0	Y
Lubricant	12	0	Y
Friction reducer	3	0	Y
H_2S scavenger	5	0.5	Y
Biocide	4	0.2	Y

After the well have been perforated, the well will start to flow unassisted based on low density inhibited completion brine. The initial flow will be completion brine from the well head to the perforation depth. Following the completion brine, the perforations debris with the formation fluid (oil + associated gas) will start flowing to surface. As a minimum, a 12-hour flow period is expected after the appearance of formation fluids at surface. Following the clean-up, the well will be closed-in for 2 hrs, then opened-up for a 24 hour well test until acceptable production fluid values are reached.

Clean-up and well test will take place via rig-based test equipment until acceptable production fluid values are reached. Well fluids will be produced to a test oil separator on the rig. Debris will be shipped to shore, produced oil will be pumped back to the South Arne process facility and gas will be burned via a rig-based burner. Minor droplets of oil can reach the sea which can create a sheen at surface (expected order of magnitude: ~1 litre per well). When the perforation, clean-up and well test has been completed the wells are handed over to the Production Operations Department.

The clean-up and well test is expected to produce approx. 2,600 Sm^3 oil per well and up to 1,200,000 Sm^3 gas per well.

Barrier repair of HA-5

The temporarily abandoned well HA-5 has an issue with the downhole cement plug set inside the 13-5/8” casing to create a barrier against any potential shallow permeable layers.

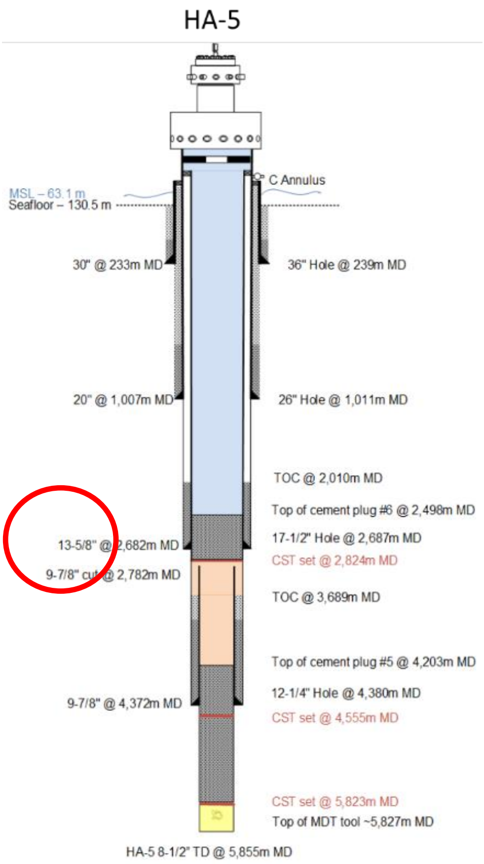


Figure 3-6 HA-5 cement plug.

The pressure between the plug and the surface barrier is slowly building up, and it will be required to enter the HA-5 well to repair the cement plug. The repair work will include the following activities:

- Skid to HA-5
- Remove the temporary abandonment (TA) cap, rig up the blow-out preventer (BOPs) and riser on HA-5
- Enter the well and drill out/dress-off part of the established cement plug

- Set a new cement plug on top and load- and pressure test same
- Rig down, re-install TA cap and skid away from HA-5.
- The existing plug will only be partly drilled out, to keep the plug as an additional safety barrier, while setting the new cement plug above.

For completion of the three existing Hejre wells chemicals will be used for the completion brine. No discharge is expected except for utility chemicals. Initial well flow during clean-up will require methanol injection to avoid hydrates across the production choke and a glycol water mix will be required for service equipment pressure test. The majority of these chemicals will be left in the well, whereas a smaller part will be discharged via South Arne.

For repair of the HA-5 barrier repair, drilling mud, cement and completion fluid will be used for drilling out the cement plug, setting a new cement plug and displacing the well to inhibited fluid whereafter the well will be left as temporarily abandoned. OBM will be used to drill out the cement plug. All OBM will be contained and shipped to shore for re-use or disposal. The cementing chemicals will run through the OBM system and will thus also be shipped to shore for re-use or disposal. The inhibited fluid in the wells will be led to the rig's slop unit and further on to South Arne for processing and reinjection with produced water. New inhibited water will be left in the HA-5 well. Thus, no discharges will take place.

Table 3-4, Table 3-5 and Table 3-6 provides overview of chemicals used for drilling out the plug, cementing and inhibited fluid for preservation, during repair of HA-5.

Table 3-4 Estimated use of chemicals for drilling out the plug of HA-5. All the usage figures include 100% for contingencies.

Drilling out plug	**Planned use [tons]**	**Planned discharge [tons]**	**Colour code**
Base Oil	258	0	Y
Viscosifier	11	0	Y
Alkalinity	16	0	G
Emulsifier	13	0	Y
Brine	70	0	G
Fresh water	103	0	G
Filter loss	8	0	R
Weight material	1,018	0	G

Table 3-5 Estimated use of chemicals for cementing of HA-5. All the usage figures include 100% for contingencies.

Cementing	**Planned use [tons]**	**Planned discharge [tons]**	**Colour code**
Anti-sedimentation	4	0	G
Dispersant	2	0	G
Viscosifier	0.2	0	G
Dispersant	0	0	Y
Anti-Foam	0.2	0	Y
Fluid Loss Control	0.5	0	Y
Solvent	0.5	0	Y

Surfactant	0.6	0	Y
Cement	41	0	G
Weighting Agent	21	0	G

Table 3-6 Estimated use of inhibition chemicals for preservation of HA-5. All the usage figures include 100% for contingencies.

Preservation	Planned use [tons]	Planned discharge [tons]	Colour code
Drill water/freshwater	460	0	Y
Biocide	0.7	0	Y
pH control	1.4	0	G
Alkalinity control	2.3	0	G
Oxygen scavenger	0.7	0	Y

A limited number of chemicals will be used on the rig. It is assumed that all rig chemicals will be discharged to sea via e.g. open drain.

The rig wash will be discharged with the washing water. It is assumed that the amount of water is 10 m³ and will be discharged within 1 hour. The use and discharge of rig wash is estimated to 0.3 tons rig wash per event and there will be approx. 25 events per well. In total that is 30 tons rig wash for the four wells.

The jacking grease is used when the rig is jacking up and down and thus only in the beginning and finalization of the rig activities. It is assumed that the jacking grease will be discharged over 10 days with a flow rate of 10 m³/day.

The hydraulic oil is assumed to be discharged over 10 days with a flow rate of 10 m³/day.

Table 3-7 Estimated use of utility chemicals. All the usage figures include 100% for contingencies.

Utility chemicals	Planned use [tons]	Planned discharge [tons]	Colour code
Rig wash	30	30	Y
Jacking grease / skid grease	0.2	0.2	Y
Pipe dope / tubing dope	3.2	0.3	Y
BOP control fluid	116	23	Y
Hydraulic fluid	1.6	0.1	Y
Wireline fluid	20	10	Y

Summary of use and discharge of chemicals

In summary, the expected usage of chemicals in the different stages of the perforation, clean-up and repair of the Hejre Legacy wells are listed in Table 3-8 segregated into the main hazard categories (DEPA colour classification red, yellow and green).

Table 3-8 Overview of expected usage (in tons) of chemicals per classification.

Activity	Red chemicals		Yellow chemicals		Green chemicals	
	Use (tons)	Discharge (tons)	Use (tons)	Discharge (tons)	Use (tons)	Discharge (tons)
Perforation & clean-up	0.2	0	2569	0.7	2949	0.1
Drilling out plug	8	0	282	0	1,267	6
Cementing	0	0	2	0	68	0
Preservation	0	0	462	0	4	0
Utility	0	0	171	64	0	0

Emissions to air

Emissions to air in relation to rig and well activities are related to:

- Rig activities (mainly running power generator)
- Crew transport activities by helicopter and standby boat
- Transport of rig (rig move)
- Flaring during well clean-up and well test
- Supply vessels (transport of goods).

Table 3-9 Type of transport related to completion activities for 3 production wells and repair of HA-5.

Vessel type	Number of vessels	Days	Fuel consumption [m3/day]
Rig operation during completion and clean-up			
Rig	1	100	10
Supply vessel	1	13	10
Standby boat	1	100	3
Tugs	1 (main) + 2 (assisting)	20	20 (main) + 10 (assisting)
Helicopters (kerosene)	1	13	1.2

The assumptions are:

- All estimated days include weather delays and unforeseen events.
- The rig is operating 100 days in total for all three wells.
- The supply vessels operating 11 hours/day, 2 times a week in 100 days equivalent to approx. 13 full days in total.
- The standby boat is available 24 hours/day while rig is operating.
- The helicopters are operating 3 hours/day in 100 days equivalent to 13 full days.

- The clean-up and well test is expected to produce approx. 2-4 well volumes. The total gas volume expected to be flared from the three wells is up to 3,600,000 Sm^3.

3.4.2 Lunde well

INEOS has optional plans to drill a new production well, Lunde. The Lunde discovery was made in the 5/98 Licence by the HA-4 well, which encountered oil bearing reservoirs in the uppermost part of the Farsund Formation referred to as the Gertrud sands, while drilling to the target of the deeper Gert Member sandstones (Hejre Field). Lunde covers an area of 5 km^2 and is located less than 2 kilometres east of the Hejre template, in the Danish Central Graben area.

The two reservoir zones with movable oil in Lunde discovery could be produced by drilling a well from the Hejre facilities to a position near the HA-4 well trajectory. Within the frames of the current development plan the Lunde could be co-produced with Gert reservoir reserves from the Hejre Field.

Well design and drilling

Drilling of the potential Lunde well is planned to take place in 2027 at the earliest, after finalising work on the Hejre Legacy wells, or alternatively in a later campaign. The potential Lunde well is expected to be drilled from the Hejre platform using a similar type jack-up rig as for the Hejre Legacy wells. The planned drilling period is estimated to last approximately 160 days. Additionally, there is a possibility of drilling technical side-tracks or geological side-tracks (to be decided later).

When drilling the well, first the conductor is drilled and cemented into the seabed. Installation of the conductor typically takes between 24 and 86 hours.

Use of chemicals in the construction phase

Chemicals will be used for a variety of purposes. Chemicals are added to the drilling muds to optimise the drilling process and subsequently for cementing and completion of the wells prior to initiation of the production. Also, chemicals are needed on the rig itself (utility chemicals). Each chemical is assigned to an environmental category by use of colour codes.

It should be noted that many of the chemicals mentioned in the following tables are not or only to some extent being discharged to the sea after use. Some will remain completely or partially in the formation, while others are brought onshore e.g., along with cuttings/mud for treatment and disposal.

Furthermore, it has not yet been decided whether the mud system will be water-based mud (WBM) or oil-based mud (OBM) and thus the chemicals mentioned below include all chemicals for both mud systems including contingency, optional sidetrack and with a safety factor applied. Thus, the total amounts of chemicals used and discharged is overestimated as only one of the mud systems will be applied. The total estimated use and discharge of chemicals can be seen in Table 3-8.

Drilling muds and chemicals

Offshore drilling typically applies two types of drilling mud: water-based mud (WBM) and low toxicity oil-based mud (OBM), see Table 3-10. WBM is applied in the 36" (30” casing) and the 26” (20” casing) sections, and OBM is applied in the 17-1/2” (13-5/8” casing), the 12-1/4” (9-7/8” casing) and in the bottom 8-1/2” (5-1/2” completion) sections. Table 3-11 and Table 3-12 show the planned usage of chemicals for the drilling of the well.

Table 3-10 Types of drilling mud for the Lunde well for the two types of mud systems. Water-based mud (WBM), low toxicity oil-based mud (OBM).

Section	Casing size	Mud system
36"	30”	WBM
26”	20”	WBM

17-1/2"	13-5/8"	OBM
12-1/4" (incl. sidetrack)	10-3/4" x 9-7/8"	OBM
8-1/2" (incl. sidetrack)	5-½"	OBM

Drilling muds have the following primary purposes:

- Moving the cuttings (produced by the drill bit) from the well to the surface.
- Lubricating and cooling the drill bit during operation.
- Maintaining hydrostatic pressure in the well so that gas and fluids in the surrounding environment do not enter the well, thereby minimizing the risk of a kickout or a blowout.
- Building a protective layer on the well wall to prevent loss of fluids.
- Supporting and preventing collapse of the wellbore.
- Inhibiting wellbore and cuttings

The drilling rig circulates the mud by pumping it through the drill string to the drill bit. From there it travels back up the annulus space between the drill string and the walls of the hole being drilled and the last casing installed. Cuttings are separated from the mud on the shale shaker. During drilling of the lower part of the well using OBM, the rig switches to total containment mode to obtain zero discharge, in accordance with OSPAR Decision 2000/3. It is a closed circulating system where the mud is recycled throughout the drilling period for the well.

The principle is illustrated in Figure 3-7 below.

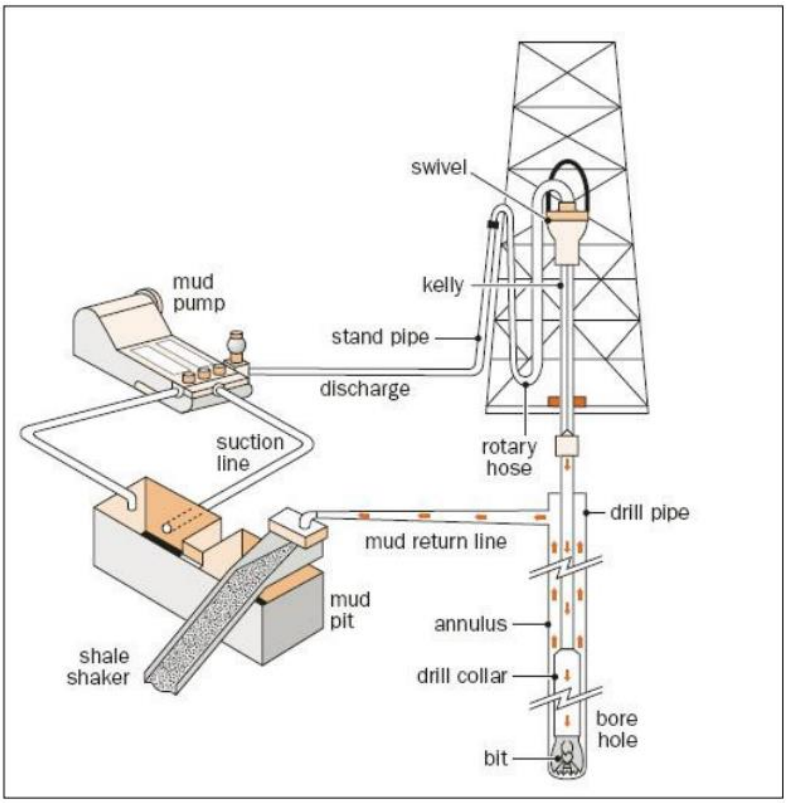


Figure 3-7 Drilling fluids system schematics.

All WBM and the associated chemicals and cuttings are discharged to the sea a few meters below the sea surface. All OBM fluids used to drill the lower sections will either be left in the well or circulated to surface where they are either reused or shipped for onshore disposal or recycling. Associated drill cuttings will also be shipped to shore.

It is envisaged that a water treatment unit similar to the type used during drilling of the Hejre Legacy wells may be used for treatment of fluids during drilling of the Lunde well. In that case, the water phase ('slop') from the OBM drilling and completion will be treated in the unit and discharged to sea. The majority of water discharged will be slop processed from collected rainwater and water used for cleaning drilling unit while drilling. As part of the treatment process, oil will be separated from the water before discharge takes place. In general, the oil in water concentration in the discharged water is expected to be in the level of 5-10 ppm. The discharged water will also contain traces of water-soluble chemicals used during OBM drilling.

Table 3-11 Estimated usage of WBM chemicals for the Lunde well. All the usage figures include 200% for contingencies.

WBM chemicals	Planned use [tons]	Planned discharge [tons]	Colour code
Viscosifier	3	3	G
Weighting agent	10,000	10,000	G
Lubrication	307	307	G
pH control	142	142	G
Torque reducer	30	30	G
Fluid Loss	6	6	G
Reduce Calcium	9	9	G
Manage Clays	900	900	G
H2S scavenger	0.23	0.23	Y
Biocide	30	30	Y

Table 3-12 Estimated usage of OBM chemicals for the Lunde well. All the usage figures include 200% for contingencies. Discharges of water-soluble chemicals from a water treatment unit not quantified.

OBM chemicals	Planned use [tons]	Planned discharge [tons]	Colour code
Fluid Loss	455	0	G
Weighting agent	10,000	0	G
Fluid Loss	75	0	G
Inhibition	900	0	G
Wetting Agent	27	0	G
Well stimulation	1	0	G
pH control	142	0	G
Torque reduce	30	0	G
Manage Clays	900	0	G
Fluid Loss	180	0	G
Viscosifier	45	0	G
Fluid Loss	55	0	R
Polymer	182	0	R
Emulsifier	212	0	R

Well cleanup	20	0	Y
Viscosifier	20.3	0	Y
Lubrication	75	0	Y
Emulsifier	502	0	Y
Filtration control agent	104	0	Y
Formation damage removal	31	0	Y
Oxygen scavenger	1	0	Y
H2S scavenger	0.23	0	Y
Biocide	0.10	0	Y
Weighting agent	0.56	0	Y
Oil mud base	3013	0	Y

Cementing

Casing is cemented into place in all the sections of the well. When drilling of each section is completed, sections of metal casing, slightly smaller than the well diameter, are placed in the hole to provide structural integrity. These are fixed into place by pumping cement into the annulus space between the casing and the well wall.

The cement fluids are pre-mixed in mix tanks on the drilling rig before being pumped into the well. To minimize the quantities of chemicals used, a cement liquid additive system is used to calculate the volumes of pre-mixed fluids required. The majority of the cement will be left in the well. Possible dead volumes may remain in surface tanks and lines after the operation and excess cement may return from the well. In both cases, the cement will be sent to slops and further to shore for disposal. No red chemicals will be discharged to sea.

Table 3-13 gives an overview of the estimated usage of cementing chemicals at Lunde.

Table 3-13 Estimated usage of cementing chemicals for the Lunde well. All the usage figures include 200% for contingencies. Discharges of water-soluble chemicals from a water treatment unit not quantified.

Cementing chemicals	Planned use [tons]	Planned left in well [tons]	Planned discharge [tons]	Colour code
Weighting agent	168.6	54.7	113.9	G
Hydration process	307.0	307.0	0.1	G
Cement	606.9	601.8	5.1	G
Cement additive	17.7	17.4	0.3	G
Increase slurry stability	1.0	0.9	0.1	G
Retarder	4.3	3.9	0.4	G
High specific gravity material	10.2	9.3	0.9	G
Improve hardening	70.9	69.0	1.9	G
Free water control	2.0	1.8	0.2	G
Loss cirulation preventer	7.1	6.7	0.4	G
Maintain integrity	312.0	312.0	0.0	R
Dispersant	11.8	11.2	0.6	Y
Cement defoamer	0.8	0.8	0.0	Y
Fluid Loss	15.2	14.6	0.6	Y
Solvent	2.4	2.2	0.2	Y
Defoamer	1.4	1.3	0.1	Y

Cement retarder	18.9	17.8	1.1	Y
Emulsifier	2.8	2.6	0.3	Y

Completion and borehole clean-up

When reaching the reservoir, the completion process begins. A sand control completion is installed in the reservoir section. Then, the top completion takes place installing the production tubing, safety valves, sensor for pressure and temperature measurements and valves for injection required downhole chemicals.

Completion of a well consists of a few processes that start after the well has reached TD. The well must first be circulated clean for drill cuttings and the fluid conditioned to ensure the reservoir completion can be run to TD. The reservoir completion is run in weighted and cleaned drilling fluids. A tubing string is run to TD, cemented in place and later perforated. Then the top completion is installed and prior to setting the production packer the upper part of the well is displaced to a clean and inhibited completion fluid as the fluid could be static for a longer period between the production casing and the production tubing.

Table 3-14 provides an overview of the estimated amounts of completion chemicals to be used at Lunde. Possible amounts for contingencies are included in the figures.

Table 3-14 *Estimated usage of completion and clean-up chemicals for the Lunde well. All the usage figures include 200% for contingencies. Discharges of water-soluble chemicals from a water treatment unit not quantified.*

Completion chemicals	Planned use [tons]	Planned discharge [tons]	Colour code
Lubricant	0.2	0	R
Viscosifier	1	0.2	G
Brine	1203	0.1	G
Hydrate removal	12	0	G
MEG	533	0	G
Brine	300	0	G
Manage Clays	900	0	G
Well cleanup	127	0	Y
Viscosifier	15	0	Y
Corrosion Protection	3	0	Y
Brine	2400	0	Y
Lubricant	12	0	Y
Friction reducer	3	0	Y
H_2S scavenger	5	0.5	Y
Biocide	4	0.2	Y

The wellbore displacement to completion fluid will displace the OBM drilling fluid out of the well and up to the rig, where it will be treated and contained. In this process, a spacer train containing viscous and detergent pills is pumped into the well ahead of the completion fluid to maintain a good interface between the two types of fluids.

As much as possible of the returned drilling fluid from the borehole clean-up will be collected for reuse, recycling or disposal onshore.

After the well has been perforated, the well will start to flow unassisted based on low density inhibited completion brine. The initial flow will be completion brine from the well head to the perforation depth. Following the completion brine, the perforations debris with the formation fluid (oil + associated gas) will start flowing to surface. As a minimum, a 12-hour flow period is expected after the appearance of formation fluids at surface. Following the clean-up, the well will be closed-in for 2 hrs, then opened-up for a 24 hour well test until acceptable production fluid values are reached.

Clean-up and well test will take place via rig-based test equipment until acceptable production fluid values are reached. Well fluids will be produced to a test oil separator on the rig. Debris will be shipped to shore, produced oil will be pumped back to the South Arne process facility and gas will be burned via a rig-based burner. Minor droplets of oil can reach the sea which can create a sheen at surface (expected order of magnitude: ~1 litre per well). When the perforation, clean-up and well test has been completed the wells are handed over to the Production Operations Department.

The clean-up and well test of the Lunde well is expected to produce approx. 2,600 Sm^3 oil and up to 1,200,000 Sm^3 gas.

Utilities

A limited number of chemicals will be used at the rig (utility chemicals), mainly for cleaning, sealing and lubricating purposes. Table 3-15 lists the estimated amounts of utility chemicals planned to be used for Lunde. Discharge to sea via e.g. open drain.

Table 3-15 Estimated use and discharge of utility chemicals for the Lunde well. Numbers are totals for the four wells and include 100% contingency.

Rig chemicals	Planned use [tons]	Planned discharge [tons]	Colour code
Thread compound	0.95	0.95	Y
Corrosion Protection	5	0	Y
BOP control fluid	116	23	Y
Rig wash	21	21	Y
Jacking grease	0.5	0.5	Y
Hydraulic fluid for well control	0.4	0.004	Y
Wireline fluid	10	5	Y

Summary of use and discharges of chemicals, mud and cuttings

In summary, the expected usage of chemicals in the different stages of the construction are listed in Table 3-16 segregated into the main hazard categories (DEPA colour classification red, yellow and green). As mentioned above, contingencies are included (200%).

Table 3-16 Overview of expected usage (in tons) per well of chemicals per classification. All the usage figures include amounts for contingency.

Activity	Red chemicals		Yellow chemicals		Green chemicals	
	Use (tons)	Discharge (tons)	Use (tons)	Discharge (tons)	Use (tons)	Discharge (tons)
Drilling, WBM	0	0	30.2	30.2	1,407	1,407
Drilling, OBM	459	0	3,767	0	2,765	0
Cementing	312	0	55.8	2.9	1,196	123.4
Completion	0.2	0	2,557	0.7	2,950	0.4

Activity	Red chemicals		Yellow chemicals		Green chemicals	
	Use (tons)	Discharge (tons)	Use (tons)	Discharge (tons)	Use (tons)	Discharge (tons)
Clean-up	0	0	0	0	10	2
Utility	0	0	154	51	0	0

During the construction of a well, a number of the materials or chemicals being used or generated will be discharged to the sea. In terms of tonnage, the discharge of cuttings and water-based drilling mud, WBM, are the most significant. WBM consists mainly of a brine with added bentonite and barite and a number of agents aimed at regulating viscosity and stabilising clay.

Table 3-17 provides an overview of the amounts of cuttings and mud/cement from different drilling sections including the optional sidetrack and their fate for the two options for mud systems. All OBM cuttings and mud will be shipped onshore for further treatment and disposal.

Table 3-17 Estimated generation/use and discharge of cuttings and drilling mud for the Lunde well including the optional sidetrack, including 100% contingency.

Section	Mud type	Cuttings [mT]	Discharge to sea
36"	WBM	380	Cuttings: 1,982 mT WBM: 2,150 mT
26"	WBM	1,602	
17-1/2"	OBM	2,013	Cuttings: 0 mT OBM: 0 mT
12-1/4" (incl. sidetrack)	OBM	926 + 926	
8-1/2" (incl. sidetrack)	OBM	348 + 348	

Cuttings shipped to shore are expected to be sent to a treatment facility approved by the authorities in Norway or the UK, while slop as a base case is shipped to shore is expected to be sent to Esbjerg and from there sent to a treatment facility approved by the authorities. The expected amount of slop is approximately 500 m^3. Alternatively, the slop will be treated on site in a water treatment unit and the water phase including small amounts of oil and water-soluble chemicals will be discharged to sea after treatment.

Emissions to air

Emissions to air in relation to rig and well activities when drilling Lunde are related to:

- Rig activities (mainly running power generator)
- Crew transport activities by helicopter and standby boat
- Transport of rig (rig move)
- Flaring during well clean-up and well test
- Supply vessels (transport of goods).

Table 3-18 Type of transport related to drilling of Lunde well.

Vessel type	Number of vessels	Days	Fuel consumption [m3/day]
Rig operation during completion and clean-up			

Rig	1	159	10
Supply vessel	1	103	10
Standby boat	1	159	3
Tugs	1 (main) + 2 (assisting)	20	20 (main) + 10 (assisting)
Helicopters (kerosene)	1	20	1.2

The assumptions are:

- All estimated days include weather delays and unforeseen events.
- The rig is operating 159 days in total for the full drilling campaign.
- The supply vessels operating 60 hours/run, 1.5 times a week in the 43 days of drilling with WBM and 2.5 times a week in the 90 days of drilling with OBM, equivalent to approx. 103 full days in total.
- The standby boat is available 24 hours/day while rig is operating.
- The helicopters are operating 3 hours/day in 159 days equivalent to 20 full days.
- The clean-up and well test is expected to produce approx. 1,200,000 Sm^3 gas for flaring per well.

The total emissions to air from all activities in the construction phase can be seen in Table 3-19.

Table 3-19 Summary of the estimated emissions to air during the construction phase of the Hejre tie-back to South Arne concept

Construction phase	CO_2 [ton]	NO_X [ton]	SO_X [ton]	CH_4 [ton]	nmVOC [ton]	CO_2-eq[1)] [ton]
Pipelay	5,790	106	7	0.2	7	5,796
Installation of the Hejre topside and tie-in module at South Arne	7,880	135	10	1.5	5.5	7,922
Completion and well repair activities	20,610	137	10	1.5	5	20,652
Drilling of Lunde	16,252	205	15	1	9	16,280
Total [ton]	**50,532**	**583**	**42**	**4**	**27**	**50,650**

[1)] CO_2-eq is the total emission of CO_2 and CH_4. The global warming potential for CH_4 is 28 (IPCC, 2014)

3.4.3 Platforms

Modification of the existing Hejre jacket

Before installation of the new Hejre topsides, some modifications of the existing jacket are conducted. The following activities are to take place:

- Removal of temporary items on the jacket left over from the original installation in 2014, and other temporary equipment such as solar panels.
- Completion of the Pre-Drilling Wellhead Module (PDWM) and removal of some caissons
- Installation of new fortified riser. The existing Hejre risers will remain in place as they could be utilised in the future. I.e., they can only not be used for the Hejre to South Arne concept due to the export pressure and temperature, which is different from the Hejre Legacy concept.

The activities will be conducted by a small Heavy Lift Vessel (HLV) and a flotel or similar will be at Hejre for accommodation.

Installation of new Hejre topsides

The new Hejre topsides module main frame on Figure 3-8 is designed to fit onto the existing Hejre jacket. The module follows the existing jacket leg spacing with 20 meters in both directions. The deck height follows the existing wellhead module.

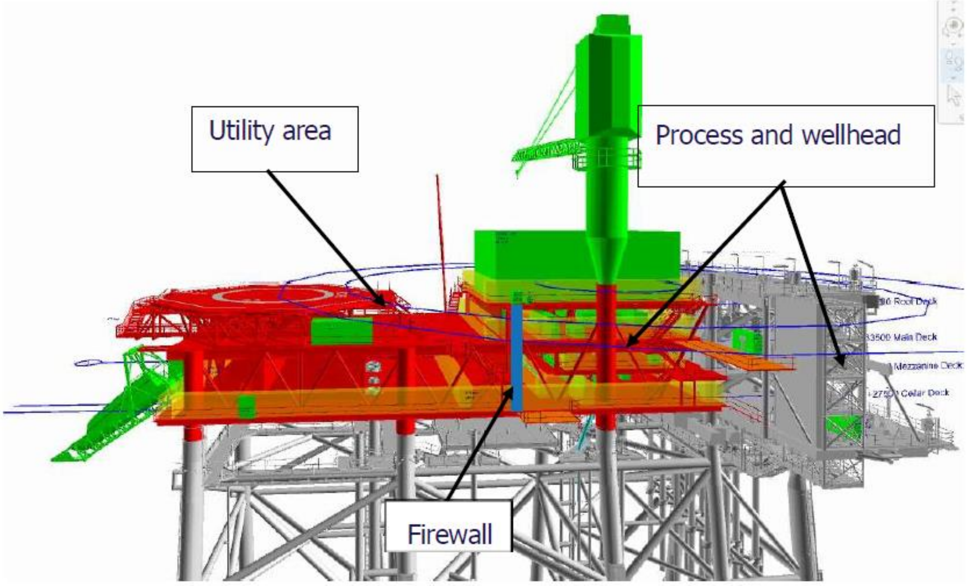


Figure 3-8 *The Hejre new unmanned topside located on existing jacket structure. Grey is existing structure, red is new structure incl. helideck, green is new equipment such as lifeboat, crane, air-cooler. Blue is the firewall separating the utility area and the process and wellhead area.*

The new unmanned topside structure includes:

- Permanent helideck
- Electrohydraulic crane
- Air-cooled exchange, well stream cooler (no processing)
- Shelter
- Over pressure protection fully rated to well shut-in pressure
- Necessary utilities incl. local chemical supply

The topsides will have an estimated weight of 2,100 ton in (dry weight).

The main principle of installation of the topside is that the module will be lifted in one lift using a HLV. A flotel or similar will be at Hejre for accommodation.

Modifications at South Arne WHPE and Main

The Hejre tie-back to South Arne concept will export the multiphase to South Arne.

The Hejre multiphase is intended to be produced through a new riser at South Arne WHPE. To tie-in the multiphase fluid from Hejre, the following new equipment are expected to be installed:

- Riser caisson at South Arne WHPE housing multiphase riser and power cable
- New tie-in module with slug catcher (metering on outlets), heater, pig receiver, NGL pumps at South Arne WHPE

- NGL injection booster pumps at South Arne Main platform

The riser caisson will be lifted by a small lifting vessel together with the tie-in module.

Emissions during installation

Emissions to air in relation to pre-installation activities, installation of the new Hejre topsides and the modifications at the South Arne WHPE and Main platform are related to: Transport activities and operations by the Heavy Lift Vessel (HLV), the flotel and special vessels used for installation of the risers at Hejre, the Hejre topside, the caisson with riser at South Arne and the tie-in module at South Arne.

The vessels listed in Table 3-20 are included in the fleet. The days include contingency for weather delays and unforeseen events.

Table 3-20 Type of transport related to topsides installation activities (INEOS).

Vessel type	Number of vessels	Days	Fuel consumption [m3/day]
Heavy lift vessel (HMC Balder or similar)	1	9	40 (mT/day)
Barge	1	35	Not applicable
Tugboats	2	35	20
Flotel for HUC (Seafox Marinia or similar)	1	125	3 (mT/day)
Heavy lift vessel (Seven Artic or similar)	1	18	30 (mT/day)

3.4.4 Pipeline and power cable

The pipeline system connecting the Hejre platform to the host platform South Arne WHPE will consist of one pipeline and one power cable: A new 30 km 10” or 12” multiphase pipeline, either wet insulated or pipe-in-pipe, from Hejre to South Arne WHPE and a new 30 km power cable with electrical power cables and fibre optic cables from Hejre to South Arne WHPE.

The expected pipeline route is presented in Figure 3-9.

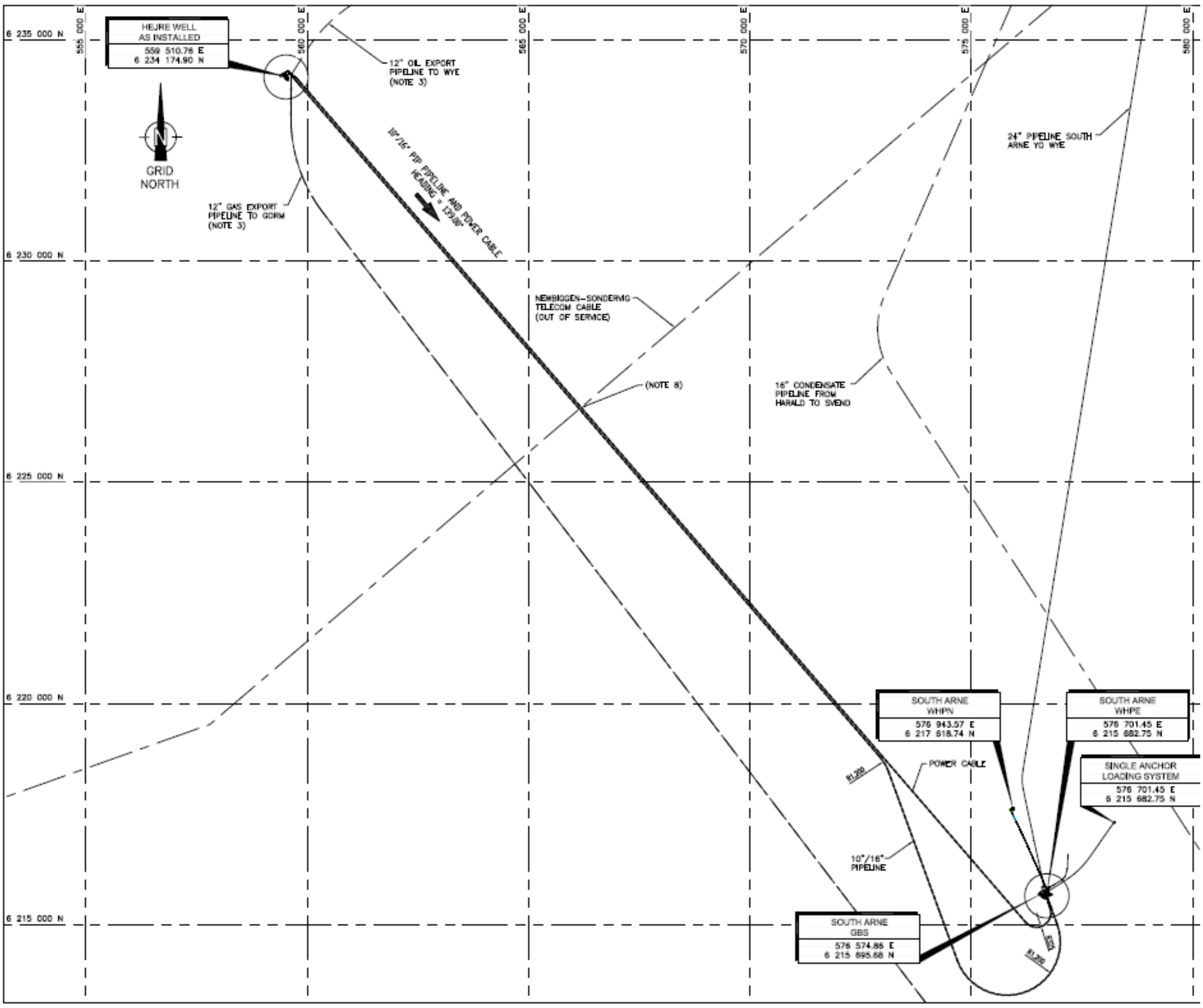


Figure 3-9 Pipeline and power cable route from Hejre to South Arne

The process of installation, burial and commissioning of pipelines and pipelines spools include the following activities:

- Pre-installation survey of the pipeline route
- Laying of the pipelines on the seabed
- Flooding with inhibited seawater
- Trenching and back-filling
- Tie-in spools
- Cleaning and gauging
- Hydrostatic testing
- Dewatering if required
- Commissioning

The pipeline alignment will initially be checked for presence of foreign objects that could interfere with the pipeline installation.

The pipelines will be laid out on the seabed using a dynamically positioned reel-lay vessel and will be flooded with inhibited seawater soon after laying to ensure the stability of the pipelines.

The pipelines will be trenched and buried in the seabed to protect from fishing trawling gear and other underwater equipment. Two trenching methods are considered, ploughing and water jetting, where the ploughing is considered the most cost-effective and a good solution for the area. The ploughing is generally giving an even vertical profile of the pipeline, which will eventually limit post-installation mitigation actions like rock dumping. In applying the ploughing method, a 1.5-2.5 m deep trench is constructed at a rate of 200-400 m per hour. Backfilling the pipeline trench is done at a similar rate. Applying the water jetting method, a 0.5 m wide and minimum 1.5 m deep trench is constructed at a rate of 200-1,000 m per hour. Use of this method is limited to sand and soft clay.

The pipeline and power cable will be trenched in parallel trenches with 50-meter distance between the trenches, see Figure 3-10 below for the pipelines approach at Hejre. After exiting the trench, the pipelines will be protected by rock dump and concrete mattresses.

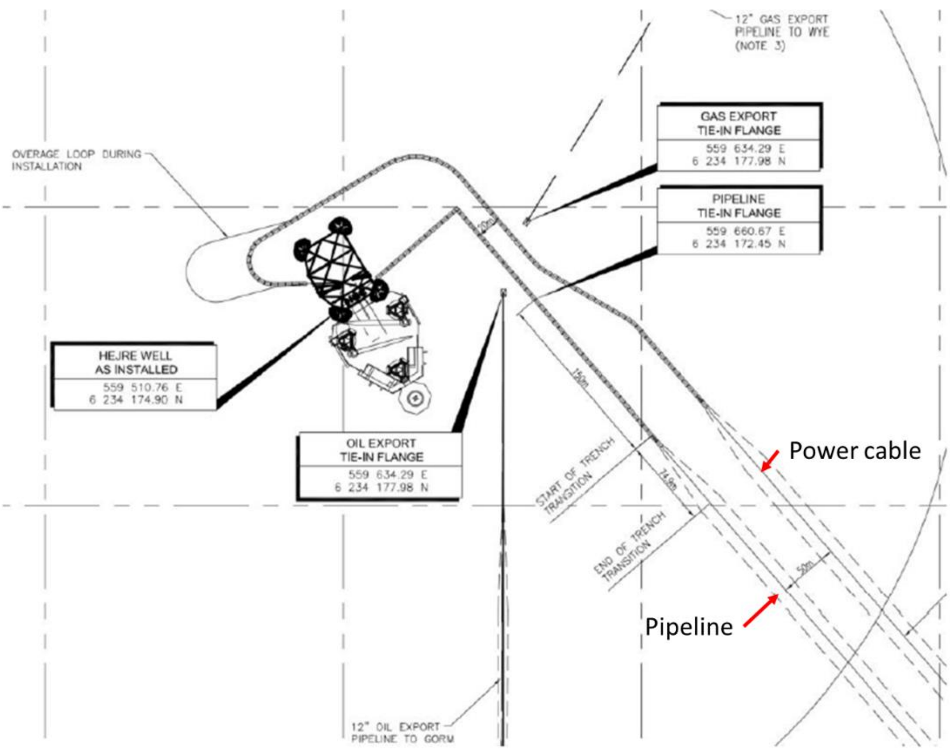


Figure 3-10 Pipeline and power cable approach to Hejre, showing the end of each trench. The untrenched part will be protected by rock dump

When the pipelines have been trenched and backfilled, the system is tied-in at the Hejre and South Arne WHPE platforms using bespoken spools, and a simultaneous cleaning and gauging process is performed by designated pigs at a speed of roughly 0.5 m per second.

Pipelines are hydrostatically tested before commissioning to make sure the pipelines do not leak. For 24 hours, the flooded pipelines are exposed to a test pressure, usually 15% greater than the design pressure, and is monitored for any pressure drops that would indicate a leak. Mechanical coupling locations, such as valves, flanges and spools have the highest probability of leaking, so these will be monitored during the hydrostatic test. The leak testing is facilitated by adding a fluorescent chemical, so even small leaks can be easily identified.

The Table 3-21 below gives an overview of the estimated amounts planned to be used during the pipeline tests. The amount is based on a dosage rate of 500 ppm in all pipelines that are tested. The dosage rate of the fluorescent is estimated to be less than 10% of the corrosion inhibitor.

Table 3-21 Estimated use of chemicals during pipeline tests

Pipeline testing	Planned use [tons]	Planned discharge [tons]	Colour code
Corrosion inhibitor	0.5	0.5	Y
Fluorescent tracer chemical	0.05	0.05	Y

The final step before commissioning is dewatering of the pipelines. If required, the multiphase pipeline will be dewatered in the direction from Hejre to the host using a pig that is forced through the pipeline.

Emissions during pipelay and power cable

Emissions to air in relation to pipelay are related to transport activities and operations by the fleet (pipelay vessel and special vessels) used for pipelay.

The operations by the fleet both include transportation activities and operations such as pipelay, rock dumping, trenching etc. The vessels listed in Table 3-22 are included in the fleet. The days include contingency for weather delays and unforeseen events.

Table 3-22 Type of transport related to pipelay activities (INEOS).

Vessel	Number of vessels	Days	Fuel consumption [m3/day]
Pipelay			
Pipelay vessel (Seven Navica or similar)	1	30	20
Survey vessel (ROV) (Seven Petrel or similar)	1	35	5
Trenching vessel (Skandi Skansen or similar)	1	20	20
DSV (Seven Atlantic or similar)	1	45	20
Guard vessel	1	30	0.5

3.5 Production phase

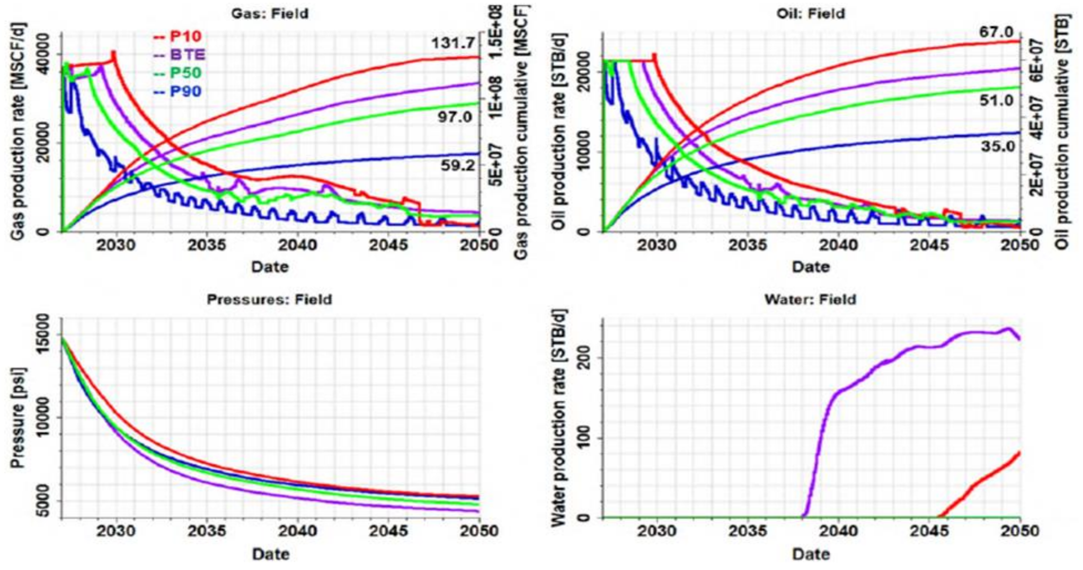
3.5.1 Production activities during operation of Hejre

In the following a description of production activities at the Hejre unmanned platform is presented. The current project redevelopment plan with South Arne as host platform anticipates first oil exported from the Hejre field in 2027 with production rates as listed in Table 3-23. No produced water is expected from Hejre in the P50 scenario, but small amounts of water (up to 240 Sm3/d may appear in late life in other scenarios (P10 and P90). The prognosis for amount of produced water is although estimated with high uncertainty.

Table 3-23 Overview of anticipated production rates from the Hejre and Lunde wells.

Production	Hejre design flow rates (P50)	Lunde design flow rates (P50)
Oil	4,000 Sm³/d (25,000 bbl/d)	3,200 Sm³/d (20,000 bbl/d)
Gas	1,220,000 Sm³/d (43 MMSCFD)	320,000 Sm³/d (11 MMSCFD)
Produced water*	0 Sm³/d (0 bbl/d)	56 - 1,430 Sm³/d (9,000 bbl/d)
Total produced liquid**	4,000 Sm³/d (25,000 bbl/d)	
*Min rate at start of operation, max rate towards end of life **The total combined fluids exported from Hejre is capped by the capacity offered at the host, South Arne (25,000 bbl/d).		

The production profile during the expected lifetime of Hejre is shown in Figur 3-1



Figur 3-1 Expected production profile of production from Hejre, during the lifetime of the field. Production of oil and gas is expected to reach a maximum before 2030, after which it will gradually decline. Water production is ex-pected to increase gradually during the lifetime of the field.

Estimated production rates from Lunde are also included in Table 3-23. Produced water is expected from the start of operation, with rates of reaching the max. level in 4-5 years, whereas oil and gas volumes will decline over the lifetime of the well.

The date for potential first oil from Lunde is not yet known, but will be later than Hejre, see Section 1.5. The Hejre and Lunde wells will not produce at their maximum at the same time, as production is limited by the capacity offered at the host, South Arne (25,000 bbl/day).

3.5.2 Discharge of produced water

During the processing on the South Arne platform, the produced water will be separated from the oil and gas and cleaned before it is discharged to sea if the produced water exceeds the injection capacity.

It is expected that the amount of produced water at South Arne to be discharged will not exceed the limits set in the existing South Arne EIA (Hess, 2006) due to tie-in of Hejre. Approximately 80% of the produced water at South Arne is reinjected.

Production chemicals at Hejre

The chemicals already in use at South Arne are assumed to be suitable for the Hejre production fluids as well. The chemicals used at Hejre and required for export of the Hejre multiphase to South Arne and treatment of the potential produced water later in the field life will be:

- Process corrosion inhibitor for continuous injection to multiphase export line
- Corrosion inhibitor for preventing corrosion in closed loop cooling system
- Wax inhibitor for continuous injection to multiphase export line
- Scale inhibitor to continuous injection to upstream choke
- MEG for intermittent services
- Hydraulic fluid to motive fluid for actuation of valves
- Cooling medium for use in closed loop cooling system.

The chemicals used at South Arne for treatment of the Hejre production will be:

- H2S scavenger for removal of H_2S from export gas to delivery specification.
- Demulsifier for continuous injection to improve separation of oil and water in the separator.
- Antifoam for continuous injection to improve the separation oil and water.

The use of chemicals will be evaluated on an ongoing basis to optimise the production process and reduce chemical consumption. The chemicals will be supplied via tote tanks at Hejre or injected locally at South Arne.

There will be no discharge point at Hejre. All water-soluble chemicals will be discharged at South Arne with the produced water. The remainder of the chemicals will be exported to shore with the export oil.

Table 3-24 provides an overview of chemicals to be used on Hejre during production. The numbers are based on the maximum oil production of 35,000 BOPD, which is a conservative estimate based on no restrictions in the production capacity at South Arne.

Table 3-24 Estimated use of chemicals at Hejre during production. Water soluble chemicals will be discharged with the produced water at the South Arne.

Hejre production chemicals	Planned use at Hejre [tons/year]	Planned discharge at South Arne [tons/year]	Colour code
Corrosion inhibitor	12	0	Y
Process corrosion inhibitor	35	0.35	Y
Scale inhibitor	3	3	Y
Wax inhibitor	610	6.1	R
H_2S scavenger	74	0	Y
Demulsifier	35	0.35	Y
Antifoam	35	0.35	Y
Cooling medium	246	0	Y
Hydraulic fluid	1	0	Y

Production chemicals at South Arne

The use of production chemicals at South Arne is based on production from the South Arne wells. The amounts of use and discharge is based on the 2021 expected use and discharge at South Arne and the additional expected use and discharges after tie-in of Hejre.

After tie-in of Hejre, South Arne will receive oil and gas from Hejre for processing. Chemicals exported with oil and gas from Hejre will be hydrate inhibitor, corrosion inhibitor, scale inhibitor, wax inhibitor, demulsifier and antifoam.

The estimated use and discharge of chemicals at South Arne after tie-in of Hejre is shown in Table 3-25.

Table 3-25 Estimated annual use and discharge of chemicals at South Arne after the Hejre tie-in.

South Arne production chemicals	Planned use after Hejre tie-in [ton/year]	Planned discharge after Hejre tie-in [ton/year]	Colour code
Antifoam (Deaerator)	2	2	Y
Biocide (process + deaerator)	18	4.4	Y
Corrosion inhibitor	60	9.3	Y
Demulsifier	41.3	0.7	Y
EVR	46	3.5	Y
H_2S scavenger	218.4	21.6	Y
H_2S scavenger	41	7.4	Y
Sodium Hypochlorite	110	110	R
TEG	8	2	Y
Antifoam (Process)	36.3	1.2	Y
Oxygen Scavenger	27	27	G
Scale inhibitor (down hole)	42	6.3	Y
Scale inhibitor (topside)	55	13.9	Y
Hydrate Disolver	40	273.2	G
Wax inhibitor		6.1	R
Total after Hejre tie-in	**745.05**	**488.65**	
Red	110	116.10	
Yellow	568.05	72.39	
Green	67	300	
Total South Arne (Hess, 2006)	**647**	**336**	
Red	82	82	
Yellow	495	188	
Green	70	66	

As can be seen in the table above the amounts of expected used and discharged chemicals will increase slightly compared to the South Arne EIA (Hess, 2006). The discharge of red chemicals will increase with approx. 42% after Hejre tie-in, the discharge of yellow chemicals will decrease, and green chemicals will increase by approx. 61% and 355% respectively compared to 2006 levels.

3.5.3 Emission sources

Emissions from Hejre

The Hejre platform is envisaged to be developed as a normally unmanned installation, controlled from South Arne. Similar to other tie-back satellite facilities operated by INEOS (such as Cecilie, Nini, Nini East), the over pressure protection philosophy is based on an inherently safe design with hydrocarbon containing process piping designed to withstand shut-in pressure. This approach eliminates the need for a flare system. Thus, no emissions will occur at Hejre apart from emissions related to transport by ship and helicopter in relations to facility maintenance.

Limited venting will take place, e.g., for routine maintenance of certain equipment and material for safety reasons prior to accessing the equipment.

Emissions from South Arne

The multiphase is transported to the South Arne Wellhead Platform East and further to the South Arne Main platform, where the processing of the oil gas and water takes place. In relation to the production, emissions to air will be generated from combustion of fuel gas, flare gas and diesel.

The tie-in of Hejre will be within the existing production capacity on South Arne. It is assumed that the emissions for combustion of fuel gas and diesel are proportional to the Hejre production volume and are within the existing environmental permits for South Arne. A temporary higher amount of flaring may be expected during tie-in of the Hejre wells compared to normal production flaring.

The emissions from South Arne are reported on a yearly basis in reports to OSPAR and the emissions from 2021 are used as the best forecast for the general level of yearly emissions at South Arne from power production and as well as for the emissions related to flaring after tie-in of Hejre, see Table 3-26.

Table 3-26 Emissions to air from South Arne, 2021.

Activity	CO_2 [10^3 ton]	NO_X [ton]	SO_X [ton]	CH_4 [ton]	nmVOC [ton]	CO_2-eq[1)] [ton]
Operation	180.2	219	3	111	333	180.3

3.5.4 Platforms

The Hejre platform is an unmanned platform and thus the crew will be transported via helicopter from South Arne.

Design of the Hejre topside is focused on high reliability, easy maintainability and good access without requirements for scaffolding or other temporary systems.

Transportation and logistics will be managed with the existing South Arne set-up, and activities will be coordinated and optimized.

Facility chemicals at Hejre and South Arne

In relation to cleaning and washing of the installations certain facility chemicals are used and discharged to sea as shown in Table 3-27. The use of facility chemicals at South Arne is additional to what is already in use on the platform today.

The chemicals will be discharged over a short period of time approx. a few hours per job and thus no continuous discharge of facility chemicals will occur during operation.

Table 3-27 Estimated annual use and discharge of facility chemicals at Hejre and South Arne

Facility chemicals	Planned use at Hejre [tons/year]	Planned discharge at Hejre [tons/year]	Planned use at South Arne [tons/year]	Planned discharge at South Arne [tons/year]	Colour code
Rig wash	3	3	0	0	Y
Wax remover	0	0	8	8	Y

Well service chemicals at Hejre

Also, well service chemicals will be used whenever needed at Hejre throughout the design life. The well service chemicals include chemicals for well head maintenance, coil tubing acid jobs, wireline jobs and coil tubing. The use and discharge of well service chemicals at Hejre can be seen in Table 3-28.

Well head maintenance chemicals are not expected to be discharged as the hydraulic fluid is used in a closed system and the remaining chemicals are for cleaning, flushing and topping up the system. Maintenance can require a small amount to be drained off. The fluid is collected and safely disposed of as per the waste management system. The well head system will subsequently be topped up with new hydraulics fluid.

Coiled tubing acid jobs are expected to be carried out 4 times over the 20 years. It will take up to 24 hours from the injection of chemicals to the discharge. The discharge is short-term at approx. a few hours per job.

Wireline jobs are expected to be carried out approx. 60 times on Hejre over 20 years. It will take up to 24 hours from the injection of chemicals to the discharge. The discharge is short-term at approx. a few hours per job.

The completion activities are expected to be carried out four times over 20 years. It will take up to 24 hours from the injection of chemicals to the discharge. The discharge is short-term over approx. 2 hours per job.

Table 3-28 Estimated use and discharge of well service chemicals at Hejre over 20 years.

Well service chemicals	Planned use Hejre [tons/year]	Planned discharge at Hejre [tons/year]	Colour code
Well head maintenance			
Wellhead hydraulic fluid	0.08	0	Y
Hydrate inhibitor	38	0	G
Base oil	4	0	Y
Grease	0.8	0	Y
Coiled tubing acid jobs			
Acid	56	56	G
Frac additive	0.2	0.2	Y
Corrosion inhibitor	1.4	1.4	Y
Corrosion inhibitor	1.4	1.4	G
Inhibitor aid	0.4	0.4	G
Iron stabilizer	0.2	0.2	Y
Wireline jobs			
Hydrate inhibitor	166	166	G
Brine lubricant	22	22	Y
Coiled tubing			
Hydrate inhibitor	4	4	G

Well service chemicals	Planned use Hejre [tons/year]	Planned discharge at Hejre [tons/year]	Colour code
Lubricant	10	10	Y

3.5.5 Pipelines

Multiphase pipelines, risers and pig traps will be designed for pigging by cleaning pigs and intelligent pigs. The multiphase system will be piggable from the Hejre platform to the South Arne platform.

3.5.6 Wells

The Hejre and Lunde HPHT wells will require regular interventions over field life. It will be possible to carry out most of the well service and maintenance activities from the Hejre WHP. More complex intervention jobs may, however, need the mobilising of a rig for equipment and crew. It is expected that a rig will be present at the Hejre platform 3 months during the lifetime of the field for maintenance of wells.

3.5.7 NORM

It is a general experience and well-known fact that offshore oil production in the North Sea is associated with contamination of certain parts of the processing equipment by small amounts of natural radioactive constituents in the reservoir, which are transported to the surface along with the extracted oil and/or particles. This material with low-level radioactivity is known as NORM (Naturally Occurring Radioactive Material).

NORM usually occurs in water injection systems where produced water is mixed with sea water but can also occur in separators, pipelines and in the production liners of the wells. In 2004, 16 tons of NORM was removed from separators and other process equipment on South Arne. The NORM deposits were reinjected into a dedicated reinjection well together with OBM-cuttings. Since start of production at South Arne in 1999, ~6 tons of NORM have been placed in temporary storage onshore.

NORM will most likely also be present at the Hejre field and will have to be handled and disposed of in accordance with the regulations for NORM administered by the Danish Health Authority, Radiation Protection. NORM contaminated equipment will be cleaned onshore and NORM material will be stored in a temporary storage approved by the authorities.

It is not possible to make an exact estimate of how much NORM will be produced at Hejre, but it is expected to be in the same range as the amount produced from South Arne in the period from 1999 to now.

3.6 Decommissioning phase

The expected lifetime of the installation is approximately 20 years. The decommissioning of the platform, wells and pipelines will be conducted in accordance with Danish legislation and international agreements in force at the end of the installation lifetime.

3.6.1 Decommissioning activities

The following is a general description of how an installation like Hejre may be decommissioned. The process will be the same as for the original Hejre project:

- Production strings are pulled out of the well and transported to shore for reuse or recycling.

- The reservoir will be secured by plugging and sealing the wells with concrete fillings in predetermined depths of the wells. The concrete fillings prevent the gasses and fluids from escaping from the wells into the marine environment or into other layers in the underground.
- The entire platform and subsea structures will be flushed for all hydrocarbons, dismantled, removed and transported to shore for recycling or reuse.
- Finally, pipelines are emptied of remaining hydrocarbons, which are transported to shore, and subsequently flooded with seawater. The pipelines remain buried in the sediment for in situ disposal if permitted by Authorities.

3.6.2 P&A of wells

When decommissioning the Hejre platform all wells will need to be plugged and abandoned (P&A) before removing the platform etc. The P&A activities are foreseen to be performed from a rig. During the P&A of the wells, different chemicals will be used for well activities and for the rig. The impact from chemical use is parallel to what is used for drilling activities.

At the moment the P&A program for Hejre has not been specified in detail. It will be developed further in due time before decommissioning. Below the indicative P&A program is described:

1. Bullhead the well free for hydrocarbons
2. Install deep mechanical barrier below Production Packer
3. Displace well to kill fluid
4. Install shallow barrier
5. Remove X-mas tree
6. Nipple up HP riser and BOP's
7. Remove shallow barrier
8. Recover production tubing
9. Install 9 5/8" mechanical plug, and set +100m primary/secondary cement plug#1 above
10. Load and pressure test plug #1
11. Install 9 5/8" mechanical plug, and set +100m primary/secondary cement plug#2 above (stringers)
12. Load and pressure test plug #2
13. Set 9 5/8" mechanical plug below 13 3/8" shoe
14. Displace well above mechanical plug to 1.52 sg OBM (same as fluid in 9 5/8" vs 13 3/8" annulus)
15. Cut and pull 9 5/8" casing
16. Displace well to 1.40 sg WBM
17. Set +100m primary/secondary cement plug #3 across the 13 3/8" shoe
18. Load and pressure test plug #3
19. Set mechanical barrier inside 13 3/8" casing
20. Displace well to sea water
21. Multistring cut 13 3/8" casing and conductor 3m below seabed. Recover to surface
22. Set Plug #4 (Environmental plug) on top of mechanical barrier inside 13 /8" casing

When developing the P&A program also the specific chemical products will likewise be decided and thus the following is only indicative for the P&A program.

During the P&A the wells will be displaced to WBM and OBM. A spacer and wash trains will be applied for cleaning the wells. Cement will be used for plugging and slop chemicals are sent to the slop pits on the rig and discharged. Also rig chemicals will be used. OBM will be shipped to shore.

Table 3-29 provides overview of chemicals used for the P&A of the Hejre and Lunde wells. One red chemical may be discharged with water from the wash trains. A yellow substitute will be used if at all possible.

Table 3-29 Estimated use and discharge of chemicals for P&A activities of the wells.

P&A activities	Function	Planned use Hejre [tons]	Planned discharge at Hejre [tons]	Sent to shore [tons]	Colour code
WBM chemicals (chemicals mixed in 2,407 mT fresh water)	Brine	75	58	-	G
	pH	2.5	2	-	G
	Viscosity	10	9	-	G
	Weight material	1,373	1,071	-	G
OBM chemicals (chemicals mixed in 206 mT fresh water)	Weight material	1,518	0	1,518	G
	Base oil	849	0	849	Y
	Salinity	280	0	280	G
	Alkalinity	50	0	50	Y
	Emulsion	50	0	50	Y
	Viscosity	20	0	20	Y
	Viscosity	1.5	0	1.5	R
	Fluid loss	14	0	14	R
	Wetting agent	10	0	10	Y
Spacer	Cement cont.	90	90	-	G
	pH	90	90	-	G
Wash train (chemicals mixed in 90 mT fresh water)	Base oil	97	97	-	Y
	Viscosity	3	3	-	G
	Surfactant	35	35	-	R
	Solvent	40	40	-	Y
Slop chemicals	pH	7.5	7.5	-	G
	H_2S scavenger	5	5	-	Y
	Biocide	5	5	-	Y
Cementing chemicals	Anti-sedimentation	36	8	-	G
	Dispersant	10	4	-	G
	Viscosifier	1	1	-	G
	Dispersant	5.6	2	-	Y
	Anti-foam	1.4	1.2	-	Y
	Extender	4.5	1.7	-	G
	Accelerator	2.5	1.3	-	G
	Fluid loss control	11	3	-	Y
	Class G cement	332	86	-	G
	Weighting Agent	120	120	-	G
Total (excl. water)		**4,625**	**1,511**	**2,998**	
Total Red		**50.5**	**35**	**15.5**	
Total Yellow		**1,126**	**147**	**979**	
Total Green		**3,449**	**1,329**	**2,003**	

The WBM and the cementing chemicals will partly be left in the well, and the remainder will be discharged to sea. The OBM chemicals will be sent to shore for treatment and disposal.

A limited number of chemicals will be used on the rig. It is assumed that all rig chemicals will be discharged to sea.

The rig wash will be used for cleaning of the rig and rig equipment. The usage is estimated at 30 tons for the entire project corresponding, which will be 100% discharged over a period of 6 hours per day. The rig wash will be discharged with a concentration of 1:400 taking into account initial water use for dilution of the product and subsequent additional water use for rinsing.

The jacking grease will be used when jacking up and down and is expected to be 50% discharged over a period of 12 hours.

The drill pipe dope will be used in the wells and 10% is expected to be discharged over a period of 6 hours.

Table 3-30 Estimated use of utility chemicals.

Utility chemicals	Planned use [tons]	Planned discharge [tons]	Colour code
BOP fluid	3.2	0	Y
Pipe dope	0.32	0.032	Y
Rig wash	30	30	Y
Jacking grease / skid grease	3	1.5	Y
Total Yellow	**36.52**	**31.53**	

3.6.3 Removal of installation and jacket piles

Before the removal of the topside process fluids, fuels and lubricants will be drained and transported ashore for disposal according to legal requirements.

The topside and the jacket will be dismantled and removed and transported to shore for further cleaning and recycling or reuse. Jacket piles will be cut approximately 1-3 meter below the seabed level dependent on sediment transportation in the area.

The topside is expected to be removed as a single lift either with a heavy lift vessel or by jack-up vessel similar to wind farm installation jack-ups.

The jacket is expected to be removed as a complete unit with a heavy lift vessel.

The removal of structures will prevent interference with fisheries in terms of damages to fishing gear. In addition, bans on fisheries within exclusion zones will be lifted.

Details about the structures to be removed is shown in Table 3-31.

Table 3-31 Information about facilities to be removed

Surface facilities information						
Facility type	Topside facilities		Jacket			
	Weight (Te)	Number of modules	Weight (Te)	Number of legs	Number of piles	Weight of piles (Te)
Fixed large steel jacket	1,650	1	7,683	8	16	1,393

3.6.4 Leaving of pipelines and jacket piles

The pipelines will be emptied for hydrocarbons and flooded with seawater. The presence of decommissioned pipelines left in-situ and jacket piles left below the seabed level will slowly degrade and will not result in any significant impacts to the seabed or the pelagic or benthic communities.

Exposed pipeline sections are rock-dumped or buried in the sediment for trawling protection.

3.6.5 Cutting piles

When a field on deeper waters is abandoned, piles of cuttings from the drilling operations are often encountered beneath platforms.

However, cuttings piles are not likely to remain develop in the relatively shallow waters (68 m) at Hejre and it also appears from subsurface surveys taken place around the Hejre jacket that the cuttings from the drilling operations has dispersed due to the relatively strong currents on the seabed and for that reason do not have a form to be able to remove.

3.6.6 Emissions to air

Air emissions can be expected from the operating fleet to execute and support the decommissioning activities such as jack-up rig, heavy lift vessel, standby boat and supply boats. The days include contingency for weather delays and unforeseen events.

Table 3-32 Overview of vessels to be used during decommissioning.

Vessel type	Number of vessels	Days	Fuel consumption [m³/day]
Rig	1	255	10[1]/ 30[2]
Heavy Lift vessel	1	83	47
Supply vessel	1	97	7
Survey vessel (ROV)	1	70	4
Pipe Trench/Jet Skid	1	5	30
Rock dumping vessel	1	8	27
Offshore construction vessel	1	28	20
Diving support vessel	1	320	24
Standby boat	1	255	10
Tugs	3	20	20
Helicopters	1	109	1.2

1) for jack-up
2) average in DP mode

3.7 Waste and waste handling

Household waste and waste will be generated at the Hejre platform throughout the different phases from construction to decommissioning.

All waste generated at the Hejre platform will be thoroughly sorted into categories agreed with the waste handling company and according to the regulatory requirements of the municipality of Esbjerg. The sorted waste will be transported to shore for treatment at approved waste treatment or waste-to-energy plants or, if necessary, for final disposal.

The amount and the composition of waste will depend on the level of activities and the number of persons on board. More waste will typically be generated during maintenance and well service campaigns than during normal day-to-day operations and these special operations will also generate other types of waste. E.g., painting campaigns will generate sand from sandblasting.

The amount of household waste is related to number of persons on board the rig or the installation.

3.7.1 Waste during construction

Waste generated during the construction phase will mainly be related to household waste from the rig and OBM mud and cuttings from the drilling operation.

Household waste and OBM mud will be transported by supply vessel to Esbjerg and from there to an approved waste treatment or waste-to-energy plant.

OBM cuttings will most likely be transported to UK or Norway for treatment and disposal as there at the time of writing of this report was no facility in Denmark able to handle this waste fraction. Cf. section 0, approx. 4,600 tons of OBM cuttings are generated from drilling of the Lunde well (including cuttings from the drilling of a potential sidetrack).

3.7.2 Waste during production

Waste production at South Arne is not expected to change significantly due to tie-in of Hejre, Waste production at South Arne was approx. 271 tonnes in 2021, see The waste treatment in Figure 3-11. The three main waste categories in 2021 was industrial waste, iron and sand from sandblasting. Most of the waste is sent for recovery or for incineration for energy production.

As Hejre will normally be unmanned, waste generated during the production phase is mainly household waste and other waste related to maintenance campaigns. Waste related to the production phase is estimated to be in the magnitude of 20-25 tonnes per year for Hejre. The waste types are expected to be similar to the waste from South Arne, although the distribution may vary from year to year depending on activities.

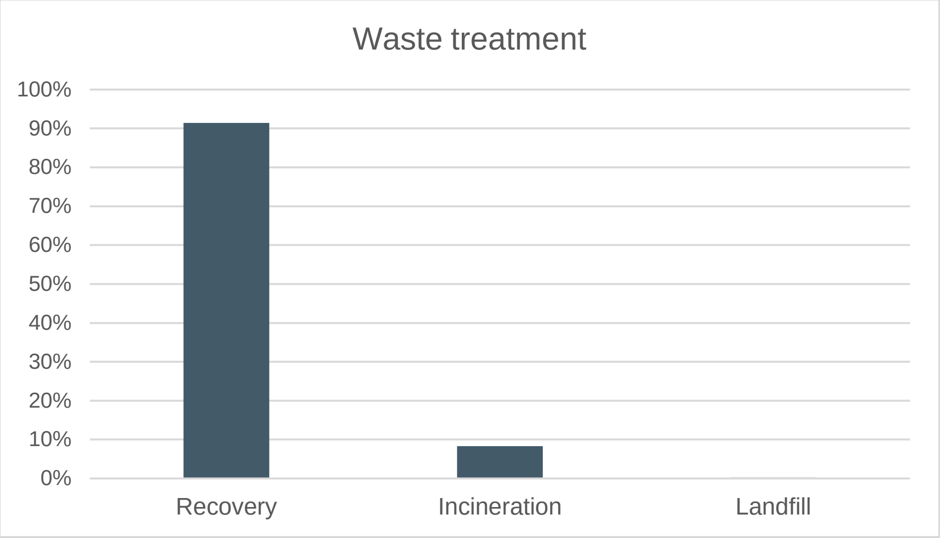


Figure 3-11 Information about treatment of waste from South Arne (2021).

3.7.3 Waste during decommissioning

Waste generated during decommissioning is mainly related to the offshore structures to be removed to shore for dismantling and recycling or reuse at an approved decommissioning yard in the North Sea region. Approx. 11,000 tons material is transported to shore, cf. section 3.6. The main waste fraction from the structures is steel.

Also, household waste from the vessels and rig performing the decommissioning work will be generated, as well as approx. 3,000 tons OBM waste from the P&A activities. All waste will be transported to shore for further treatment.

4 Methodology for assessment of impacts

The environmental significance (severity) and risk of impacts of the project on environmental receptors has been evaluated using the following methodology.

Environmental risk is the combination of the significance (severity) of an impact and the probability that an impact may arise. This implies for instance that an incidence that may cause severe impacts but is not very likely to occur has a low environmental risk.

For each operation or incidence, the assessment of environmental risk includes three steps:

› Assessment of environmental significance (severity) of an impact;

› Assessment of the probability that an impact will occur;

› Assessment of risk by combining severity and probability.

4.1 Assessment of environmental significance (severity) of an impact

Qualitative assessments of environmental severity of impacts of different operations and events will be carried out for both the EIA screening and the Natura 2000 screening. The assessment of severity includes the following steps:

› Assessments of nature, extent, duration and magnitude of impacts using the criteria shown in Table 4-1 including whether the impact is positive or negative, temporary or permanent.

› Assessment of the severity of impacts combining the assessments of extent, duration and magnitude of the impacts using the criteria shown in Table 4-2.

Table 4-1 Criteria for assessment of nature, extent, duration and magnitude of impacts.

Criterion	Description
Nature	***Nature of the environmental change***
Positive	Beneficial environmental change
Negative	Adverse environmental change
Extent	***The geographical area that may be affected by the impact***
Local	Only the place where the activities directly related to construction may occur
Regional	Effects may occur in the Central North Sea
National	Effects may occur in Danish waters
International	Effects may occur in the entire North Sea
Duration	***Period along which the impact is expected to occur***
Short-term	Less than 8 (eight) months
Medium-term	Between 8 (eight) months and 5 (five) years

Long-term	More than 5 (five) years
Magnitude Small Medium Large	***The magnitude of impacts on environmental and social processes*** If possible, the magnitude of an effect is assessed from results of environmental modelling. Otherwise, the magnitude of an effect is based on an expert assessment based on previous experience from other projects. The following factors are taken into consideration: › The extent to which potentially affected habitats and organisms are unaffected by human activity › The numbers/areas of an environmental feature that will be potentially affected › The uniqueness/rarity of potentially affected organism and habitats › The conservation status of habitats or organism (Natura 2000 areas, Annex IV species etc.) › The sensitivity of the habitat/organism › The robustness of the organism/habitats against impacts, i.e., and evaluation of the ability to adapt to the impact without affecting the conservation status, uniqueness or rarity › The potential for replacement i.e., an assessment of to what extent the loss of habitats or populations of organisms can be replaced by others.
Frequency Low Medium High	***How often the impact will occur*** The impact occurs rarely or as a single event The impact happens regularly The impact happens often or continuously
Reversibility Reversible Irreversible	***Whether or not an impact is permanent*** The impact is not permanent The impact is permanent

Table 4-2 Criteria for assessment of severity of potential impacts of the project.

Severity rating	Relation with the criteria on nature, extent, duration and magnitude that describe the impact
Positive impact	The assessed ecological feature or issue is improved compared to existing conditions
No impact	The assessed ecological feature or issue is not affected
Insignificant impact	Small magnitude, with local extent and short-term duration
Minor impact	1) Small magnitude, with any combination of other criteria (except for local extent and short-term duration, and long-term duration and national or international extent) or 2) Medium magnitude, with local extent and short-term duration
Moderate impact	1) Small magnitude, with national or international extent and long-term duration; or

	2) Medium magnitude, with any combination of other criteria (except for local extent and short-term duration; and national extent and long-term duration 3) Large magnitude, with local extent and short-term duration
Major impact	1) Medium magnitude, with national or international extent and long-term duration; 2) Large magnitude, with any combination of other criteria (except for local extent and short-term duration)

4.2 Assessment of the probability that an impact will occur

The probability that an impact will occur will be assessed using the criteria shown in *Table 4-3*.

Table 4-3 Criteria for assessment of the probability of that and impact will occur.

Probability criterion	Degree of possibility of impact occurrence
Very low	The possibility of occurrence is very low, either due to the project design or due to the project nature, or due to the characteristics of the project area
Low	The possibility of occurrence is low, either due to the project design or due to the project nature, or due to the characteristics of the project area
Probable	There is possibility of impact occurrence
Highly Probable	Possibility of impact occurrence is almost certain
Definite	There is certainty that the impact will occur

4.3 Risk assessment

The environmental risk of different operations and incidences will be assessed combining significance (severity) and probability of an impact according to a risk matrix as outlined below (*Table 4-4*).

Table 4-4 Qualitative risk assessment matrix.

	Significance (severity) of impact			
Probability	**Insignificant Impact**	**Minor impact**	**Moderate impact**	**Major impact**
Definite	Negligible risk	Low risk	Significant risk	High risk
Highly probable	Negligible risk	Low risk	Significant risk	High risk
Probable	Negligible risk	Negligible risk	Low risk	Significant risk
Low	Negligible risk	Negligible risk	Low risk	Low risk
Very low	Negligible risk	Negligible risk	Negligible risk	Low risk

5 Potential transboundary impacts

The following impacts have been identified as potential transboundary impacts and are described and evaluated in chapter 6:

Potential transboundary impact	Receptor
Impacts of planned discharges to the sea during drilling and completion of wells and pressure testing of pipelines i.e., during construction phase.	Fish eggs and larva, fish, plankton (pelagic organisms)
Impacts of planned discharges to the sea (produced water, production chemicals).	Fish, plankton (pelagic organisms)
Impacts of accidental spills and blowout events.	Fish, marine mammals, birds, ecosystems, tourism
Impact of air emissions during construction, production and decommissioning phases.	Air quality and climate

A screening of potential transboundary impacts has been carried out based on the methodology described in section 4 and the detailed assessments made in the EIA report (INEOS Energy Denmark (2023)).

Based on the results of the detailed assessment, the Espoo report presents a screening of the same impacts in relation to their potential transboundary effects. Because of the low range for most of the project impacts, significant transboundary impacts can be ruled out with certainty in many cases. Subsequently, these impacts are not further elaborated on in this chapter, and focus is given to those impacts for which significant transboundary impact cannot be excluded in the first round.

Table *5-1* shows the result of the screening and points out the potential transboundary impacts that are assessed in detail further below in this chapter.

Table 5-1 Screening of potential transboundary impacts

Activity	Potential impact	Transboundary evaluation
Environmental impacts of activities during the construction phase		
Presence of rig	› Impacts on fisheries and shipping due to exclusion zones around rigs	› Local impact only.
Well completion	› Discharges of completion fluids and drilling chemicals can	› Possible local impact

Activity	Potential impact	Transboundary evaluation
	impact water quality and marine fauna. Green and yellow chemicals are discharged.	
Testing of pipelines	› Impacts of planned discharges to the sea from pressure testing of pipelines.	› Possible local impact
Construction operations causing emissions to the air. Release of particles from pipelaying vessels	› Release of particles (PM_{10}) and gaseous emissions (SOx, NOx, CO_2) from vessels with potential effects on air quality	› Regional and international short term minor impacts
Accidental spills and blow-out	› Mainly birds, marine mammals, fish, coastal ecosystems may be affected. Blow-outs are extremely rare events	› **Potential transboundary impacts may occur**
Laying of pipelines/umbilical and installation of structures	› Physical impact on the seabed and benthic fauna through placement and presence of pipelines or subsea structures › Noise disturbance to marine mammals resulting in behavioural avoidance	› Local impact only
Artificial light during the construction phase	› Artificial light at sea may attract and trap certain species of birds especially during bad weather and overcast nights.	› Local impact only
Environmental impacts of planned activities during the production phase		
Presence of structures Rig, platform and pipeline including 500 m exclusion zone	› Reef effect of platforms (Positive effect on epifauna and fish) › Potential disturbance to migrating birds from artificial lightning on platforms › Interference with shipping due to exclusion zone › Loss of access to fishing grounds due to exclusion zone	› Local impact only › Local impact only › Local impact only › Local impact only
Discharge to sea Impacts of planned discharges to the sea (produced water, production chemicals, discharge of facility and well service chemicals).	› The discharge may affect marine organisms, particularly pelagic organisms such as plankton including fish eggs and larvae	› Model calculations show local impacts only with a maximum distance of 5.000 m from platform
Emissions Emissions to air	› Release of particulates and gaseous compounds (SOx, NOx, CO_2) from generators, compressors and other machinery on the production platform and due to flaring	› Calculations of the magnitude of emission of SO_X and NO_X and of CO_2-eq are considered regional but are short term and with a minor impact and are considered negligible

Activity	Potential impact	Transboundary evaluation
	operations and transport operations	
Accidental spills Blow-out Accidental spills from pipeline rupture	› Extremely rare events. Experience from previous blow outs and oil spills at sea have shown that it is mainly birds, marine mammals, fish, coastal ecosystems that may be affected › Mainly birds, plankton, fish eggs and larvae may be affected.	› **Potential transboundary impacts may occur.** › **Potential transboundary impacts may occur**
Environmental impacts from decommissioning		
Removal of installations	› Impacts of underwater noise arising during the cutting of the legs of the platforms. › Removal of artificial reef	› Local impact only › Local impacts only
Discharge from P&A of wells	› The discharge may affect marine organisms	› Model calculations show local impacts only with a maximum distance of 5.000 m from platform
Emissions to air	› Release of particles (PM_{10}) and gaseous emissions (SOx, NOx, CO_2) from vessels with potential effects on air quality	› Regional and international short term minor impacts

6 Environmental assessment of accidental oil spills

Accidental spills may cause transboundary impacts. These are assessed in the sections below. The original oil spill modelling from Hejre Legacy was updated in 2020 as the Hejre has been developed and data on reservoir pressure, flow rates from wells etc. is available, see DNV (2020). The following section is based on the updated oil spill modelling.

Accidental spills may include:

- Spill of oil and emission of gas during an accidental blow-out at Hejre. This may occur during both the construction and operation phase
- Accidental spill due to rupture of pipelines

Blow out and rupture of pipelines causing discharge and dispersal of oil are extremely rare events. However, in case of blow-out and rupture the environmental impacts may be severe. Experience from previous blow-outs and oil spills at sea have shown that it is mainly birds, marine mammals, fish and coastal ecosystems that may be affected by large oil spills.

6.1 Environmental impacts of an oil release during a blow-out incident

The worst-case scenario in terms of accidental oil spill is an uncontrolled blow out during production.

A blowout is the uncontrolled release of crude oil and/or natural gas from a well after pressure control systems have failed. The probability of a blowout occurring is very low but in case a blowout occurs, wide reaching and severe impacts on the marine environment may occur.

6.1.1 Risk of a blow-out

Blowout is an extremely rare event and extensive preventative/control measures are implemented to reduce the likelihood of such events. It has been estimated that the risk (frequency) of a blowout occurring at Hejre is 9×10^{-6} per year (INEOS Oil & Gas 2019).

A blowout will last until the well is under control again. This may take anywhere from a few hours if control can be regained using the safety systems present, up to several months if a so-called relief well needs to be drilled to regain control over the original well. History shows that most wells can be brought back under control within one to a few days.

6.1.2 Fate and effects of oil released during blow-out

During a blowout the oil is spread with the surface currents, simultaneous undergoing a wide array of processes including evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation and biodegradation. Oil components and their breakdown product may affect marine and coastal habitats and species. In general, the most severe impacts of an oil spill will occur if the oil slick passes concentrations of seabirds or if the oil ends up in near coastal waters and on shorelines.

6.1.3 Methodology

DNV GL Norway carried out oil spill modelling of topside blowouts at Hejre using the OSCAR statistical oil drift model developed by SINTEF, Norway (DNV (2020)). OSCAR is a 3D modelling tool used to predict the movement and fate of oil on the sea surface and throughout the water column. Details of the oil spill scenarios are reported in Appendix A to the EIA.

The modelled blowout case represents a variety of 3 release rates and 4 duration combinations with an individual distribution (Table 6-1). The probability of a blowout is extremely low. Furthermore, in the unlikely event that a blowout should occur, the duration will in most cases be short-term (<15 days), whereas the probability of a long-lasting blowout of 100 days is only 6.5 %. A long-lasting blowout (100 days) is the expected duration for mobilizing of a drilling rig and drill a relief well.

Table 6-1 Oil spill modelling. Summary of setup for spill scenarios in case of a blowout. Release duration and release rates as well as the probability distributions of release durations and release rates based on information from Lloyds and blowout statistics (for further information reference is made to Appendix A).

	Scenario variations			
Release duration (days)	2	15	35	100
Number of simulations (trajectories/year)	36	24	12	12
Probability distribution (%)	52.7	35.2	5.6	6.5
Release rates (Sm^3/day)	2077	2525	7328	7328
Probability distribution (%)	34	33	33	33

The assessment of the environmental impacts of accidental blowout is based on a matrix using all four scenarios representing a worst-case scenario in which no mitigating oil spill response measures are taken. The simulations have been made using both stochastic and deterministic modelling.

Stochastic modelling possesses some inherent randomness versus a deterministic model where the output is fully determined by the parameter values and the initial conditions.

The use of a stochastic model means that the blowout can be analysed statistically. However, the prediction represents the gross area that may potentially be affected by a spill as it combines the impact area of several single spill events and therefore does not represent how a blowout will look in reality (see number of simulation events in Table 6-1).

In contrast, the deterministic model simulates a single spill at a chosen date under the weather conditions at that point in time. Thus, it predicts the actual trajectory of a single spill event, but it does not consider the statistical uncertainty of the fact that the spill trajectory will be different under different weather conditions.

Efficient oil spill response measures will reduce the spreading of spills significantly and thereby the extent and magnitude of environmental damage is most likely smaller than the model results indicate.

In the following, the model results are assessed in relation to potential impacts on Nature 2000 habitats and species as well as Annex IV species.

6.1.4 Modelled dispersion of oil during an unmitigated blowout

Spreading of oil

Figure 6-1 shows the modelled stochastic probability that the sea surface in 10x10 km grid cells could be hit by more than 1 tonnes of oil released at Hejre during March-August) and September-February, respectively.

It is seen that released oil during blowout will be transported towards northeast with the prevailing currents, but may also be transported to UK, German and Dutch waters including Natura 2000 areas (SACs).

Figure 6-2 shows the seasonal resolution of arrival times (since start of the release) within the influence area to 10 x 10 km grid cells (drift time). It is seen that it will take approximately 2 weeks for oil to reach shore. However, it should be noted that although all shores are statistically affected by oil in case of a blowout according to Figure 6-1, Figure 6-3 shows that the amount of oil that hits the shore are below the detection level of 4 tonnes pr. 100 km² (0.04 µm thickness).

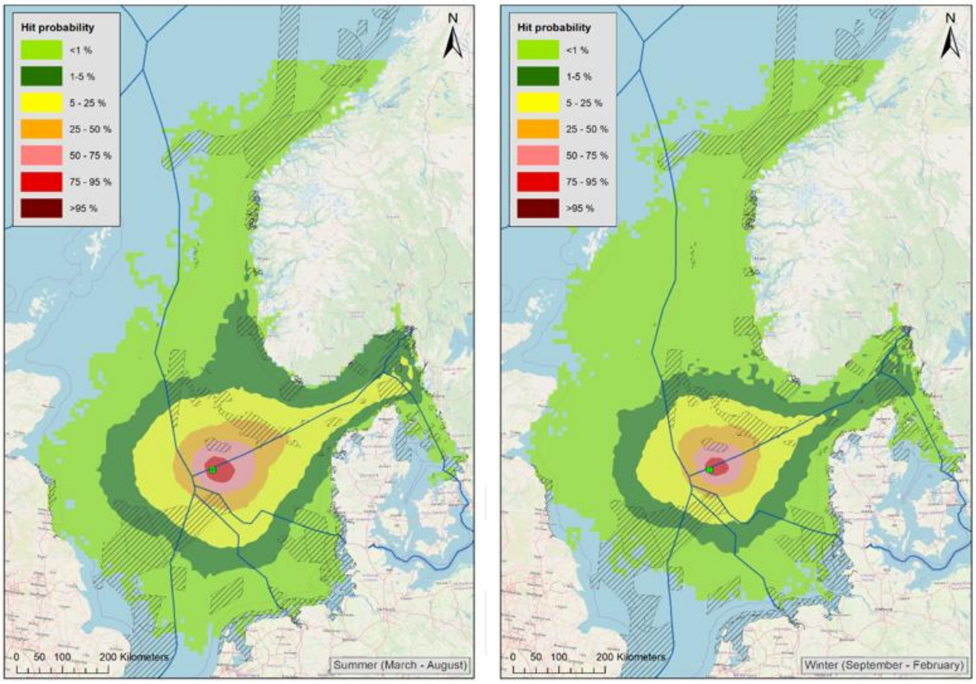


Figure 6-1 Result of stochastic oil spill modelling of a worst case, unmitigated surface release of oil during a blowout at Hejre during March-August (left) and September-February (right). The figures show the modelled probability that the sea surface in 10x10 km grid cells could be hit by more than 1 tonnes of oil released at Hejre. The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.

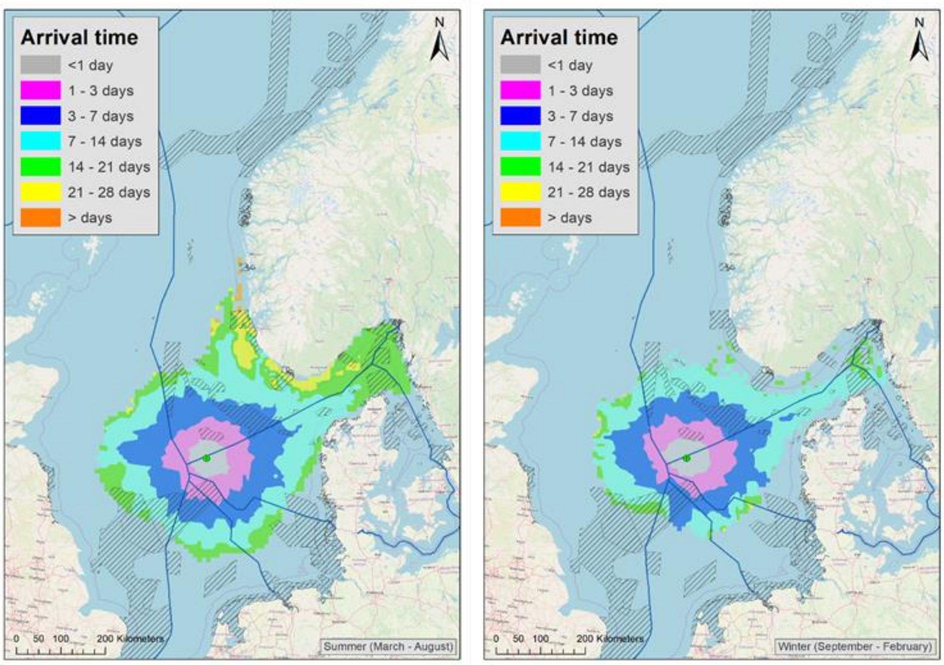


Figure 6-2 *Result of stochastic oil spill modelling of a worst case, unmitigated surface release of oil during a blowout at Hejre during March-August (left) and September-February (right). The figures show the seasonal resolution of arrival times (since start of the release) within the influence area to 10 x 10 km grid cells; The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.*

The seasonal resolution of oil mass within the influence area is shown in Figure 6-3. The figure shows that there will be up to 50 tonnes of oil per 100 km2 in the north-eastern part of the closest SAC during summer and up to 25 tonnes per 100 km² during winter.

Table 6-2 shows the expected surface oil layer thickness corresponding to the oil mass according to the Bonn Agreement (2016). Five levels of oil appearances are distinguished in the Bonn Agreement.

Birds are generally considered to be affected by surface oil when the emulsion thickness exceeds 1 µm whereas seals and cetaceans (incl. harbour porpoise) are more tolerant to surface oil. Latter being affected when emulsion thickness exceeds 10 µm and 100 µm for seals and cetaceans respectively (French-McCay 2009).

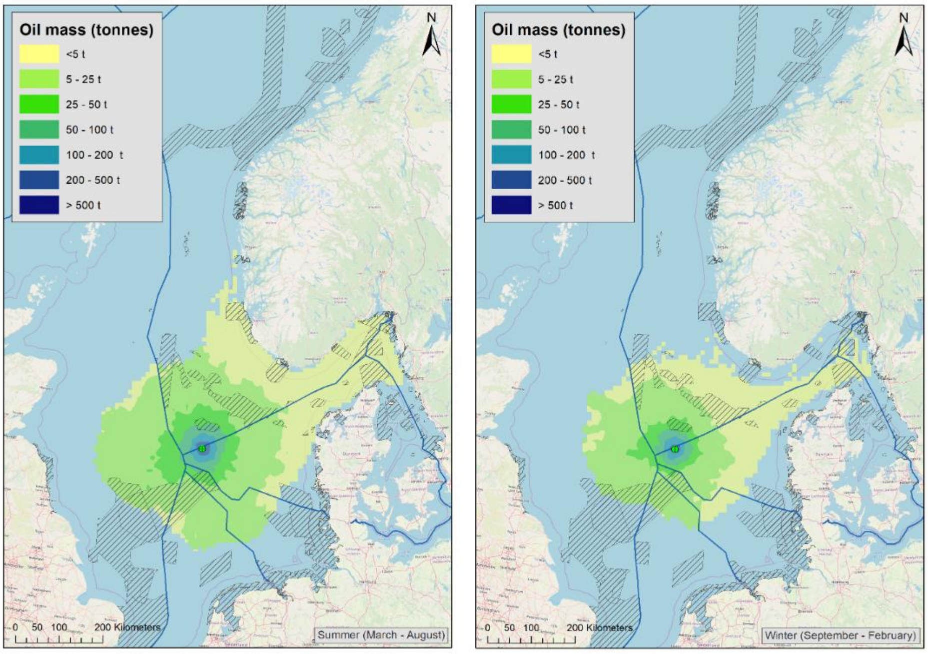


Figure 6-3 *Seasonal resolution of oil mass within the influence area in 10 x 10 km grid cells; Summer left and winter right, including marine protected areas, SVO areas and country border lines.*

Table 6-2 Levels of oil appearances distinguished according to the Bonn Agreement (2016).

Code	Description - Appearance	Layer thickness (µm)	Tonnes per 100 km2
1	Silver/grey	0.04 - 0.30	4 – 30
2	Rainbow	0.30 - 5.0	30 – 500
3	Metallic	5.0 - 50	500 - 5,000
4	Discontinuous true oil colour	50 - 200	5,000 - 20,000
5	Continuous true oil colour	> 200	> 20.000

6.1.5 Impacts on sea birds of oil released during a blow-out incident

It is well-documented that seabirds are extremely vulnerable to oil spills and that large amounts of seabirds are often killed in connection with an oil spill in areas where seabirds are concentrated. The reason for seabirds being especially vulnerable is that they are often in contact with surface water and that the oil destroys the buoyancy and the isolating quality of the plumage. Birds smothered in oil will usually die of cold or starvation or drown. Even very small spots of oil may be fatal, especially during winter. Mainly seabirds that stay on the sea surface for longer periods are at risk, but all types of seabirds may be affected (Trosi et al 2016). The threshold for emulsion thickness considered as harmful for birds is 1 µm (roughly 100 t per 10 x 10 km) (French-McCay 2009). Exposure above this threshold will lead to effects such as transferring oil to eggs reducing hatching success. Emulsion thickness of more than 10 µm will lead to immediate killings.

In the unlikely event of a blowout incident at Hejre the oil will most likely be transported towards northeast with the prevailing currents and pass the internationally important bird areas in the Norwegian part of the North Sea. The probability that this area will be impacted by a blowout is extremely low. However, in the unlikely case of a long-lasting unmitigated blowout, the probability that the area will be affected is high (i.e. 50-75 % in the eastern part of the area, decreasing to 25-50 % further away). The drift time to these areas are 1-3 and 3-7 days, respectively (Figure 6-1 and Figure 6-2). The area is important for gulls and auks (i.e. mainly little auk, but also guillemot and razorbill (Skov et al. 1995, Skov et al. 2007)). The auks are particularly vulnerable to oil spills as they spend most of their time on the sea surface. The birds are particularly vulnerable during winter where most species are clustering. It is estimated that around 1 million birds are present in the North Sea during winter (Skov et al. 2007). The northern part of the Danish EEZ in the North Sea is considered an intermediate important conservation area for seabirds (Skov et al. 2007). Consequently, there is a high risk of oiling and killing of birds in this area in the unlikely event of a blowout. On the other hand, the important bird areas in and immediately off the Wadden Sea will not be affected.

6.1.6 Impacts on marine mammals of oil released during a blow-out incident

The modelling shows that oil from a blowout may hit areas where harbour porpoise, grey seals or harbour seal may be encountered. Harbour porpoises and seals are generally less vulnerable to oil spill than birds (i.e. threshold for seals is estimated to 10 µm while the threshold for cetaceans is 100 µm, French-McCay 2009) (10 µm corresponds roughly to 1000 t oil per 10x10 km (*Table 6-2*). As their heat insulation is due to their layer of blubber a porpoise or seal smothered in oil will not be fatal as is the case with a bird.

Harbour porpoise

Comparative little is known about the effects of oil on cetaceans (whales, dolphins and porpoises), but based on scant records of cetacean mortality associated with oil spills, it has been suggested that an oil spill may only affect small numbers of cetaceans. Several authors suggest that the threat of most immediate concern is inhalation of evaporated volatile toxic components from the oil slick on the sea surface if they emerge at the surface to breathe in the middle of an oil slick. This risk is greatest near the source of a fresh spill because volatile toxic vapours evaporate and disperse relatively quickly. When concentrated vapours are inhaled, mucus membranes may become inflamed, lungs can become congested and pneumonia may ensue. Inhaled fumes from oil may accumulate in blood and other tissues, leading to possible liver damage and neurological disorders. As porpoises rely on blubber for insulation their thermoregulatory ability does not seem seriously hampered by contact with oil (Helm et. al. 2015).

Harbour porpoises in the Central North Sea may be affected in the unlikely incidence of a blowout at Hejre. However, as the oil slick during a blowout is transported in a relatively narrow band in the direction of the currents and as the density of porpoises is relatively low (0.01-8 individuals/km²) only a tiny fraction of the populations of harbour porpoise in the North Sea is likely to be affected (Geelhoed et al 2014). It is therefore not likely that a potential oil contamination from a blowout will significantly affect the population sizes of the harbour porpoises in the North Sea.

Seals

Seals may be affected by direct contact with oil in a variety of ways. Oil can coat all or portions of their body surface and they may inhale toxic fumes of hydrocarbons, which affects their lungs. In addition, they may ingest oil directly or ingest oil-contaminated prey. As seals rely on blubber for insulation their thermoregulatory ability does not generally seem seriously to be hampered by contact with oil. However, observations suggest that some individuals have become so encased in oil that they were not able to swim and subsequently drowned. In addition, observation also suggest that eyes, oral cavity, respiratory surfaces and urogenital surfaces are particularly sensitive to contact with oil (Helm et al. 2015).

It cannot be excluded that seals in the Central North Sea may be affected. However, as the oil slick during a blowout is transported in a relatively narrow band in the direction of the surface currents and as seals are relatively rare in the Central North Sea only a tiny fraction of the populations of seals is likely to be affected. It is therefore not likely that a potential oil contamination from a blowout will significantly affect the population sizes of the seals.

6.1.7 Impacts on fish eggs- and larvae of oil release during a blowout incident

Eggs and larvae are considered the most sensitive life stages of fish in terms of acute impacts of spilled oil.

The Norwegian Oil Industry Association use 25 ppb as the concentration at which fish eggs- and larvae and other sensitive marine life begin to be affected by oil components. A literature review conducted by BP suggested that oil content greater than 500 ppb will cause acute toxicity to over 50 % of the marine life in the area (DONG E&P 2015).

For oil in the water column, the modelling shows that concentrations above 25 ppb is limited to a tiny area around Hejre which constitutes a negligible fraction of the entire spawning areas for fish in the North Sea (Figure 6-4). In addition, the important nursery areas for larvae of cod, whiting, Norway pout, haddock and sandeel at the productive hydrographical front in the north-eastern part of the North Sea will not be affected by an oil blowout. It is therefore concluded that an oil blowout at Hejre will not measurably affect the amount of fish eggs and larvae in the North Sea.

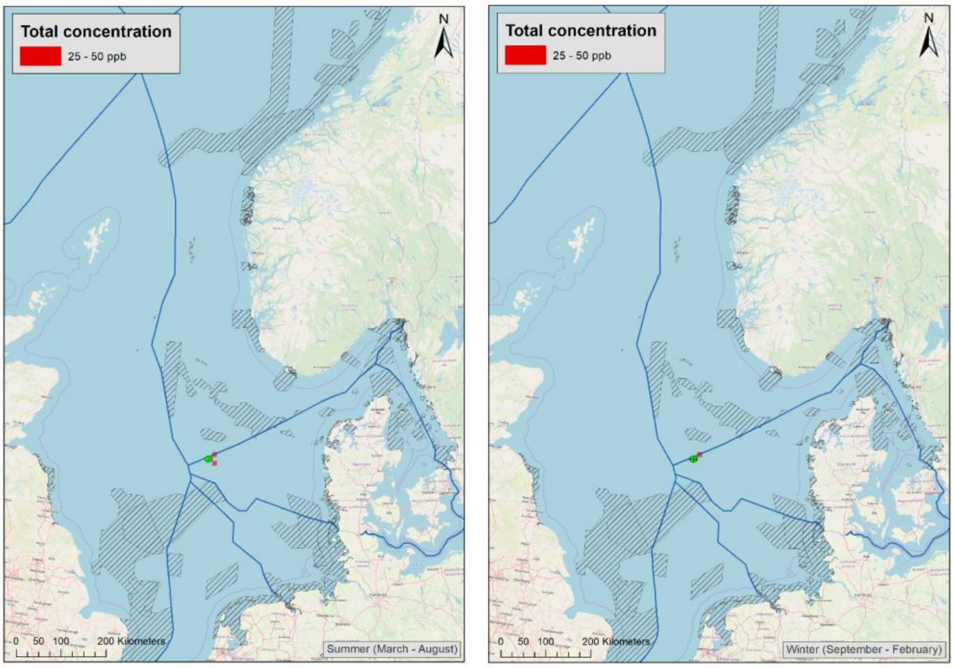


Figure 6-4 *Result of oil spill modelling of a worst case, unmitigated surface release of oil during a blowout at Hejre during March-August (left) and September-February (right). The figures show seasonal resolution of total concentration of dissolved oil components within the influence area in 10 x 10 km grid cells. Oil in the water column is only within detection level (>25 ppm) in the coloured squares. The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.*

6.1.8 Impacts of oil stranded on shorelines during a blow-out incidence

Shorelines, more than any other part of the coastal environment, are exposed to the effects of floating oil. Oil stranded on beaches often gives rise to concern because it may affect sensitive coastal habitats and important socioeconomic conditions. Further, the cleaning of oiled beaches may be costly. The vulnerability of shorelines to oil spills differs considerably depending on the type of habitat and with respect to how easy they are to clean up after an oil spill.

The modelling shows that the risk of oil stranding on coasts is negligible, the probability generally being < 1%, see Figure 6-5. In some areas, especially along the Norwegian coast, the probability has however, been calculated at 1-5 %. The modelling shows that the drift time to the coast in these areas is at least 14-28 days.

The reason for the low risk of stranding is that oil components will have undergone a wide array of processes including evaporation, dispersion, emulsification, dissolution, oxidation, sedimentation and biodegradation before reaching the shorelines.

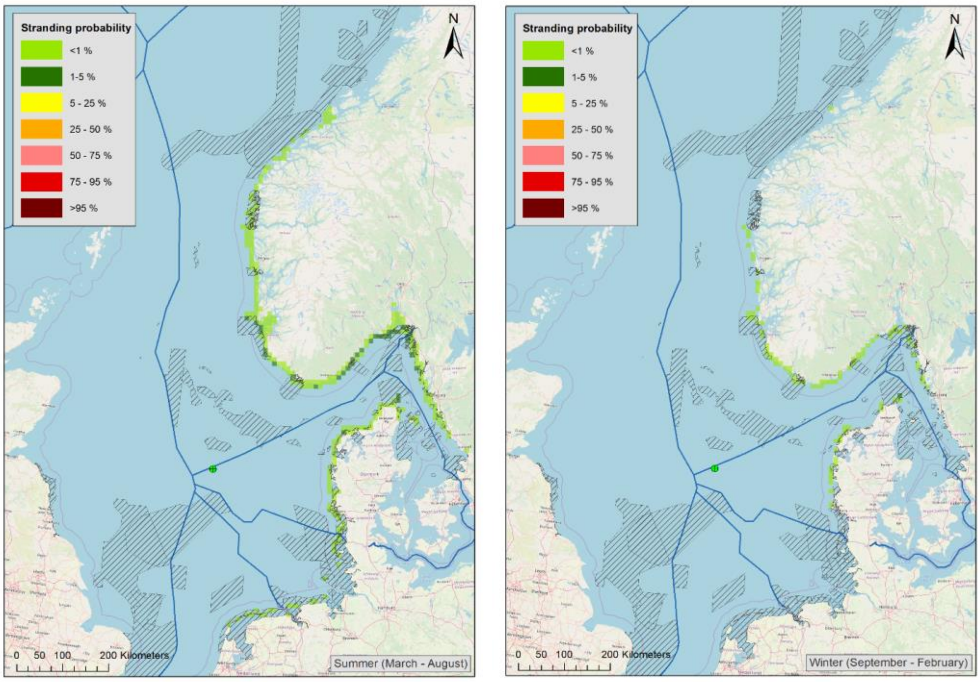


Figure 6-5 Result of oil spill modelling of a worst case, unmitigated surface release of oil during a blowout at Hejre during March-August (left) and September-February (right). The figures show seasonal resolution of shoreline oil hit probabilities of oil in 10 x 10 km grid cells. The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.

The biologically highly productive tidal flats and saltmarshes in the Wadden Sea in the southern part of the Danish coast will not be affected. The Norwegian and Swedish coastlines that may be hit by oil are rocky shores that are more sensitive to oil spills compared to the Danish sandy shores. However, with a drift time of 14-21 days (DNV, 2020) most of the oil will be in the form of tar balls, which are considerably less damaging as they are no longer sticky or toxic.

Shoreline oiling is likely to range between very light and moderate, as defined by ITOPF's recognition of shoreline oiling guidelines. Under the worst-case metocean conditions, the quickest impact on the shore-line in Denmark will be between 14-21 days. Shoreline impact may also happen in Norway (after 14-28 days) and Sweden (after 14-21 days). There will be no shoreline impact in UK, Germany or the Netherlands. In case of a blow-out with surface release during winter, the extent of affected shorelines will be consider-ably smaller than for a release during summer.

Similarly, only marginal amounts of oil will potentially reach the Swedish coast, that is <1 tonnes during the winter period and 1 tonnes during the summer period. For Norway this pattern is similar for the winter period, that is 1 tonnes, however during the summer the model results indicate that 31 tonnes of oil may reach the Norwegian coastline, which is considered to be a limited amount (DNV 2020). The modelling showed that the risk, the extent and the degree of oiling of shorelines during a seabed release of oil is quite similar to a surface release (DNV 2020).

6.1.9 Impacts on Norwegian SVOs

The modelling shows that Norwegian SVOs may be hit by oil in case of an unmitigated blowout (Figure 6-1 and Figure 6-2) i.e.:

› There is a probability of 25-50 % probability that SVO "*Makrellfelt*", which is a spawning area for mackerel from May to July will be hit by oil. The calculated drift time from Hejre is 3-7 days.

- Sandeel field south may also be hit (probability 5-25%; drift time 1-3 days. The sandeel field south is spawning and foraging areas for sandeel (*Ammodytes* sp.). Furthermore, the Sandeel field south is a valuable habitat for common guillemot (*Uria aalge*) and northern fulmar (*Fulmaris glacialis*) from April to December. The model results show that the concentration of oil in these areas are less than 25 ppb, which is below concentrations that are harmful to fish eggs and larvae (cf. 6.1.7) so spawning in this area is not at risk.

On the other hand, there is a risk of oiling and killing of birds on the Sandeel field South (cf. 6.1.5).

6.1.10 Transboundary impacts on SACs (Natura 2000 sites)

Assessments of the impacts on SACs (Natura 2000 sites) of oil release during a blowout incident is summarised in the following based on the modelling performed by DNV (2020).

This assessment is summarised in the following.

Impacts on German, Dutch and UK Natura 2000 areas south of Hejre

In the unlikely event of a blowout, the German, Dutch and UK Natura 2000 (SAC) areas south of Hejre may be affected by an unmitigated spill, especially the German area i.e. (cf. Table 6-3):

- There is a 25-50 % probability that oil hits the German DE 1003301 *Doggerbank* in March-August and the drift time of oil to this area is 1-3 days. During September-February the probability is lower (5-25%) and the drift time also 1-3 days

- The probability that the Dutch NL 2008001 *Doggerbank* may be hit, is 5-25 % for both seasons and with a drift time of 1-3 days during March-August and 3-7 days during September-February

- The probability that the UK SAC, UK0030352 *Doggerbank* will be hit is 5-25% March-August and the drift time to this area is drift time 3-7 days. In September-February the probability is only 1-5% and the drift time 7-14 days

Table 6-3 Results of oil OSCAR spill modelling of an unmitigated oil spill following a blow out at Hejre. Probabilities that the German, Dutch and UK Natura 2000 (SAC) sites south of Hejre are hit by oil and drift time of oil to site (the modelled drift time is shown in Figure 6-1).

Season	Site	Probability that the area may be hit by oil	Drift time from blow out to site
March-August	DE 1003301 Doggerbank	25-50 %	1-3 days
	NL 2008001 Doggerbank	5-25 %	1-3 days
	UK0030352 Doggerbank	5-25 %	3-7 days
September -February	DE 1003301 Doggerbank	5-25 %	1-3 days
	NL 2008001 Doggerbank	5-25 %	3-7 days
	UK0030352 Doggerbank	1-5 %	7-14 days

The basis for the designation of the three areas are the habitat type 1110 *Sandbanks* and the habitat species 1351 *Harbour porpoise*, 1365 *Harbour seal* and 1364 *Grey seal*.

Impacts on harbour porpoise

As described above, impacts on harbour porpoise may primarily be caused by toxic fumes from the oil slick on the surface.

It cannot be excluded that harbour porpoises in the Central North Sea may be affected in the unlikely incidence of a blowout at Hejre. However, as the oil slick during a blowout is transported in a relatively narrow band in the direction of the currents and as the density of porpoises is relatively low (0.01-8 individuals/km^2), only a tiny fraction of the populations of harbour porpoise in the North Sea is likely to be affected. It is therefore not likely that a potential oil contamination from a blowout will significantly affect the population sizes of the harbour porpoises in the North Sea.

Impacts on seals

It cannot be excluded that seals in the German, Dutch and UK Natura 2000 areas may be affected. However, as the oil slick during a blowout is transported in a relatively narrow band in the direction of the currents and as seals are relatively rare in the Central North Sea only a tiny fraction of the populations of seals is likely to be affected. It is therefore unlikely that a potential oil contamination from a blowout will significantly affect the population sizes of the seals.

Impacts on habitat type 1110 sandbanks

Oil may be incorporated in plankton or aggregate with marine snow and thus settle on the habitat type 1110 *Sandbanks which are slightly covered by sea water all the time*, especially in the German area, thereby affecting the benthic infauna community that has been characterised as a Bathyporeia-Fabulina (Amphipod-Tellina) community, with the crustacean *Bathyporeia elegans* and the bristle worms *Spiophanes bombyx* and *Spio decorata* as characterising species. However, given that fact that the risk of a blowout occurring is extremely low and that 60 % of the oil will have evaporated by the time it hits the area the risk is negligible.

Conclusion

It is concluded that the Hejre tie-back to South Arne development will not negatively affect the conservation status of habitats and species, for which potentially affected Natura 2000- sites have been designated as well as species listed on Annex IV of the EU Habitats directive (Directive 98/43EEC of 21 May 1992). Nor will the re-development affect the integrity of the areas negatively.

The conclusion in based on following arguments:

- The risk that a blowout occur is extremely low since all safety systems and measures are in place on the platform.
- The oil slick is transported in a relatively narrow band in the direction of the surface currents.
- The INEOS Energy Denmark's oil spill contingency plan (INEOS Oil and Gas, 2022) will be activated, and oil spill combat will be carried out, which will reduce the spreading of oil and mitigate impacts of any spill.

6.2 Environmental impacts of gas released during a blowout

In the unlikely event of a blowout at Hejre, gas may also escape from the formation.

In general, the extent of environmental impacts of escaped gas is not comparable to the impact of oil blowouts. The bulk of the gas, bubbles to the surface and escape to the atmosphere within a relatively small area around the platform and does not disperse in the water to the same extent as oil. On the other hand, field and laboratory investigations have demonstrated that severe environmental impacts may be observed in the immediate vicinity of the platform. The investigations clearly proved that severe damages and mass mortality on zooplankton, benthic fauna and fish might occur within the small gas affected area (Table 6-4).

Although gas blowout has smaller environmental impacts than oil blowouts, the gas may pose a severe safety risk for personnel on rig, platform and vessels. If the gas ignites and causes fires or explosions, installations and equipment will be damaged and in case personnel is not evacuated in due time, injuries or loss of life of personnel may occur. However, the risk of this is minor due to technical safety features on the platform that prevent blowout from happening. During an unlikely situation, the existing contingency arrangements involving evacuations of personnel from platforms will minimise the risk even further.

Table 6-4 Field-and laboratory studies on impacts of methane gas in the marine environment.

Study	Observations	References
Field survey in connection with a gas blowout at drilling rigs in the Azov Sea summer/autumn 1982 and in 1985	95 % of the escaped gas was methane. The concentration of methane in the vicinity of the well was 4-6 mg/l. The concentration had decreased to 0.07-1.4 mg/l 200 m from the well. In areas with a high concentration of methane, the biomass of benthos declined. Some declining of the zooplankton biomass also occurred in the vicinity of the accidental well Fish in the vicinity of the well clearly developed significant intoxication symptoms such as impaired movement coordination, weakened muscle tone, pathologies of organs and tissues, damaged cell membranes, disturbed blood formation, modifications of protein synthesis, radically increased total peroxidase activity, and some other anomalies typical for acute poisoning of fish.	Glabrybvod 1983 AzNIRKH 1986
Laboratory investigations of impacts of natural gas on fish	Fish clearly avoided concentrations of dissolved gas of 0.1-0.5 mg/l	Sokolov and Vinogradov 1991
Laboratory investigations of acute toxicity of natural gas on fish and zooplankton	48h LC_{50} for fish = 1-3 mg/l 96h LC_{50} for zooplankton = 5.5 mg/l	Umorin et al 1991
Laboratory investigations of acute toxicity of natural gas on zooplankton, benthic fauna and fish fry	96h LC_{50} for zooplankton, benthic fauna and fish fry = 0.6-1.8 mg/l	Borisov et al 1995
Laboratory investigations of impacts of natural gas on fish	Exposure to 1 mg/L and above induced intoxication symptoms (Impaired movement coordination, impaired oxygen absorption. disorientation. Lethal effects were observed after two days.	Patin 1993

6.3 Environmental impacts of pipeline rupture

Rupture of pipelines may occur as a result of corrosion or damage caused by trawlers. However, the risk of spills of larger amounts of oil or gas in case of rupture is minor.

Pipeline pressure is continuously monitored from the production platform. In case of pressure drop, the system closes. In addition, any spills are dealt with in accordance with the oil spill contingency plan for INEOS Energy Denmark's offshore operations, recent version from March 2022 (INEOS Oil & Gas DK 2022).

6.3.1 Modelled dispersion of oil during pipeline rupture

Spreading of oil

The unlikely event of subsea leakage from rupture of the longest pipeline has been modelled for Hejre to Siri tie-back. This modelling is viewed as a conservative scenario, as the Hejre to South Arne will have a shorter pipeline with potentially fewer leakage points and thus overall lower risk for leakage. Figure 6-6 shows the modelled probability that a subsea leakage from pipeline rupture will be hit by ≥1 % of 1 tonne of oil per 10 x 10 km grid cells during March-August and September-February, respectively.

It is seen that released oil during pipeline rupture will be transported with the prevailing current towards the North-eastern part of the Norwegian and Danish part of the North Sea. In the unlikely case of unmitigated pipeline rupture, the hit probability in Danish waters is above 94 % in the vicinity of the release location. In Norwegian waters the hit probability is 75-95 % during summer and 50-75 % during winter. For all other neighbouring countries including Natura 2000 areas (SACs) the hit probability is 0-50 %. The model shows that even for an unmitigated spill, the risk of oil stranding on coasts is 0 %. This means that there will be no stranding of oil in coastal areas such as the Wadden Sea in Germany, the west coast of Jutland or the Norwegian coast.

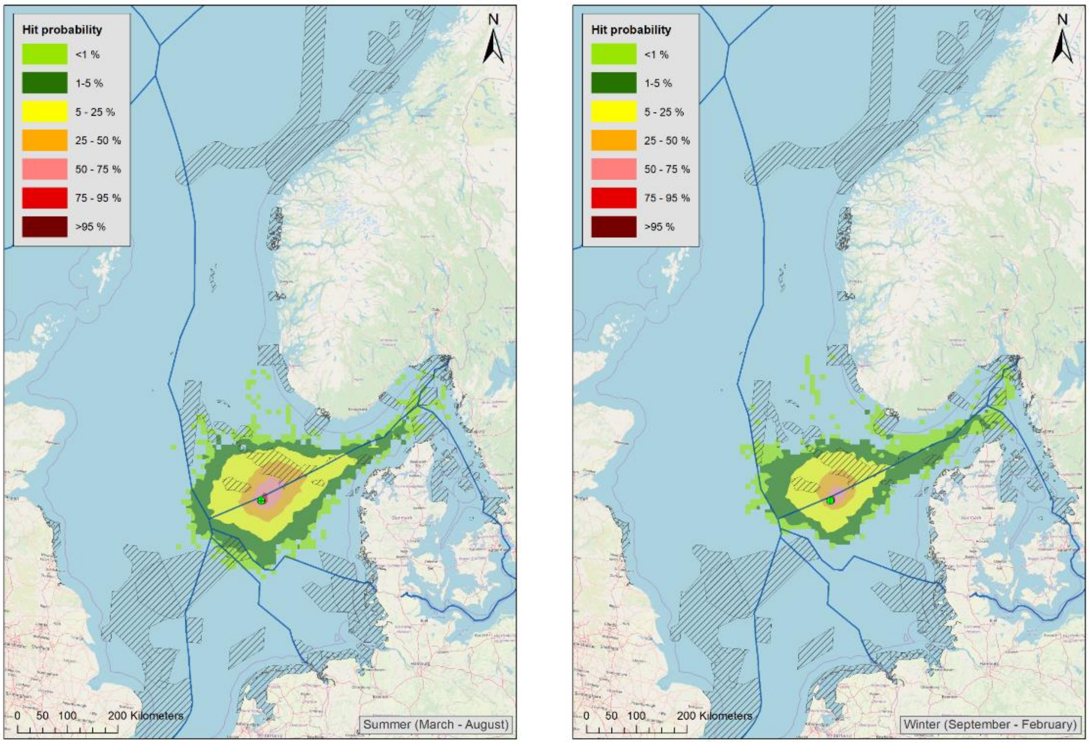


Figure 6-6 Result of stochastic oil spill modelling of a worst case, unmitigated release of oil during a full pipeline rupture at Siri during March-August (left) and September-February (right). The figures show the modelled probability that the sea surface in 10x10 km grid cells will be hit by more than 1 tonnes of oil. The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.

Figure 6-7 shows the seasonal resolution of arrival times from pipeline rupture within the influence area to 10 x 10 km grid cells (drift time).

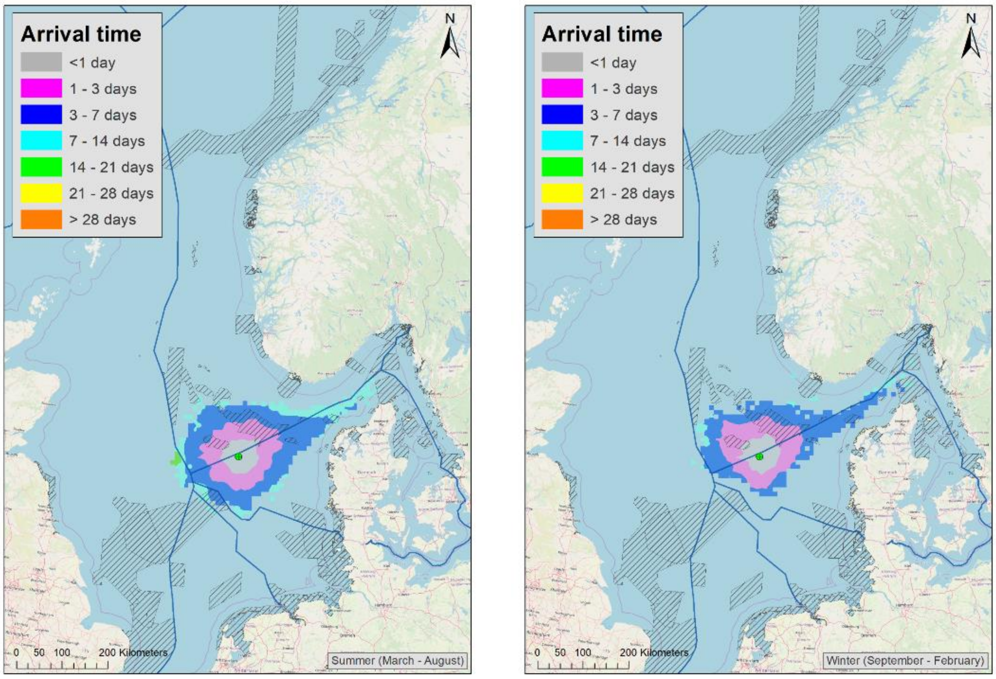


Figure 6-7 Result of stochastic oil spill modelling of a worst case, unmitigated release of oil during a pipeline rupture of the Hejre tie-back to Siri development during March-August (left) and September-February (right). The figures show the shortest arrival times (since start of the release) within the influence area to 10 x 10 km grid cells. The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.

Figure 6-8 shows that there will be <5 tonnes of oil per 100 km^2 in the north-eastern part of the closest SAC during summer and no detectable oil during winter.

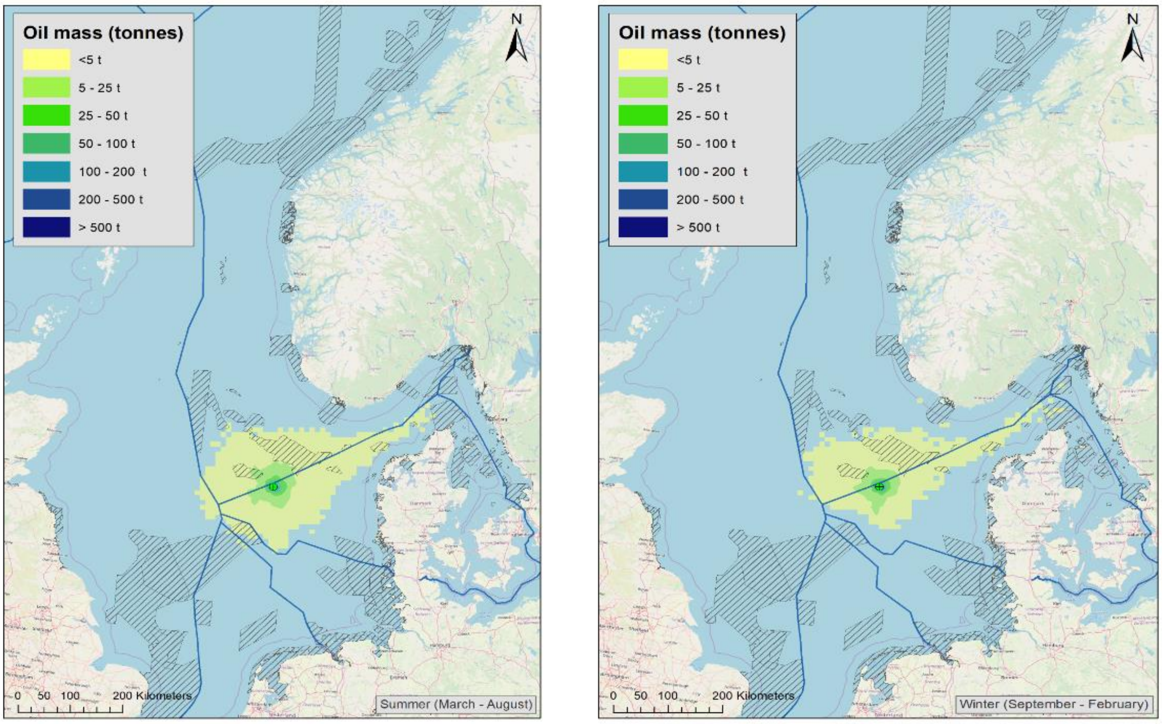


Figure 6-8 Seasonal oil mass within the influence area in 10 x 10 km grid cells during a pipeline rupture of the Hejre tie-back to Siri development during March-August (left) and September-February (right). The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.

6.3.2 Impact on seabirds of oil during pipeline rupture

As addressed in section 6.1.5 birds are extremely vulnerable to oil spills and they are often killed if occurring within the area of an oil spill. Oil spill from pipeline rupture impact a much smaller area than an oil blowout (green area on Figure 6-8). In the unlikely event of an unmitigated pipeline rupture, seabirds occurring in the vicinity of the pipeline will be affected. The oil will be transported with the current towards the internationally important bird area in the Norwegian part of the North Sea. However, most of the oil will have evaporated at the time of arrival and the oil sheen thickness will most likely be so thin that birds will survive.

Marine habitat areas off and along the coast of Norway, Sweden, Germany, The Netherlands and United Kingdom will not be affected by pipeline rupture.

6.3.3 Impact on marine mammals of oil during pipeline rupture

The modelling shows that oil spill from pipeline rupture may hit areas where harbour porpoise, grey seals or harbour seal may be encountered. However, since the influence area is limited to a relatively small area in the vicinity of the pipeline and since marine mammals in general are robust to oil spills (threshold is ca. 10 µm for seals and 100 µm for cetaceans, French-McCay 2009) only a small number of the North Sea populations of cetaceans and seals is expected to be negatively affected. Based on this it is assessed that the impact of an unmitigated oil spill from pipeline rupture on harbour porpoise and seals is negligible. The effect of oil spill on marine mammals is described in more details in section 6.1.6.

6.3.4 Impact on fish eggs- and larvae of oil during pipeline rupture

Eggs and larvae are considered the most sensitive life stages of fish in terms of acute impacts of spilled oil. The Norwegian Oil Industry Association use 25 ppb as the THC concentration at which fish eggs- and larvae and other sensitive marine life begin to be affected by oil components (see also section 6.1.7). THC concentration does not exceed 25 ppb given a 10 x 10 km grid cell resolution and therefore fish eggs and larvae are not expected to be affected by oil during pipeline rupture.

Figure 6-9 shows the probability of oil released during pipeline rupture will strand. The calculations show no hit probability during summer season. During winter there is <1 % stranding probability.

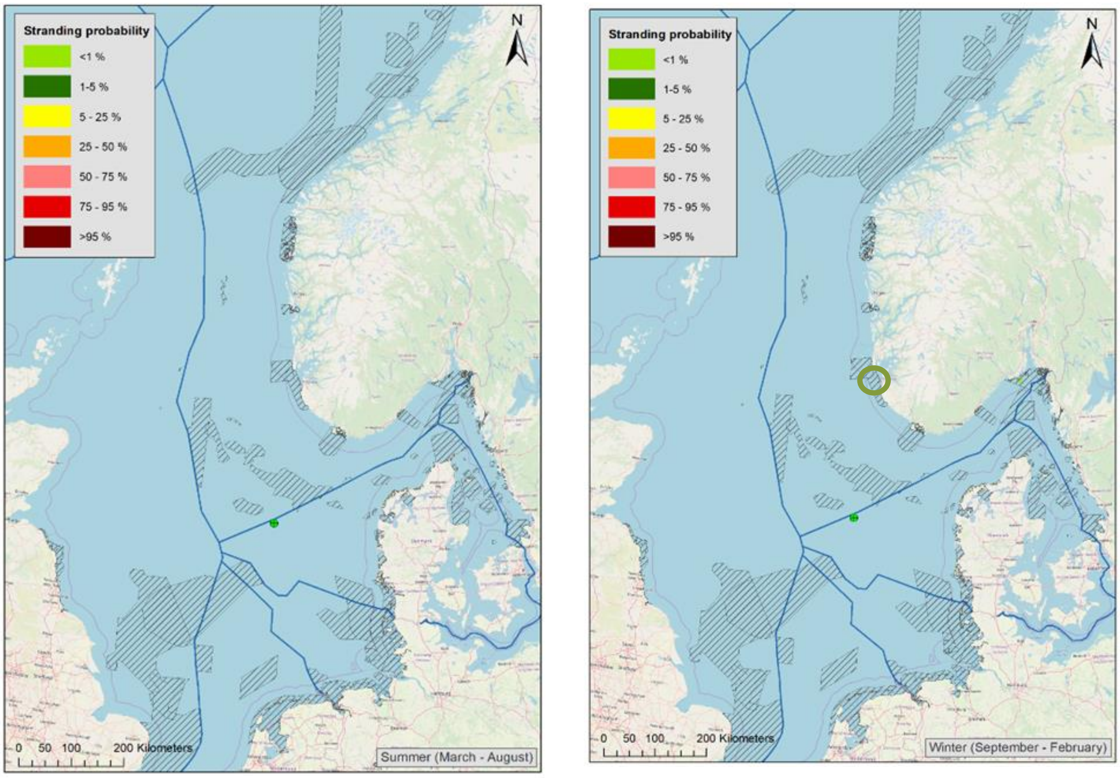


Figure 6-9 Result of stochastic oil spill modelling of a worst case, unmitigated release of oil during full pipeline rupture at the Hejre tie-back to Siri development during March-August (left) and September-February (right). There is a stranding probability of <1% in Norway (light green area in red circle). The figure shows the shortest arrival times (since start of the release) within the influence area to 10 x 10 km grid cells. The hatched areas show Natura 2000 areas (SACs) in territorial waters of EU countries and SVO areas (valuable and vulnerable areas) in Norwegian waters.

6.3.5 Impact on Norwegian SVOs

The modelling shows that Norwegian SVOs may be hit by oil in case of an unmitigated pipeline rupture (Figure 6-1 and Figure 6-2) i.e.:

- Sandeel field south may be hit by oil from pipeline rupture. The hit probability has been estimated to 25-50% during summer; drift time <1 day. The Sandeel field South is spawning and foraging areas for sandeel (*Ammodytes* sp.). Furthermore, the Sandeel fields South is a valuable habitat for common guillemot (*Uria aalge*) and northern fulmar (*Fulmaris glacialis*) from April to December. The model results show that the concentration of oil in these areas are less than 25 ppb, which is below concentrations that are harmful to fish eggs and larvae (cf. 6.1.7) so spawning in this area is not at risk.

- The SVO "*Makrellfelt*", which is a spawning area for mackerel from May to July has no hit probability.

6.3.6 Impact on SACs (Natura 2000 sites)

The oil spill modelling of a pipeline rupture shows it is very unlikely that Natura 2000 areas will be hit by oil. The hit probability within the German SAC DE 1003301 Doggerbank is thus < 1 %. DE 1003301 is designated to protect sandbanks, reefs and different species of fish and marine mammals (see further description in section 6.1.10). SACs in the Netherlands and UK show no hit probability. Based on the low hit probabilities in neighbouring SACs it is assessed that that pipeline rupture will not significantly impact the basis of the designation of these areas.

6.4 Marine Strategy Framework Directive (MSFD)

The impacts identified to have potential transboundary impacts as described in the previous sections in chapter 6 may potentially affect the Marine Strategy Framework Directive's (MSFD) 11 descriptors of Good Environmental Status (GES).

The most important parameters from the project is planned and unplanned discharge of chemicals and oil to the sea.

A summary of the potential impacts from the potential transboundary impacts of the 11 descriptor is provided in Table 6-5.

Table 6-5 Potential impacts on the 11 descriptors given by the Marine Strategy Framework Directive is summarised below. The environmental risk is assessed. NOTE: The impact identified to have potential transboundary impacts is highlighted with italic style.

	Descriptor	Potential impact	Environmental risk
D1	Biodiversity (birds)	The project area is not an important area for birds listed on the Birds Habitat directive. Possible impacts include:	
		Noise and light: Impacts from ship noise, noise from rig and installation of topside and pipelaying are considered to be low and temporary.	Negligible
		Accidental spill and blow-out events: very unlikely events. In case a large blow-out event occurs, it will have major impact on sea birds.	*Low*
	Biodiversity (mammals)	The project will not prevent harbour porpoise, harbour seal and grey sels of obtaining good environmental status. Possible impacts include:	
		Accidental spill and blow-out events Large blow-outs events are very unlikely but will affect marine mammals if they occur.	*Low*
		Underwater noise: See descriptor 11	Negligible
	Biodiversity (pelagic habitats)	Planned discharge of chemicals used for pipeline testing and discharge of treated sewage.	Negligible
		Unplanned discharge to the sea including accidental spills and blow out events (unlikely).	*Low*
D2	Non-indigenous species	The project will not have impact on D2	None

	Descriptor	Potential impact	Environmental risk
D3	Commercially exploited fish stocks	The spawning biomass of commercially exploited fish stocks can be affected due to disturbance of seabed and sediment dispersal during the construction phase. This is particularly relevant for sand eel that is buried in the sediment. <u>Disturbance of seabed and spreading of sediment</u>. Sandeel is particularly vulnerable to physical disturbance close to the trench since they live buried in the sediment. The impact is temporay and local. Sandeels in the trenched area will make up a minor fraction of sandeel populations in the North Sea. <u>Planned discharge of chemicals and treated sewage</u>. The impact is marginal and not measurable on spawning stocks. *<u>Unplanned discharge to the sea</u> (blow out and pipeline rupture): A blow-out event is very unlikely but may have major impact on spawning stocks.*	Negligible Negligible *Negligible*
D4	Marine food webs	Focus in the marine strategy II is phytoplankton- and zooplankton, since they form the base of the marine food web. Zooplankton will be affected by: <u>Sediment disposal:</u> temporary and local <u>Planned discharges to the sea</u>: The fitness (survival and fecundity) of zooplankton will decrease in the vicinity of the platform. The area is not important production front and the impact is considered to be negligible. *<u>Unplanned discharge to the sea (blow-out):</u> blow-out events have potential significant negative impact on all elements of the marine food web. Blow-out events are very unlikely. Mitigating measures are descried in section 6.5.*	Negligible Negligible *Low*
D5	Eutrophication	<u>Release of treated sewage:</u> There is obtained good environmental status for D5 in the North Sea. Release of treated sewage will be marginal and local.	Negligible

	Descriptor	Potential impact	Environmental risk
D6	Sea floor integrity	Physical damage and loss of seabed: Establishment of new pipelines will cause physical damage and loss of seabed. Loss and damage of seabed will affect offshore circalittoral mud and sand, which makes up 24.4 % (18170 km^2) and 27.3% (20322 km^2) of the seabed sediment in Denmark respectively.	Negligible
D7	Alteration of hydrographical conditions	The project will not alter hydrographical conditions.	None
D8	Contaminants (concentrations and species health)	Planned discharges to the sea: Discharge of produced water, production chemicals and pigging operations will not exceed threshold values set in the Marine Strategy II. See section 6.5 for mitigating measures to reduce negative impacts of chemical and oil discharge.	Negligible
D8	Contaminants (acute pollution events)	*Accidental spill and blow-out events are extremely rare events. The risk of accidental spill and blow-out is prevented through a number of mitigating measures (see section 6.5).*	Low
D9	Contaminants in fish and other seafood for human consumption	Planned discharges to the sea: Discharge of produced water, production chemicals and pigging operations may increase the level of contaminants in fish and other seafood. Measurable contaminants in fish and other seafood only occur as a result of major oil spill.	Negligible
D10	Marine litter	Impact of marine litter: there is an increased risk of contributing to marine litter in the area of the platform due to human activities. Littering will be prohibited on the platform and all waste are collected, sorted and send to shore. Observation of any marine litter on the seabed will be included in the decommissioning pre-survey and collected if present.	Negligible

	Descriptor	Potential impact	Environmental risk
D11	Underwater noise	Impact of underwater noise on marine mammals: during construction marine mammals will be disturbed due to ship noise, noise from rig, installation of topside and pipelaying. Noise levels are below thresholds for temporary and permanent underwater noise levels for marine mammals.	Negligible

6.5 Oil spill contingency plan

The modelling and assessments described above, are made under the assumption that all safety systems on the platform fail and that oil spill combat actions are not taken. In case of an uncontrolled blowout or other types of spill INEOS's oil spill contingency plan will be activated, which will significantly mitigate the impacts of spills (INEOS Oil & Gas 2022).

INEOS Energy Denmark has established a legally binding cooperation arrangement with Total E&P Denmark for mutual assistance in case of an oil spill incident from one of the operator's production installations. This arrangement ensures that four containerized DESMI (provider of pumps and systems for oil spill) fast sweep oil collection systems will be available for containing and collecting spilled oil, depending on the magnitude of the spill. In case of a blowout further oil spill mitigation resources will be provided by Oil Spill Response Ltd (OSRL). Oil spill contingency plan are thus in place and implemented. The plans are forwarded to Authorities for approval. In Denmark, the preferred response strategy is containment and recovery of spilled oil. Dispersant spraying may be used, subject to a case-by-case approval from the DEPA. Details on the specific equipment available for the preferred response strategy (mechanical containment and recovery) for the three tier responses are outlined in Table 6-6 and Table 6-7.

Table 6-6 Characteristics of the Tier 1, Tiers 2 and Tier 3 oil spills (INEOS Oil & Gas 2022)

TIER 1	TIER 2	TIER 3
Oil spills are likely to be small and effect a localized area. The spill can be managed by using INEOS pre-arranged PSV resources.	A spill incident in which TOTAL response resources and support are required to control the spill	An incident where assistance is required from international (OSRL) and national resource (other operators based on OCES agreement).
Characteristics of a Tier 1 oil spill	**Characteristics of a Tier 2 oil spill**	**Characteristics of a Tier 3 oil spill**
Spill occurs within immediate site proximity and is likely above 5 m3	Spill extends beyond the immediate site proximity	Uncontrolled Well blowout/ loss of control / risk of total GBS inventory loss.
Spill can be easily managed using response resources available on site.	Tier 1 resources are overwhelmed	Spill has crossed international maritime boundaries
The spill source has been secured	Spill source cannot be immediately secured	Tier 1 and Tier 2 resources are overwhelmed

Table 6-7 Characteristics of the Tier 1, Tiers 2 and Tier 3 oil spills and available resources for combatting the three types of spill (INEOS Oil & Gas 2022)

Tier	Resources for each Tier
Tier1	One containerized DESMI Speed Sweep 1500 system (swath width 25 m) with an in-built Ro-Skim 1500 skimmer connected to a DOP 250 pump system (nameplate capacity: 100-125 m^3/hour). The sweep system is operated along with a DESMI Ro-Kite 1500 allowing operation of the sweep system by one vessel. The system is stored permanently on Esvagt Innovator - ready for immediate deployment. Esvagt Innovator liquid storage capacity for recovered oil: 1200 m^3. System is owned by INEOS
Tier 2	One containerized DESMI Speed Sweep 1500 system with in-built skimmer (as described for Tier 1). The system is stored permanently on TOTAL PSV – ready for immediate deployment. Esvagt Dee liquid storage capacity: 510 m^3. One containerized DESMI Speed Sweep 1500 system with in-built skimmer (as described for Tier 1). The system is stored on the TOTAL offshore installation crossway Eagle – in case of mobilization the system – ready for deployment within 8 hours onto a support vessel nominated on the day. Preferably Hvila Fanø with a 1150 m^3 liquid storage capacity for recovered oil. One containerized DESMI Speed Sweep 1500 system with in-built skimmer (as described for Tier 1). The system is stored onshore in Port of Esbjerg ready for deployment onto a vessel of opportunity. The timeline for this will be dependent on vessel availability and location. All three systems are owned and operated by TOTAL
Tier 3	OSRL Tier 3 Provider OSRL has a variety of booms and skimmer systems including fast sweep systems that can be operated by one vessel. Provision of personnel to operate and manage the incident is a part of the service. INEOS will hire suitable vessels of opportunity on the day.

6.6 Risk assessment of Accidental spills

Based on the above and using the criteria described in section 4, it is assessed that the environmental risks related to accidental spills during construction and operation of Hejre to South Arne Development Project is **Low** to **Negligible** (Table 6-8).

Table 6-8 Environmental risk of accidental spills during operation of Hejre.

Impact	Extension of impact	Duration of impact	Magnitude of impact	Severity of impact	Likelihood of impact	Environmental Risk
Impacts of oil release during blowout	Inter national	Medium term	Large	Major impact	Very low	Low risk
Impacts of gas release during blowout	Local	Short term	Large	Moderate impact	Very low	Negligible risk
Impacts of rupture of pipeline	Local	Short term	Moderate	Minor impact	Low	Negligible risk

7 Conclusion

Most of the environmental impacts from the Hejre to South Arne Development Project are local or are confined to Danish waters. These impacts have been assessed in the EIA report to have an insignificant or minor impact on the environment. Underwater noise is assessed to have a moderate but short-term impact and it is confined to Danish waters.

The environmental impact of accidental oil spills and especially an uncontrolled blow out during drilling of a well or during normal production may, however, have transboundary impacts. These have been assessed in section 6 above. The main conclusions are that impacts are low to negligible as summarized in section 6.6. In case of an uncontrolled blowout or other types of spill INEOS's oil spill contingency plan will be activated to handle the spill.

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