Centre for Environment Fisheries & Aquaculture Science

Cefas

Use of Chemicals in Offshore Wind Farm Construction and Operation

For Hartley Anderson Ltd

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Executive Summary

On behalf of the Department for Business, Energy, and Industrial Strategy (BEIS) Offshore Energy's Strategic Environmental Assessment (OESEA) programme, Cefas have been commissioned to provide information on the use of chemicals in the construction, operation, and decommissioning of Offshore Wind Farms (OWFs). Development Consent Orders (DCO) for OWFs and other Marine Renewable Energy (MRE) developments all make provision for consideration of chemicals in some form. Whilst the Offshore Chemical Regulations (as amended) (OCR 2002) do not apply to OWF, marine licence conditions predominantly prescribe that all chemicals used for the construction, operation, and maintenance of MRE are notified to the national regulator.

The aim of the project is to provide information as part of an evidence base regarding chemical use in existing OWFs, and the likely future usage based on the projected scale of OWF developments around the UK.

This report is provided as a review of the consistency within marine licence conditions pertaining to chemical use in MRE and to what extent they have been applied. Development consent orders for all OWFs in England, Scotland and Wales were collated and the licence conditions pertaining to chemicals were extracted and categorised using expert judgment. Relevant documentation regarding the chemicals including developers reports and Cefas advice were interrogated using systematic search terms to generate a list of chemicals notified to the national regulator that are used within OWF construction, operation, and maintenance. This was done for both the generating (components of an energy development which generate the energy, e.g., wind turbine generators) and export (the components that export energy from the wind farm to the national grid e.g., cables) assets.

A list of the chemicals including their type of use, frequency, and quantity, where known were collated together with any risk assessments to determine their use in the marine environment for OWFs. These data were then compared to the types of chemicals used in the construction, operation, maintenance, and decommissioning of oil and gas platforms. The usage of chemicals, informed through available published data, was used to calculate potential quantities used for a generic OWF, with an average number of 50 monopiles. The usage was then compared to the quantities of chemicals used for an oil or gas platform using data from the annual status report (published from operator reports selected randomly in 2019).

A total of 316 Licence conditions were extracted from 49 DCOs and deemed to be relevant to the use of chemicals in OWFs. The most common licence condition (56 out of 316) stipulated that the chemicals used must be on the Offshore Chemical Notification Scheme (OCNS) Definitive Ranked list of registered chemicals (products), or that approval would be needed from the regulator prior to use. The second most common licence condition (33 out

of 316) stipulated regulatory approval for use of non-water-based drilling muds. Whilst many licence conditions extracted perform similar functions, differences in wording have led to there being some variation in requirements for the use of chemicals in OWF construction and operation, and the reporting of their use.

From the anonymised chemical risk assessment (CRA), over 300 different chemicals were declared for use in the construction, operation, and maintenance of an OWF. The most used chemicals were grout and cementing chemicals, which aligned with the authors' expectations before starting the project. For these types of chemicals, up to 70 tonnes of each per turbine were used to connect the base of the turbine to the transition piece that connects to the tower.

Chemicals were found to be used that were common to both the oil and gas sector and OWF sector, namely lubricant oil (needed to maintain low friction, efficient heat transfer and maintenance of hydraulics or moving mechanical parts), greasers (to prevent wear and tear used for bearings and gears), cement and grout, corrosion inhibitors, biocides, rigwash and dye.

Predominantly chemicals found to be used in very large quantities were found to be within 'closed systems', with no intentional discharge into the marine environment (e.g., transformer oil). However, for one installation, discharge of a chemical specified for use only in a closed system was seen to be captured routinely in a rainwater reservoir and discharged with the rainwater. Without description of the mechanism for use and top up requirements this was unlikely to have been captured, as for OCR any chemical described for use within closed systems are not assessed.

Although there is an identified difference between regulations/requirements for chemicals for use in OWFs, paints and coatings are exempt for notification to regulators for the oil and gas industry, whereas the OSPAR guidance (2008-3) states that for OWFs they are reported and their ecotoxicological properties are known. As there has been little research to date on chemicals that are routinely topped up and where they go (i.e., are they discharged?) for OWF, this could lead to inadvertent discharge of chemicals into the marine environment without adequate assessment of their impacts.

The usage data from the CRA for the generic OWF were scaled with both the type of foundation and likely number of turbines to provide an estimated annual tonnage, using an anonymised OWF as a basis. The use and discharge data from the annual returns statement from a random oil and gas operator was used as a comparison to those used for the generic OWF. The oil and gas operator declared 1834.15 tonnes of chemicals used in 2019 of which 165 tonnes were discharged by 12 assets. This equates to approximately 153 tonnes of chemicals used per asset and 14 tonnes discharged. By comparison, the generic 50 monopile foundation offshore wind farm was observed to use 709 tonnes of chemicals for construction and likely far less during operation and maintenance.

Gaps were identified in the supporting information and site-specific risk assessment of chemicals for environmental consideration supplied to regulators for the construction, operation and maintenance of OWFs.

Glossary

BEIS	Department for Business, Energy and Industrial Strategy
BOP	Blow-Out Preventers
COSHH	Control of Substances Hazardous to Health Regulations 2002
CRA	Chemical Risk Assessment
DCO	Development Consent Order
dML	deemed Marine Licence
Generating Assets	Components of an energy development which generate the energy, e.g., wind turbine generators
HDD	Horizontal Directional Drilling – trenchless method of installing subsea infrastructure
HMCS	OSPAR Harmonised Mandatory Control Scheme
MMO	Marine Management Organisation
MSDS	Material Safety Data Sheet
MODU	Mobile Offshore Drilling Units
MRE	Marine Renewable Energy (includes coastal and estuarine)
OCNS	Offshore Chemical Notification Scheme
OCR	Offshore Chemical Regulations (2002) (as amended)
OESEA	Offshore Energy Strategic Environmental Assessment
OIC	OSPAR Offshore Industry Committee
OPRED	Offshore Petroleum Regulator for Environment and Decommissioning

ORED	Offshore Renewable Energy Developments
OSPAR	Oslo and Paris commission for the Protection of the Northeast Atlantic
OWF	Offshore Wind Farm
(P)EMMP	(Project) Environmental Management and Monitoring Plan
PLONOR	Pose Little or No Risk to the marine environment, they contain substances whose use and discharged offshore are subject to expert judgement by the competent national authorities or do not need to be strongly regulated (updated 2019 OSPAR PLONOR 2019_13-06e_agrrement_plonor-6-2019) (OSPAR Agreement 2013-06)
PEC/PNEC	Predicted Effect Concentration/Predicted No-Effect Concentration
Transmission Assets	Components of an energy development which transport energy produced by Generating Assets (e.g., cables and substations)

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1. Introduction

The UK Government has committed itself to adopting an ambitious policy agenda to adapt to and mitigate climate change, ultimately, to become carbon neutral by 2050. Alongside this, the Government's Clean Growth Strategy aims to "*maximise the advantages for UK industry from the global shift to clean growth*" (BEIS, 2017). The construction and operation of offshore wind farms (OWFs) are playing a key role in realising both these ambitions and will likely continue to do so in the future. As the UK moves into Round 4 of leasing marine space for OWFs from The Crown Estate, the evidence base for the impacts from OWF construction and operation on a range of species, populations and habitats continues to develop (Bray *et al.* 2016; Verfuss *et al.* 2016; Vallejo *et al.* 2017; Gill *et al.* 2020). Research focus has also been directed to developing new methods and procedures for impact assessment in the marine environment which complement research into OWFs, including for emerging and poorly understood impact pathways (Cooper and Barry, 2017; Willsteed *et al.* 2018; Hutchison *et al.* 2021). Whilst this research effort is welcomed by the wider scientific community, NGOs and regulators alike, comparatively little has been directed towards understanding the use of chemicals in the construction and operation of OWFs. This is mirrored by the lack of grey literature and information available for their use, as there is no legal requirement to collate or publish this information. As such, the risks posed by the use of these chemicals within the marine environment is not fully understood.

In light of this evidence gap, and the risks posed, Hartley Anderson Ltd have commissioned a review of the information available concerning the use of chemicals in the construction, operation and, if available, decommissioning of OWFs. In the UK, licensing authorities[1] for marine renewables energy (MRE) infrastructure make some informal provision for the consideration of chemicals but there is no legislative framework pertaining to chemicals used for OWFs. In absence of such a framework, the offshore chemical regulations (OCR, 2002) are considered the most relevant statutory instrument available to enable authorities to judge applications for chemical use, however as the systems in which chemicals are used differ greatly the OCR only provides a very rough indication of potential risk. As the OCRs were drafted under the Petroleum Act (1998), they pertain only to chemicals used in Oil and Gas Extraction infrastructure, and do not apply to OWF. Currently, OSPAR guidance (2008-3) is that the national regulator is notified of all chemicals used for the construction operation, maintenance, and, if relevant, decommissioning, of OWFs, and their ecotoxicological properties known, however there is no established reporting mechanism.

A review of the licensing history of MRE infrastructure (OWF, wave, and tidal) from England Wales and Scotland will form the basis to research advice provided to regulators, comprising

[1] In England and Wales (for >350MW projects), the Planning Inspectorate for Nationally Significant Infrastructure Projects with consultation from the MMO (England only) and Planning and Environment Decisions Wales (PEDW) (Wales only); in Scotland, Marine Scotland; and in Northern Ireland, the Department for Agriculture, Environment and Rural Affairs (DAERA).

a collation and review of all licence conditions relevant to chemical use which have been stipulated so far. Specialist advice provided to regulators (by Cefas Chemical Hazard Assessment advisors) will also be collated and reviewed, to form an overview of which chemicals have been used, how they have been used, and the likely associated impacts both now and in the future. This evidence will form part of the Department for Business, Energy, and Industrial Strategy's (BEIS) latest Offshore Energy Strategic Environmental Assessment (OESEA).

1.1. Aims

The aim of the project is to consolidate the evidence base of chemical use in existing OWFs, and predict the likely future usage based on the projected scale of OWF developments which have either been leased by The Crown Estate, or authorised by the licensing authority, using only evidence and information available through the licensing process. More specifically, the work aims to review the range of chemicals used, the volumes used/discharged or otherwise entering the sea, the controls and data reporting in place, and identify any potential risks to the marine environment. This report does not seek to make any formal recommendations.

1.2. Objectives

a) Review the marine licence conditions on consented/constructed offshore wind farms across the UK[2] to identify which OWF have conditions pertaining to the notification of chemical(s) for construction and operation purposes.
b) Review case histories across the UK to identify type, frequency and purpose of chemicals currently used by the OWF (construction, operation, and decommissioning). This will include looking at previous advice requests and marine licence conditions.
c) To compare chemical type and usage classed as exempt under OCR by oil and gas industry that might need to be notified under any OWF chemical regulations (e.g., paints, coatings).
d) Based on past chemical usage and number of OWFs, to estimate the likely scale of chemical usage from future OWF construction and operation (and decommissioning, if available). The work will include consideration of any gaps in understanding or regulation. The information will be split by OWF type (e.g., monopile, jacket, gravity-based) and into different phases of an OWF construction, operation, maintenance.

[2] Not including Northern Ireland as there are no OWFs in Northern Ireland at the time of writing.

1.3. Regulations

Licensing authorities and national regulators are the key decision-makers for energy generation infrastructure and resource extraction in the marine environment. Whilst MRE and Oil and Gas extraction may comprise different elements, there are many similarities in the construction and operation of associated infrastructure. As such, certain policy tools and statutory instruments are utilised for both MRE and Oil and Gas extraction. BEIS is the principal environmental regulator of the offshore oil and gas industry, promoting the economic development of the offshore oil and gas industry balanced with effective environmental protection. Although the European Strategic Environmental Assessment (SEA) Directive (Directive 2001/42/EC) was not adopted by the UK until 2004, BEIS has undertaken SEAs since 1999. The SEA looks at future Leasing/Licensing for Offshore Renewable Energy, Offshore Oil & Gas, Hydrocarbon Gas and Carbon Dioxide Storage and Associated Infrastructure.

The recent offshore energy SEAs (OESEA, OESEA2 and OESEA3) incorporated the entire UKCS (with the exception of Northern Ireland and Scottish territorial waters for renewable energy, and Scottish territorial waters for carbon dioxide transport and storage), for technologies including oil and gas exploration and production, gas storage and offloading including carbon dioxide transport and storage, and renewable energy (including wind, wave and tidal power). In these SEAs the main objectives are to outline the contents of the main plan or programme and the relationship with other relevant plans and programs together with the current state of the environment to support Ministerial decisions. Looking at the environmental characteristics of areas likely to be affected, of particular interest are areas relating to impacts under the Conservation of Habitats and Species Regulations (2017) any other environmental protection objectives or likely significant effects from issues of biodiversity, population, human health, fauna, flora, soil, water, air and climate, as well as any mitigation and monitoring.

For this project, focus will be limited to regulations which pertain to the use or impacts of chemicals in the marine environment. Many of these are relevant to the marine environment as a whole, however in this project, they are insofar as they pertain to chemical use, specifically:

- ***Offshore Chemical Regulations 2002*** **(as amended 2017)** – implements the OSPAR Harmonised Mandatory Control System for the Use and Discharge of Offshore Chemicals (HMCS).
- ***Marine and Coastal Access Act 2009*** **(as amended)** – regulates all chemicals to be used in marine energy infrastructure in England and Wales, with offshore petroleum infrastructure being regulated by the Offshore Petroleum Regulator for

Environment and Decommissioning (OPRED)[3]. Marine licensing and regulation in Scotland are devolved under the *Marine (Scotland) Act 2010*.

- ***Planning Act 2008*** – regulates nationally significant infrastructure projects (NSIPs) such as MRE. The Planning Inspectorate – consenting authority for the *Planning Act 2008* – is ultimately responsible for the licensing of all NSIP works, however, other regulators provide formal opinion as to certain components, such as the use of chemicals in the offshore marine environment. In certain cases, such works are consented outside of the *Planning Act 2008*, such as operational activities applications (e.g., cable repair).
- **OSPAR guidance (2008-3) for OWF** – provides practical advice to regulators.
- ***EU Water Framework Directive 2000*** – provided an EU-level framework for protection of water bodies and resources with regard to threats posed by pollution and discharges.
- ***Bonn Agreement 1969***[4] - provided a framework for international cooperation in mitigating pollution.

Whilst the Regulation Evaluation Authorisation and Restriction of Chemicals regulations (REACH) (2007) now superseded by UK REACH – UK Statutory Instruments 2021 No. 904 The REACH etc. (Amendment) Regulations 2021 may be relevant to offshore chemical use, they do not materially affect the outcome or requirements for the reporting of data for signatory and regulatory purposes, and so are not commented on within this report. The OCRs were introduced in 2002 to ratify OSPAR signatory obligations into UK legislation with regard to the offshore oil and gas industry. The OCR applies specifically to chemicals used for the extraction of oil and gas, as detailed by Regulation 2, which states:

> "'*offshore activities' means any activities in respect of which the Secretary of State exercises functions under the Petroleum Act 1998(4), being activities carried out in the relevant area".*

This definition can be interpreted to stipulate that MRE infrastructure are excluded from needing a permit to use or discharge chemicals offshore under the OCRs. However, Regulation 3 of the OCRs states:

> *"Requirement for permit to use or discharge offshore chemicals.*
>
> *"**3.**- (1) Subject to paragraphs (2) and (3), no person shall use or discharge any offshore chemical in the relevant area after the prescribed date otherwise than in accordance with the terms of, and conditions attached to, a permit.*

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[3] OPRED is a regulatory arm of BEIS that regulates environmental and decommissioning activities for offshore oil and gas operations, as well as carbon capture and storage operations, on the UK continental shelf

[4] Multilateral agreement between Belgium, Denmark, the European Community (EU in 1983), France, Germany, Ireland (2001), the Netherlands, Norway, Sweden, and the United Kingdom.

"(2) Where a person is using or discharging any offshore chemical in connection with any offshore activity that began on or before the date on which these Regulations come into force, that person may continue to use or discharge that offshore chemical until—

(a)such time as the Secretary of State may specify by notice; or

(b)(if no notice is given by the Secretary of State in accordance with sub-paragraph (a)) the date after the day on which the period of two years commencing on the prescribed date expires.

"(3) A person using or discharging an offshore chemical in accordance with paragraph (2) shall provide the Secretary of State with such information as the Secretary of State may reasonably require for the purpose of performing her functions under these Regulations."

The OCR applies to chemical use and discharge offshore, and even if not discharged, if used, and falls under OCR then OCR applies. There are exemptions such as those used solely within accommodation areas of vessels, additives to potable water systems, chemicals in "closed systems" where periodic refill is not needed, and so on. As part of the permit-application requirement for the oil and gas industry, and due to the requirement to inform OSPAR of the UK's annual quantities of chemicals discharged into the marine environment, BEIS commissions Cefas to review the hazard and risk of all chemicals used by the oil and gas industry. Cefas registers chemicals that have been reviewed and ranks them using an (offshore) industry standard risk model (the chemical hazard and risk model (CHARM)). The resultant "definitive ranked lists of registered products" are publicly available[5].

In England the Marine and Coastal Access Act (MCAA) (2009) transferred the authority for granting consents under section 36 of the Electricity Act 1989 for the construction of generating equipment to the Marine Management Organisation (MMO). Under MCAA, the MMO are responsible for regulating the deposit of any substance or object anywhere in the sea, on or under the seabed from a British vessel, aircraft or marine structure. In Wales for projects >350MW projects fall under nationally significant infrastructure projects (PINS) .Therefore, although the applications for NSIPs like OWF are primarily consented via the Planning Inspectorate, – an executive agency of the Ministry for Housing, Communities and Local Government – national regulators like the MMO (and Marine Scotland and Planning and Environment Decisions Wales (PEDW)) feed into and support the regulation for the construction, operation and decommissioning of MRE infrastructure and any subsequent discharges.

Whilst the OCRs are used as a proxy for a formal legislative framework for MRE chemical use, the actual requirements for chemical use in OWFs are slightly different. OSPAR

[5] *Offshore Chemical Notification Scheme (OCNS) – Definitive Ranked Lists of Registered Products,* Cefas. Available at: https://www.cefas.co.uk/data-and-publications/ocns/definitive-ranked-lists-of-registered-products/ (Accessed 7th July 21)

guidance (OSPAR 2008-3, sections 57 and 81) is for all chemicals (including paints, coverings etc.) used in OWF construction to be approved for use in the marine environment and have their ecotoxicological properties known, however there is no formal mechanism to do so. Therefore, under national legislation, chemicals used in MRE may be exempt from regulation and reporting, despite the OSPAR guidance.

2. Materials and methods

2.1. Identifying and obtaining licences

Consented and operational OWFs were identified by using the UK's most recent submission for the OSPAR annual Offshore Renewable Energy Developments (ORED) returns (see Annex 3), which consolidate all proposed, designated, authorised and operational MRE infrastructure in the UK. As such, at the time of conducting the analysis, the development status of OWF infrastructure (includes OWF demonstrators) was correct as of the 31st December 2020. OWFs for which a consenting decision had not been made at the time of the ORED return were cross-referenced against the Planning Inspectorate[6] and MMO public resources[7] to ascertain whether there had been any change in development status. Those which were still under the application process, e.g., East Anglia ONE North (DCO/2016/00004) which is currently being examined, were excluded from this study.

Following the identification of relevant OWFs and clarification as to their current development status, documents of consent (Development Consent Orders [DCO] and deemed Marine Licences [dML]) were located and downloaded. Various resources were utilised to locate relevant DCOs and dMLs. For England and Wales, a Freedom of Information Request (FOIR) was initially made to the Planning Inspectorate, requesting all documents of consent for all offshore wind infrastructure in England and Wales. The Planning Inspectorate's public database was also consulted. As the Planning Inspectorate became the relevant authority under the Planning Act (2008), the FOIR yielded only those OWF licensing documents which had been consented since 2008. OWFs consented before 2008 were licenced under the Electricity Act (1989), thus a subsequent FOIR was made to the Department for Business, Energy, and Industrial Strategy (BEIS) for their archived records. For Scotland, Marine Scotland's Information Portal[8] was consulted.

2.2. Extraction and synthesis of relevant licence conditions

Once documents of consent had been located for authorised and operational OWF infrastructure, each document was reviewed to identify and extract licence conditions which pertained to the use, storage, and management of chemicals in the marine environment.

[6] Planning Inspectorate public database. Available at: https://infrastructure.planninginspectorate.gov.uk/ (Accessed 23 June 21)

[7] MMO list of Nationally Significant Infrastructure Projects currently in the application process. Available at: https://www.gov.uk/government/collections/marine-licensing-nationally-significant-infrastructure-projects (Accessed 23 June 21)

[8] Marine Scotland Information Search. Available at: https://marine.gov.scot/search/content (Accessed 23 June 21)

This was done by navigating to the appropriate subsections within each licence document, e.g., Schedule 2 – Licence Conditions, and extracting all relevant conditions. Conditions were deemed relevant if they stipulated any requirements or restrictions for the use, storage, management, disposal, and reporting of any chemicals. Once these were identified and extracted, the PDF or MS Word search function was used to ensure that all relevant conditions had been captured as a final check. Terms used for the final search comprised: “chemical”, “substance”, “grout”, “cement”, “slurry”, “discharge” and “mud”.

All relevant conditions were then imported into an Excel spreadsheet, with a unique identifier applied to each condition. Conditions were then sorted into various categories of condition type (Table 1). These categories were initially developed through expert judgment and experience with OWF chemical advice, however, categories were subsequently refined and amended as conditions were reviewed and examined, so that categories would be better representative of conditions present.

Table 1. Condition type categories and their definitions

Category of condition type	Definition
Audits registers and lists	*Condition stipulates requirements for auditing e.g., to aid identification of dropped objects.*
Chemical specific	*Condition stipulates requirements for a named chemical, e.g., “Bentonite”*
Cement grouting and or slurry	*Condition concerns the use of grouting or slurry*
Disposal of non-chemicals	*Condition concerns the disposal of non-chemicals e.g., water, (not including dredged sediment)*
Health and Safety Executive	*Condition concerns health and safety requirements*
Loss/spill incident	*Condition stipulates requirements for the prevention of and response to any marine pollution incidents caused via loss or spill*
Not relevant to chemicals	*Condition does not concern the use, storage, management, disposal or reporting of chemicals*
Scour	*Condition relates to materials used to be free from contaminants*
Specify use of ranked list of registered chemicals	*Condition requires chemicals to be on the Cefas ranked list of registered chemicals*
Storage handling and transport	*Condition concerns the storage, handling and other management of chemicals*

There is some overlap between categories, e.g., a condition may stipulate both use of grouting and performing an audit. In these cases, conditions were assigned a second category in a separate column. Once all conditions were assigned a primary and, if appropriate, a secondary category, the category assignments were then discussed and reviewed between all report authors to finalise each condition's classification.

2.3. Collation of advice on chemicals

A developer or operator will apply, or notify the national regulator in England, Scotland, or Wales (MMO, Marine Scotland, NRW) of their intent, to use specific chemicals for OWF construction and/or operation. Cefas, as a non-statutory advisory body, provides advice on the hazard and risk of those chemicals when requested. In England, such regulatory advice provided by statutory and non-statutory bodies is usually available on the MMO's Public Register, and so, can be located publicly.

However, the nature of the Public Register platform does not easily facilitate the locating of specific types of advice for an application. The Public Register search function only permits searching by licence or application reference number, and currently there is no type of keyword or advanced search feature. In addition, consultations for OWF applications can take several years from pre-application work to a decision being made, and hence, there may be a large number of consultations to search through before locating a consultation which contains a specific advice type. These limitations ultimately do not make it feasible to locate chemical advice on the Public Register within the context of this project. As such, the decision was taken not to use the Public Register in the first instance.

Rather, Cefas' internal filing system was utilised. In accordance with ISO standard 9001, advice provided to the MMO must be filed internally using strict guidance. The filing system is Hewlett Packard Enterprise Content Manager (HPE CM), and provides broader search functioning than the Public Register, e.g., keyword, record number, advanced searching. As such, it proves a useful resource for locating regulatory advice. To accurately delimit search results, simple Boolean search strings ("AND", "OR" and "NOT") were inputted into the advanced search function, including wildcard searching (e.g., "fish*" would return both "fishing" and "fisheries").

The search strings would comprise the OWF name, a combination of terms to be included via "AND", and a combination of terms to be excluded, via "NOT" (e.g., "noise", "fish*", "benth*"). For OWFs with easily distinguishable names, such as "Burbo Bank" and "Gunfleet Sands", search strings returned mostly relevant results, whilst for OWFs with less easily distinguishable names, such as "Lynn", the search strings did return some irrelevant results, such as advice provided for applications in King's Lynn and the River Lynher. Any such irrelevant results were screened out.

All documents within an HPE CM container ("folder") that included the word chemical were reviewed for content. Documents were examined that were likely to include any chemical information provided by the applicant. In addition to any advice response provided to the

MMO, these included select volumes and chapters of Environmental Statements, construction method statements, technical installation documentation (e.g., assembly information), Environmental Management and Monitoring Reports (EMMPs), and Chemical Risk Assessments (CRAs).

Once relevant documents were found following the screening out of irrelevant documents, each document was then scrutinised to determine whether they comprised advice on chemical use. Using the MS Word search function, the following terms were used:

- chemical*
- lubricant
- degreas*
- grout*
- cement
- anod*
- cathod*
- corrosion OR corrode

Where individual chemicals were identified to have been assessed or commented on, any available information on ecological criteria (persistence, bioaccumulation potential, and toxicity (PBT)), volume for use or packaged, or other risk assessment was recorded. A summary of the types of chemicals identified was then tabulated (see Annex 1 Table A) and advice located was reviewed and the information pertaining to chemical types also tabulated (see Annex 2).

2.4. Case studies and comparison of chemical use between an OWF and an oil and/or gas platform

Information from the review of the advice records and from developer's documents (e.g., CRA) were used to obtain data which were suitable to enable a comparison between an OWF and an oil and/or gas platform.

Chemical information publicly available for oil and gas platforms were downloaded from the OSPAR website[9] and annual industry statements from the Gov.UK website[10]. To comply with regulations, oil and gas operators' performance records are published annually on the Gov.UK website, which includes information such as the tonnage of chemicals used and discharged. The quantities of chemicals with and without substitution or product warnings by process (e.g., production, drilling, pipeline and decommissioning) are declared. The

[9] *OSPAR Data and Information Management System (ODIMS)*. Available at: https://odims.ospar.org/en/ (Accessed 8th July 2021)
[10] *Oil and gas: Public statements relating to 2020 operations,* Offshore Petroleum Regulator for Environment and Decommissioning, GOV.UK (July 2021). Available at: https://www.gov.uk/government/publications/oil-and-gas-public-statements-relating-to-2020-operations (Accessed 8th July 2021)

volume of oil (hydrocarbons) in water discharges are also provided. The operators' emissions, waste and spill performance too are logged. The chemical use and discharge quantities published are for the total usage for an operator and each operator may have a number of assets. For comparison of chemical use, Perenco's annual statement returns data were randomly chosen as a representative for an oil or gas platform. Perenco UK Southern North Sea states that in 2019 a total of 1834.15 tonnes of chemicals were used of which 165 tonnes were discharged by 12 assets.

For oil and gas extraction, chemicals are further defined into those which were considered to pose little or no risk (PLONOR) in the marine environment, those with substitution warnings, and those without substitution warnings. Where there were substitution warnings, additional explanation using a risk quotient and justification of why those products were used were given. Additional information for each process included any emergency works e.g.,

> *"While the discharge of cementing chemicals is usually limited to the cleaning out of lines and dead volumes within the mixing pits, during 2019 two emergency aborted cement batches were discharged to sea resulting in a higher discharge volume than would be expected for normal operations."*

Information on individual assets were limited to the volume of hydrocarbons released in the produced water compared to the consented limit (30mg/l) and the reasoning for the exceedances (where appropriate) were discussed. Releases were seen to be from a wide range of activities, and all accidental releases were reported.

Publicly available datasets were those contained in the OSPAR discharges spills and emissions from offshore oil and gas installations. These provide data for individual rigs or platforms where the hydrocarbons release exceeded the consented limits. Tonnages of chemicals used were further subdivided using the OSPAR 'Pre-Screening' (e.g., LC50 less than 1mg /l, biodegradation less than 20% etc.) categories in volume of chemicals per country.

For the OWF sector, no information is published on the total tonnages used and or discharged, on an annual basis. The information pertaining to chemicals for OWF are predominantly found in CRAs contained within documents such as a developer's Project Environmental Management and Monitoring Plan (PEMMP). These documents often comprise the CRA, contingency plans for pollution, as well as the waste management and disposal plans. Sometimes quantities are provided for use as most of the chemicals declared are for use in closed systems or use on vessels or discharged via grey or black water, they are not further assessed for chemical risk regarding signatory obligations to OSPAR or under OCR.

With the lack of published returns or direct operator information, it was determined that a CRA would likely be the best available resource. The data provided includes construction, operation and maintenance. The data can either be per structure or in total, therefore an anonymised CRA was used from an operational OWF to ensure there was sufficient construction and maintenance information. The usage data in the CRA was then divided by the average number of turbines to estimate usage per turbine, using the 2020 OSPAR ORED returns. There are several different types of OWF foundation on which to base an estimate of usage per turbine, and each type can differ considerably in the types and volumes of chemicals used. Monopiles were ultimately chosen as they are the most common foundation type according to the 2020 OSPAR ORED returns (Annex 3 Table D). Overall, the use of monopile foundation data with the assumption that an average of 50 turbines was representative of a generic OWF.

Therefore, all individual structure quantities for each chemical for the construction and operation values for the turbines suggested in the CRA were multiplied by 50 unless the chemical total was given. All data for the offshore substations were taken at face value, without further calculations, as it was assumed for the generic operational wind farm that there was only one offshore substation. Both the generating asset and the export asset chemicals were considered. The chemicals were then grouped by type and the chemical names removed to provide a table of quantity of chemicals used by type.

The total tonnages of chemicals used from the randomly chosen oil and gas platform operators annual statement were compared to the derived figures calculated from the anonymised OWF CRA. Whilst not all chemicals are discharged for the OWF, each type of chemical was considered for its potential to be released e.g., grout and dye. The total quantity of those chemicals was then calculated to provide a potential value for discharge This comparative case study is therefore only intended to be a high-level assessment, using estimated values.

3. Results

3.1. Licence conditions and examples

A total of 316 Licence conditions were extracted from 49 DCOs and dMLs, representing all currently authorised and operational OWFs in England, Scotland and Wales. Conditions found pertaining to “material” or “substance”, which on further evaluation concerned debris were scoped out as they were not relevant to chemicals (n = 7). Table 2 details the results of the licence condition categorisation exercise.

Table 2. Results of the condition review and analysis, with exemplar text per condition category.

Condition Type (*and sub-type if appropriate*)		Number	Example text
Audits, registers and lists		45	*"The Licence Holder must create, maintain and submit to the Licensing Authority a detailed transportation audit sheet, prior to sailing, for all aspects of the wind farm construction…* [including]*… all materials (e.g., piles, cables, blades, nacelles, chemicals If the Licensing Authority becomes aware that any materials on the audit sheet are missing… the licence holder… must undertake a side scan sonar survey in grid lines… across the area of development… All* obstructions *found on the seabed must be plotted."*
Chemical Specific	Oil-based drilling muds	4	*"…if oil-based drilling muds are utilised they must be contained within a zero-discharge system. Any drill cuttings associated with the use of water-based drilling muds situated within the outer boundary of the Works need not be removed from the seabed."*
	Fluorinated compounds	4	*"…all equipment to be utilised in the Works that contains fluorinated greenhouse gases (…listed in Annex I of Regulation (EU) 517/2014 and The Fluorinated Greenhouse Gases Regulations 2015, or mixtures containing any of those substances) must take precautions to prevent the unintentional release of those gases. They must take all measures which are technically and economically feasible to minimise leakage of fluorinated greenhouse gases.* *"Where a leakage of fluorinated greenhouse gases is detected, the Licensee must ensure that the equipment is repaired without undue delay.* *"…all equipment to be utilised in the Works that contains fluorinated greenhouse gases in quantities of 5 tonnes of CO2 or more and not contained in foams* [must be] *checked for leaks in accordance with the Regulations. Records of leak checks must be kept in accordance with the Regulations. These records must be submitted to the Licensing Authority annually, and immediately in the event of discovery of any leak.* *"Where the equipment is subject to leak checks under the Regulations, and a leak in the equipment has been repaired, the Licensee must ensure that the equipment is checked by a certified person within one calendar*

			month after the repair to verify that the repair has been effective. In such event, the Licensing Authority must be informed of the date of discovery, date of repair and date of inspection."
	Cement, grouting, and or slurry	16	*"The Licence Holder must make every effort to recover any bags of grout that may be lost overboard.* *"The undertaker must ensure that no waste concrete slurry or wash water from concrete or cement works are discharged into the marine environment. Concrete and cement mixing and washing areas should be contained to prevent run off entering the water through the freeing ports."*
Disposal of non-chemicals		33	*The licensee shall ensure that only the substances or articles described in part 1 of the schedule shall be deposited under the authority of the licence and that any debris or waste materials arising during the course of the works are removed from the site of the works for a disposal at an approved location above the tidal level of Mean High-Water Springs.*
Loss/Spill		29	*"The Licence Holder must submit a Marine Pollution Contingency Plan (MPCP) for the approval of the Licensing Authority at least four months prior to… construction works. The MPCP must outline procedures to be implemented in the event of spills and collision incidents (including oil, chemical and grout spills) during construction and operation… The MPCP must take into account existing plans for all operations, including offshore installations that may have an influence on the MPCP. Practices used to refuel vessels at sea must be detailed in the MPCP and must conform to industry standards. Construction must not commence until the Licensing Authority has given its written acceptance of the MPCP."*
Health and Safety Executive related		31	*"The Licence Holder must ensure that any protective coatings and paints used are suitable for use in the marine environment and, where necessary, are approved by the Health and Safety Executive. Such coatings should be utilised in accordance with best environmental practice."*
Scour		12	*"The undertaker must ensure that any rock material used in the construction of the authorised scheme is from a recognised source, free from contaminants and containing minimal fines."*
Storage handling or transport		42	*"The Licence Holder must ensure that storage, handling and transport of fuels, lubricants, chemicals during*

		construction on vessels and equipment will prevent releases to the marine environment, i.e., bunding must be 10% greater than the total volume of all reservoirs, containers of such substances."
Specify use from definitive list ranked chemicals	87	*"All chemicals utilised in the drilling operation must be selected from the List of Notified Chemicals assessed for use by the offshore oil and gas industry under the Offshore Chemicals Regulations 2002 (this list can be viewed/downloaded at www.cefas.co.uk). Should any system other than water-based mud be considered for use in the drilling operation written approval and guidance of disposal of any arisings will be required from the Licensing Authority.* *"The Licence Holder must ensure that any chemical agents placed within the void of a foundation, e.g., biocides, corrosion inhibitors etc. are selected from the List of Notified Chemicals (see Supplementary Condition 9.34). The use of any chemical not contained on this list will require prior consent from the Licensing Authority following a comparable ecotoxicological hazard/risk assessment undertaken at the Licence Holders own expense."*

Conditions referencing "**audits, registers, or lists**" were split into three or more licence conditions surrounding dropped objects. They were initially included in the extraction due to reference of waste or arisings which may have been relevant for chemicals and drilling. Having reviewed these, no further assessment was made of the conditions as they were confirmed as pertinent to transportation and shipping of objects and ultimately screened out.

"**Chemical specific**" licence conditions pertained either to:

- "**cement grout and slurry**" (n = 16), to ensure that foundations are connected using appropriate products. Cement grout connects the foundation or base to the transition piece. The use of this product can lead to waste concrete slurry or wash water which could enter the marine environment.
- "**fluorinated compounds**" (n = 4), to minimise the emissions of internationally restricted compounds such as perfluorocarbons and fluorinated greenhouse gases found in aerosols and other products (listed in Annex I of Regulation No 517/2014 of the European Parliament and of the Council of 16 April 2014 on Fluorinated Greenhouse Gases ("F-Gas Regulation")), and.
- "**drilling muds**" (n = 17), included seven that were to ensure that any such muds would be sufficiently inert or used in zero-discharge systems.

All of these conditions also included reference to the discharging of named chemicals, to ensure appropriate control and mitigation.

Of the 32 licence conditions pertaining to the "**disposal of non-chemicals**", the majority were for ensuring disposal returns for the areas of the OWFs designated as disposal for mechanically moved material e.g., seabed levelling and sandwave clearance. The licences were selected as they contained reference to arisings and water-based muds combined with deposits. These conditions were all reviewed before a selection were dismissed as having no further relevance for consideration within the report.

The licence holders were tasked in 33 conditions to have regard for all protective coatings and treatments such that only those suitable for use in the marine environment were used, and where necessary approved by the "**Health and Safety Executive**". In some conditions there was additional wording for the chemicals to be utilised in accordance with best environmental practice.

Only 29 conditions were found to contain requirements regarding "**loss or spill**" of oil, fuel and chemicals and these covered the production of marine pollution contingency or response plans for spills and collisions. They were all retrieved due to the wording containing reference to oil, fuel and chemical. Some contained dual reference to specific chemicals like that for Race Bank, Gwynt y Mor and Gunfleet Sands II OWF (see Annex 3) which include cements and grout conditions with the conditions for reporting spills.

For the 12 licences referring to "**scour protection**" these ranged from ensuring that the rock material was from a recognised source and free from contaminants to notification of misplaced or lost and seeking approval prior to dumping. Following review of the conditions these were scoped out of the assessment.

The majority of the OWF licences include a condition for "**storage handling or transport**", with 42 licence holders tasked with ensuring that accidental release does not occur during these activities. The condition covers the potential loss of chemicals including those used within closed systems like transformer fuels and lubricants. It also is a requirement under the OSPAR OWF guidance to ensure that adequate bunding for operations are in place and specifies that "*bunding must be 10% greater than the total volume of all reservoirs, containers of such substances."* "*" denotes that the use must be for drilling or construction.

Some conditions that specifically referred to using "**chemicals selected from the 'definitive ranked list of registered chemicals'**" required written approval for use of chemicals, one for chemicals used in the drilling operation and the other for chemicals to be used within the void of the monopile (e.g., biocides, corrosion inhibitors). Written approval by the regulator was required in 56 licence conditions if the chemicals to be used were not on the ranked list of registered chemicals that prior written approval of the regulator is required (table 3).

Table 3. The number of licence conditions which stipulated a requirement to use chemicals from the ranked list and/or to notify a regulator for the use of a chemical. "*" denotes that the use must be for drilling or construction.

ID	Part of licence condition	Number
i	Drilling mud- if non-water-based mud is needed notify regulator	33
ii	Must be on list or seek approval from the regulator	56
iii	Specified for use inside monopile void	32
iv	Must be on ranked list but doesn't give contingency if not on list	12
v	Request approval even if chemical is on ranked list	0
vi	Mentions Fluorinated chemicals	3
vii	Specifies Paints and coatings	1
viii	Chemical must be on ranked list or has ecotoxicological test, but does not specify seeking approval	4
ix	List of all chemicals used is required	3
x	All chemicals used need approval	10
xi	Specific requirement of notification of chemicals if used in open systems	2
xii	Specified for use during a specific phase*	24
xiii	Combination of ii and iii	14
ix	Combination of i and ii	12

The licence condition appearing the most (n = 56) specified that the chemicals used must be on the list of ranked registered chemicals or approval would be needed from the regulator. Another 33 conditions stated that if the drilling mud was not water-based that the approval would be required from the regulator, and another 24 conditions were pertaining to the drilling or construction. Some licences included two or more of these conditions.

Twelve conditions suggested that chemicals must be selected from the list of notified chemicals, but no contingency is offered for chemicals not on the list and further information is not required to be provided to the regulator. Four licence conditions required that if chemicals were not on the ranked list that further ecological assessments will be required at the cost of the developer but no further information on what was necessary is provided.

One licence stipulates that written approval from the licensing authority is required for chemicals used in construction, operation and maintenance that are in an "open system". If the chemicals are on the ranked list produced through the Offshore Chemical Notification Scheme (OCNS) the chemical name volume or quantity to be used together with the OCNS grouping or rank and frequency of use is required. If the proposed chemical is not on the OCNS list, then details must include the safety data sheet depth and current at the site quantities or volumes and prosed frequency of use. Those chemicals in a closed system also need to be notified (Moray OWF 2019).

Three licences asked for a list of all chemicals and 10 licences specified that all chemicals used should be approved by the regulator prior to their use by a developer/contractor.

3.2. Specific chemical advice

Advice and notifications

Search of Cefas internal records via HPE CM and the MMO Public Register for England produced 32 individual responses with regard to chemicals used, and two for Scotland. (See Annex 2 Table C). No advisory responses were identified for OWFs in Wales.

The main chemicals for which advice was provided were corrosion inhibitors, leak detection dyes, bactericides, rust and paint remover, lubricants, grout, grease and rigwash/degreasers. For some OWFs the chemical risk assessments provided were fully comprehensive, disclosing all chemicals used including those on vessels and within systems that are discharged to grey water.

Predominantly, the chemicals listed by the developer as part of their chemical risk assessments do not require further notification as they are used within "closed systems" and have no intention of being discharged and if not used up (e.g., burnt fuel) they are collected and shipped back to shore. For chemicals like the firefighting foams (AFFF), these are discharged via hazardous waste drains. This is the same for some hydraulic fluids or fluids that are used in machinery like the antifreeze or suppressants.

For most of the other chemicals that were listed (other than cement/grout) volumes used are relatively small like the use of chemicals from aerosols (e.g., 40ml of WD-40 per turbine) and threading grease on washers and bolts. This is in comparison to the weights of chemicals like drilling compounds (15-25 metric tonnes (T) per drill) and grout/cementing compounds (70 T per foundation for an OSP). Of these, few were on the list of ranked registered chemicals and were not reported with quality supporting documents regarding the environmental properties, to be able to conduct appropriate site risk assessment in the first instance. The main supporting chemical documentation was the product leaflet information and the Material Safety Data Sheet (MSDS).

Grout and cementing

Notification on one occasion was for comment on the accidental loss overboard of bags of grout. On another occasion a developer had to inform the regulator of grout failure, this is where the compound had been lost from the annulus during curing.

Tracer dye

Sometimes dye is used to be able to detect when the cement is at the correct level but only two examples of advice for dye used simultaneously was found (see Annex 2 Table C). Tracer dye is also used to detect how leak proof a structure is. The inside of a monopile can be dosed with dye to detect structural failures along with bactericides to help prevent fouling and corrosion. Tracer dyes by nature usually carry product warnings due to the nature of the chemicals they are made of.

3.3. Chemical use

Number of chemicals

To be able to assess the quantity of chemicals used, firstly the range of chemicals used was reviewed from CRA data available on the MMO public register. These data were synthesised to capture the types and quantities of chemicals used for construction including the foundation installation and the joining of the transition piece, assembly and installation of the turbine. For construction, these works included the generation assets, i.e., turbines, and transmission assets, i.e., cables and the offshore substation, as well as the completion of the export assets which included the cable laying and landfall of the cables. The same was then done for the chemicals used during the operation and maintenance.

Towards the end of the scale of the number of chemicals listed for use, over 300 chemicals were identified for use on one OWF during construction and operation and maintenance activities. Most chemicals observed in the CRA lists were specified by the developers as exempt under OCR/OSPAR or Bonn Agreements with no further information provided. This was because they were considered either for use on the vessel (different regulations apply to these chemicals) or being used in a closed system. Under the OCR paints and coatings are exempted from notification.

From the anonymised synthesized example approximately 3 % of the chemicals (9 of 333) listed were thought to require further approvals for use from the national regulator (e.g., potential for discharge to the marine environment).

Most of the chemicals used were for the construction of the offshore substation platform. On occasion it was observed that there was reference to construction of turbine on vessel and minor ambiguity as to whether the chemicals were for use in construction carried out on the vessel or for use of the vessel.

Quantities of chemicals used for an OWF

The individual chemical data quantities from the anonymised CRA were scaled up to be representative of an average wind farm (50 monopiles and one Offshore Substation Platform). The resulting list comprised of over 300 chemicals which were then grouped using expert judgment into broad types of chemicals, for various stages of the works. The volume of chemicals used was calculated to be 709,000 L per wind farm (Table 4).

Table 4. Example of numbers of chemicals used on an OWF (not including base of monopiles) using anonymised data and average of 50 turbine construction. . (Transition piece (TP), Offshore substation platform (OSP).

Infrastructure/OWF Component	Chemical	PHASE	Volume per Wind farm (Litres)
Foundation (construction)	Cement/grout	TP Installation	3,000
	Adhesive/sealant	TP Installation	50
	Grease	TP Installation	1
	Lubricant	TP Installation	2
	Grease	Commissioning	4
	Lubricant	Commissioning	50
Foundation (operation and maintenance)	Marine grease	Repair and clean	5
	Paint	Repair and clean	14
	Rig wash /Degrease	Repair and clean	150
	Thinners	Repair and clean	500
Substation platform (1 platform)	Adhesive	OSP construction	24
	Anti-scale cleaner	OSP construction	36
	Anti-seize	OSP construction	11
	Cleaning	OSP construction	343
	Coatings	OSP construction	544
	Corrosion inhibitor	OSP construction	28
	Disinfectant	OSP construction	5
	Fuel	OSP construction	7
	Firefighting foams	OSP construction	30
	Dyes	OSP construction	11
	Grease	OSP construction	125
	Lubricant	OSP construction	149
	Hydraulic Oil	OSP construction	1,009
	Paint	OSP construction	308
	Miscellaneous	OSP construction	590
	Refrigerant	OSP construction	112
	Grout/cementing	OSP construction	70,000
	Rig wash/degreaser	OSP construction	32
	Sealant	OSP construction	52
	Transformer oil	OSP construction	48,588
	Refrigerant gas	OSP construction	214
Export Array	Insulator	Cables	10,000
Turbine (construction)	Adhesive	Turbines	60
	Cleaner	Turbines	145
	Coatings	Turbines	765

	Cooling system	Turbines	33,000
	Corrosion inhibitor	Turbines	20
	Drilling fluid	Turbines	90,000
	Drilling Additive	Turbines	22
	Gear oil	Turbines	8,000
	Grease	Turbines	9,022
	Hydraulic Oil	Turbines	38,500
	Insulator gas	Turbines	240
	Lubricant	Turbines	288
	Nitrogen	Turbines	390,000
	Sealant	Turbines	13
	Paint	Turbines	38
	Sealant	Turbines	15
Turbine (operation and maintenance)	Cooling Liquid	Turbines	2,500
	Gear oil	Turbines	125
	Lubricant	Turbines	365
	Paint	Turbines	15
	Sealant	Turbines	63
	Total		**709,190**

The largest quantities of chemicals used were observed for cement grouts and drilling fluids during construction, and some, but far less, for maintenance, as well as use of transformer oil, fuel and coolants during construction and operation.

Nitrogen gas was observed to be used in large quantities. It is conventionally used for blanketing (this inert gas is added to avoid impact of oxygen, for safety, longer and or effective working of equipment) in offshore applications. There are wider uses comparatively for oil and gas extraction and a greater use in drilling injection for reservoir and wellbore pressure maintenance, and in coiled tubing operations for the oil and gas sector for nitrogen other than blanketing.

Grout and cement

Typical quantities of grout suggested for the anonymised OWF are 70 tonnes for the OSP. From information readily available typical transition piece additions for operations for 116 monopiles in 19m of water took 4,000 tonnes of material (per turbine). The works provided by Core Grouting[11] were part of the installation of the bolted flange monopile to transition piece foundation. This provided impact and corrosion protection to the foundation. During this operation corrosion inhibiting additive was added to the grout during mix with Portland Cement.

[11] Grouting of Monopiles for Transition Pieces – Case Study: 116 Piles, United Kingdom. Core Grouting Services. Available at: https://www.coregrouting.com/wp-content/uploads/2016/05/Grouting-of-Monopiles-Transition-pieces.pdf (Accessed 7th July 2021)

Other than for joining transition pieces to the pile, grout can be used structurally and to repair and strengthen structures. Grout has also been used to strengthen and prevent corrosion of conductors. As grout has to be of a certain specification to be effective the material is tested prior to use. Some operators may apply to dump the defective grout and specific conditions are provided to the number of times this can be done by operators in the oil and gas sector. Alternatively, many companies choose to return and dispose of defective loads to land. No observations of licence conditions regarding testing and return were observed from the advice found for OWFs.

Paints and coatings

Roughly 18% of chemicals used were paints and coatings. The latest technology is intended to ensure long life of the structure. The Crown Estate (2019) guidance provides a comprehensive break down, with examples, of the likely parts and components and environmental protection methods used (e.g., paint or gel coat on surface of blade to protect against erosion and UV damage).

3.4. Comparison of chemical use

There are many chemicals used for the production of oil and gas. The type of chemicals used in each phase of the activity (construction, operation, and decommissioning) were tabulated (see Annex 1 Table B). The table was used to identify chemicals for use within the construction and operation of OWF that are also used for oil and gas platforms (Figure 1).

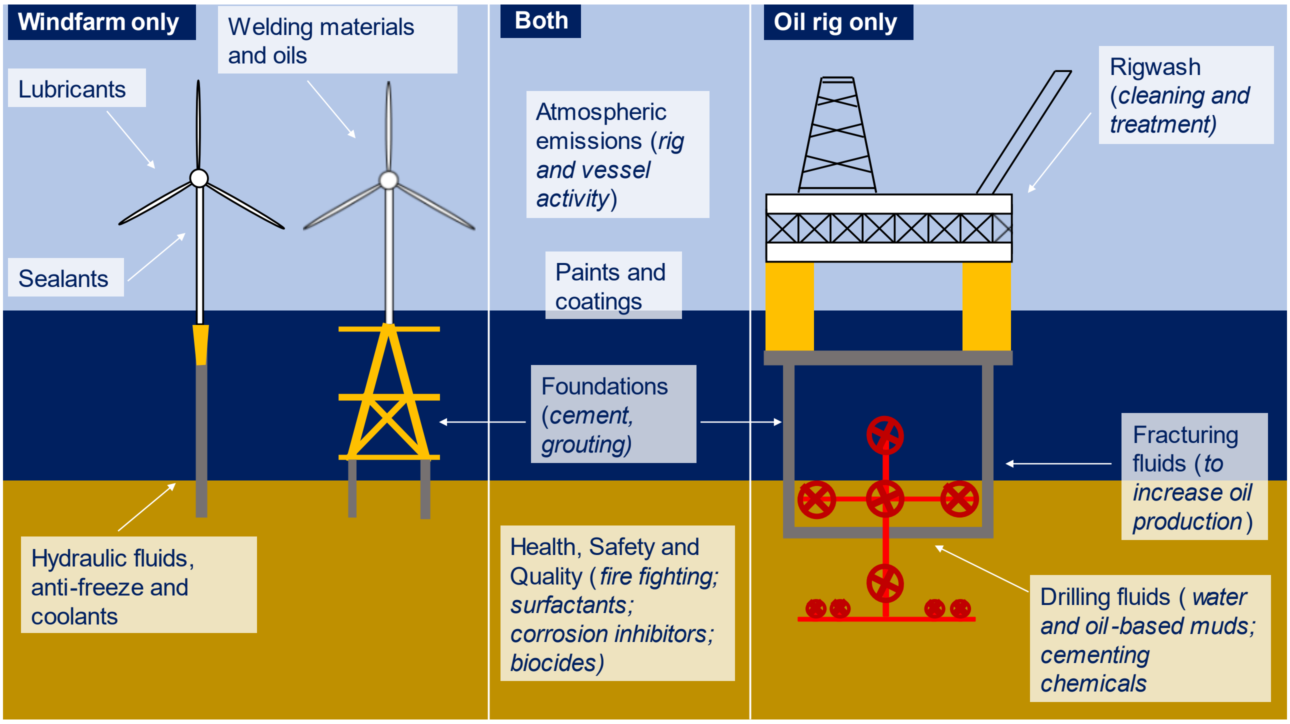

Figure 1. Indicative figure to show the types of chemicals used by oil and gas rigs (right panel) compared with select wind turbine generators (monopile and gravity-based) (left panel) with synergies and overlap (centre panel), during the construction phase.

Discharge of chemicals from OWF verses an Oil or Gas platform

Examples of release from oil and gas extraction that may be from similar activities as those that could potentially be encountered for OWF include drilling, grouting and cementing for platform and turbine constructions, crane hose failure and leaks from annulus. Rigwashes, lubricants and sealant use were similar as were most likely paints and coatings applied to legs of structures.

Within piles, the use of corrosion inhibitors and bactericides would also use similar technology. Externally the use of anodic or cathodic corrosion protection would also be similar but due to the potential for increased number of jacket legs from pin piles and the potential number of structures per wind farm, they could cumulatively be considerably larger for OWFs than for oil and gas platforms.

4. Discussion

In OSPAR 2008-3, sections 57 and 81 it is stated that all chemicals (including paints, coverings etc.) used in OWF construction need to be approved for use in the marine environment and have their ecotoxicological properties known, however there is no formal mechanism to do so. The MMO in England and Marine Scotland therefore include conditions with regard to chemicals. These licence conditions do not appear to be consistent across applications and do not always result adequate to provide enough information for assessors to make well evidenced advice and thus the regulator to make informed decisions.

4.1. Extracted conditions from development consent orders

Initially there looked to be fewer licence conditions than the authors expected for what might seem like essential conditions like for spills or for consideration of health and safety. On review this was due to how the conditions were written and the inclusion of more than one purpose for a condition. For seeking approval, there appeared to be more conditions than the authors expected. This was observed to be due to the fact that some were regarding notification of chemicals used, that were not on the ranked list of registered chemicals, and some were due to oil-based mud use. Although the need to use chemicals from the ranked list was specified in 87 conditions, there is no requirement for applicants to provide additional information on the chemical use for 31 of the conditions if they are on the list. This would accidentally exclude chemicals on the list that are discharged from needing to seek further approvals for use.

Although 10 OWFs were tasked with providing information on all chemicals used, this was not universally applied. Without this information, which includes quantity, potential dilution/release information or frequency, estimates on quantities that may be used going forward are almost impossible to accurately assess.

Although licence conditions may request that the chemicals used by the OWF are registered and ranked there are two issues of concern in this regard.

- The model used in the ranking of chemicals on the registered list is not directly relevant to an OWF application as generic oil and gas platform data is used. The processes and dilution factors used are not transferable.

- Chemicals on the ranked list still contain harmful chemicals that would require justification by the oil and gas operators before the regulator approved their use.

The list of ranked chemicals is used to derive a generic risk and not a site specific one. For the oil and gas industry when an operator wants to use a chemical, they have to submit an application for a permit. The permit application provides a list of the chemicals and how they are to be used together with the quantity of all chemicals and where appropriate (e.g., not PLONOR) a site-specific risk assessment is calculated. For each chemical used the risk is characterised. This is where a risk quotient approach is used based on the predicted effect concentration (PEC) and the predicted no effect concentration (PNEC) for different environmental compartments. When the PEC divided by the PNEC is less than one, the risk is acceptable (PEC/PNEC<1 = Acceptable risk).

The ranked list of registered chemicals also contains chemicals that may be made up of substances that attract warnings. For those chemicals with warnings (e.g., substitution) justification that this chemical cannot be exchanged for one with a more environment friendly assessment has to be supplied. Only two examples of site-specific risk assessment were found in the search of advice comments for OWF. One was for the potential risk of drilling fluid used for a horizonal directional drilling of the cable asset to the shore, and the other discharge of chemical used in a 'closed system' that drained to a sump tank which discharged with the rainwater.

The typical wording on the licence requires chemicals used to have undergone an ecological assessment or have to be agreed by the regulator e.g.,

> *'All chemicals used in the construction of the authorised development must be selected from the List of Notified Chemicals approved for use by the offshore oil and gas industry under the Offshore Chemicals Regulations 2002(a), unless otherwise agreed by the MMO.'*

The condition does not provide a mechanism to notify the regulator of the type or frequency and volume of use of the chemical, or when chemicals are on the ranked list but have hazard phrases warning of harm to the aquatic environment on their SDS (e.g., H410, H411, H412, and H413).

For the Moray OWF, the licence condition requires some detail regarding volume or frequency as well as rank or grouping, however without the persistence, bioaccumulation or toxicity (PBT) data, adequate hazard and risk assessment (if the chemical is used in an open system) is not possible. Whilst it is good to have the material safety data sheet (MSDS) this does not provide all the information that would be required for an accurate site-specific risk assessment. Some recent MSDSs do contain relevant marine REACH scenario information that would be of use, but these are currently limited.

Walney OWF had a condition (stipulated on the licence in 2014) that required disclosure of paints and coatings however, this was limited to the construction phase of the works.

> *'All protective coatings and paints must be suitable for use in the marine environment.*

> *Details of such coatings and paints and how they will be used must be submitted to the MMO as part of the construction method statement required under condition 11(1)(c).'*

4.2. Offshore wind farm verses Oil or Gas platform

The data used for this report should be heavily caveated in that operators data will only provide an estimate of use and discharge for offshore wind of products there are no requirements for them to supply information of what was actually used and how much, only the amount intended for use. Where products contain components that may be contaminants of concern (e.g., those OSPAR suggest are substitutable due to their persistence toxicity or potential for bioaccumulation, hazard ranking above one, or presence of chemicals on lists for priority action) operators for the oil and gas sector have to provide justification for use. The oil and gas operators then have to supply annual use and discharge returns. The returns include detailed quantities of component chemicals used and discharged in products that in some cases make up less than one percent of the formulation. In addition, the operator has to produce an annual technical justification document for substitutable chemicals highlighting the measures undertaken and progress for their replacement. There is no such requirement for the offshore renewable sector. A ‘generic’ chemical use for OWF was estimated and using real OWF product and quantities from CRAs to be used an estimate of the quantities of products used during the construction and operation activities was calculated as a best alternative at this time. This meant that where data was for each turbine this was multiplied or divided to achieve the overall use for the derived characteristics of a generic OWF (e.g., the quantity of the product per turbine used multiplied by the number of turbines in a generic wind farm of 50 turbines as stated above). Considering the increasing size and extent of wind farms being built now this is likely to be a conservative figure.

Use of the ranked list of registered chemicals

For OWF construction or maintenance, OSPAR guidance simply states that for chemicals used in the marine environment including paints and coatings, their ecotoxicological properties should be known. The majority of licence condition do require chemicals used to be on the list of ranked chemicals, and although only those chemicals with a pathway to the marine environment need to be from the list, most notified chemicals were not seen to have been on the list. Most chemicals in the CRAs described under the regulations are exempt as they are used in closed systems, this leaves the paints and coatings that are also included by developers as exempt.

Drilling muds

Water-based muds used for OWF do not need to be notified as a result of many licence conditions. Only where organic (synthetic)/ oil muds are used do conditions require approval, however even components in water-based fluids may contain substances that can form surface slicks. For the oil and gas industry the chemicals would still require a site-specific risk assessment as part of the permitting process. Not only do these drilling muds have to appear on the ranked list but they usually have to remain listed for the duration of the operations or to be added to updates. Chemical registrations expire after 3 years, the suppliers of the chemicals have to ensure that they are re-assessed in line with current regulatory requirements. When the operators wish to use the chemicals, they have to submit them in a permit with a site-specific risk assessment. Without a formal legislative framework, there is no such similar process for MRE, indicating that the risk assessment process is more comprehensive for oil and gas extraction than for OWFs.

For cements and muds not in closed systems they often are stated to have no discharge and likely shipped to shore. Other than WBM chemicals discharged from OWF are likely to be small quantities used from small containers by brush or sprayed e.g. (lubricants like WD-40). There is no data for release or spills from OWF.

By comparison details regarding chemicals for use and discharge from the oil and gas sector are more transparent. Tonnages discharged using the random oil and gas return statement suggested 1834.15 tonnes of chemicals were used, and 165 tonnes were discharged. The report indicated that the most chemicals used and discharged were PLONOR with only 2% (15 chemicals) of use of chemicals that were candidates for substitution. The report suggested that 14 tonnes of chemicals were spilled (2019). Whilst it is likely to be considerably more than a generic OWF annually there are no returns or detailed product information to be able to make an adequate comparison.

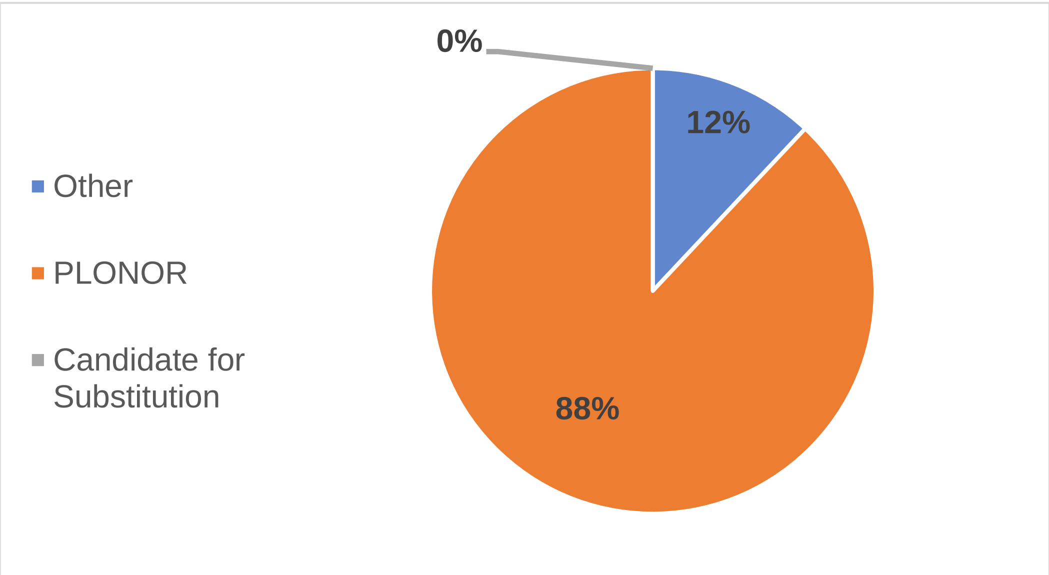

Figure 2. Chemical usage by category (2019) for random oil gas return statement

There is no requirement for OWF operators to make annual use and discharge assessments.

WBMs are routinely discharged, however in the oil and gas sector this is risk assessed and the chemicals justified where substitution warnings have been applied under the UK national plan. Muds used in the uppermost section (first 3-5m sometimes called spud muds) may only contain PLONOR listed substances, this would be what we would expect for shallow

OWF foundations. Oil well sections requiring risers to reduce fluids loss to the environment and allow the fluids used to be recycled, can include substitutable chemicals and these would be likely discharged with cuttings and at the end of the drilling process due to either best available technique not exceeding costs (BATNEEC) or best possible environmental option (BPEO) because of the distance of the proposed wells from coastlines and ports accepting waste for treatment and the costs, in terms of CO2 emissions of transport and additional chemical use for treatment onshore which would ultimately see the chemicals discharge once again to sea.

Oil Phase Fluid (OPF) /Oil Based Muds (OBSs) are not routinely discharged however during completion processes it is expected that some OBM/OPF will be entrained in the completion fluids, however there are limits on oil in water content that is permitted via an Oil Pollution Emergency Plan (OPEP) permit (issued by BEIS rather than assessed by Cefas). The maximum oil in water content is typically 200mg/L and for only small discharge volumes, these must be fully justified and measured by the operator throughout any disposal process.

As stated above some chemicals can be used in both types of mud or not specified by the supplier and, depending on the other chemicals present can have characteristics that would cause surface slicks, or have other detrimental effects not indicated on the ranked listing alone.

Cement and Grout

Cement and grout are comprised sometimes of similar chemicals. Where cement might be used to fill voids or spaces, grouting is likened to mortar to join pieces together like sealing the transition tube to the turbine’s foundation.

Other chemicals that appeared to be treated differently in the two sectors were cement and grout. As well as joining transition pieces to the pile, grout can be used structurally and to repair and strengthen structures. Grout has also been used to strengthen and prevent corrosion of conductors. Grout/cement is usually made at the time of use and has to be tested to ensure it be fit for purpose within technical parameters. Some oil and gas operators may apply to regulators to discharge defective cement, and specific conditions are attached as to the amount (depending on the volume of the mix pit, or the minimum volume of an ‘on the fly’ mix) that can be used for this purpose and is called an aborted job. Cement trials may be permitted using the PLONOR elements and not the full cement type to ensure that the cement mixing system is operating correctly. Cement mixture requirements are tested onshore for the oil and gas sector with specific formulations calculated for specific conditions, such as high temperature and pressure or formation stability, the aborted discharge would only arise if a mistake was made regarding which chemical is added and the amount for example instructions were not followed or the wrong chemical added. There were no observations of licence conditions regarding testing and potential disposal or return to shore observed from the advice found for OWF. Only one licence condition was focused on grout and that specified any lost bags of grout should be retrieved.

Other chemicals on the ranked list

In addition to the construction phase for the oil and gas sector there are chemicals used for completion (on the ranked list) that may be discharged to sea but would not be used for the oil and gas sector. Similarly fracturing wellbore clean up chemicals may also be used (that would not be required for OWF) before the well goes online and then chemicals assessed going forward as part of the operations permits. Chemicals used during the production phase for oil and gas such as scale, wax, asphaltene and hydrate inhibitors and flow improvers and production corrosion inhibitors, biocides and injection and stimulation chemicals may also be listed but their use may not be appropriate for use in other sectors, or for different scenarios in hydrocarbon production.

4.3. Notification of chemicals used in closed systems.

For the oil and gas industry, the intention of OSPAR Decision 2000/2 is to permit the use and discharge of offshore chemicals. This applies to chemicals which are used in the actual exploration, exploitation and associated offshore processing of oil, gas and condensate within the OSPAR Convention area. Some chemicals are exempt from this provision, for example chemicals used on vessels or from wastewater as these are covered by other regulations. Some chemicals considered to be used within ‘closed’ systems like lubricants on gears may also be exempted from this provision.

Closed systems are considered to be such that the chemicals used do not require periodic top up with no loses to the marine environment. Chemicals used on platforms within ‘closed’ systems that do not require top up, are exempt from notification under the Harmonised Mandatory Control Scheme (HMCS) and thus from requiring assessment under OSPARs Harmonised Offshore chemical Notification Scheme (HOCNF) as specified in the OCR Regulations (2002).

Lubricants

As the losses of lubricants that occur during the operation of production-related equipment or machinery in the oil and gas sector are considered small, they are not covered by the chemical permitting system, and the lubricants do not require to be notified and included in the approved chemical lists. This means that valve lubricants, wire-line lubricants etc, are excluded from requiring to be notified.

As the OCR regulations and the OSPAR Decision 2002 applies solely to the Oil and Gas sector there is no equivalent requirement or exemption for the Offshore Wind industry. In the offshore wind industry applicants are requested to determine if chemicals need to be notified. This is specified as having a pathway to the marine environment. For chemicals used in ‘closed’ systems this could lead to applicants suggesting that as the chemical is to be used in a closed system that it does not need to be notified without consideration of needing top up. This lack of equivalency leaves discrepancy between the disclosure of all chemicals on some OWF licence conditions and requirements for the oil and gas sector. The Marine Management Organisation try to capture these chemicals by asking for potential mechanisms for closed chemicals to reach the marine environment (e.g., where does the chemical go if the system requires top up) since the interpretation of 'closed' is not always transparent in the chemical risk assessments provided.

Hydraulic fluids

Hydraulic fluids which are only discharged in an emergency are not covered by the chemical permitting system. Thus, fluids that are used in down-hole safety valves on platform development wells etc. are also excluded. Neither are the fluids used in "Xmas Trees"[12], and Blow-Out Preventers (BOP) on platform development wells, which are also excluded.

Hydraulic fluids that are used in control devices that are routinely activated, resulting in a discharge to the environment, are covered by the chemical permitting system, and the chemicals must be notified and included in the approved chemical lists. Thus, fluids used in the well control devices that are normally operated by Mobile Offshore Drilling Units (MODU) must be approved and included in chemical permit applications. At the meeting of the OSPAR Offshore Industry Committee (OIC) in Cadiz in February 2002, it was confirmed that the Harmonised Mandatory Control Scheme (HMCS) applied to all hydraulic fluids used to control wellheads, blow-out preventers and subsea valves. All hydraulic fluids used in these systems must therefore be notified and included in chemical lists for approval. However, as the chemicals are not directly released into the water column but contained within enclosed systems, with only the potential for small losses from operation of machinery or equipment they fall under the exemption clause and can be used in the marine environment. Currently hydraulic fluids are listed on CRAs, and no further information provided when used in closed systems. Greasers and lubricants used for construction of the OWF nacelle can include use on washers and threads these uses also can be considered very small.

4.4. Gaps and opportunities

4.4.1 Licensing

The review of OWF licence conditions indicate that there is some variation and a lack of consistency in approach likely due to improvement of wording over time. Licence conditions may state that chemicals should be from the list of ranked chemicals, but then further information on their environmental properties or impact are not required. Whilst paints and coatings are noted on CRAs, they are generally referred to as exempt from OCR or Bonn

[12] A type of well used in oil and gas extraction defined as such due to the number of valves and fittings present (see Figure 1 for a graphical interpretation)

agreement. To be considerate of OSPAR guidance, the ecotoxicological properties of these chemicals need to be declared. However, at present there is no mechanism (outside of MCAA) for this within OWF applications.

Monopiles can corrode from the inside or the outside and require either sacrificial anodes or cathodic corrosion inhibitors to prevent structural failure (Kirchgeorg *et al.* 2018). Coatings can offset some of this and some jackets are now coated in plastics. Whilst initially it was thought that monopiles would be airtight and corrosion inside would be minimal, this is now found not to be the case, and corrosion control systems can require replacement of water internally to prevent build-up of noxious chemicals. Little detailed information (usually other than that found in the ES or supporting documents) for either the Oil and Gas industry or the OWF sector, regarding anodic or cathodic use was found.

Whilst there are new and emerging technologies that use paints and coatings for structural protection instead of heavy metals, these replacements are plastic based, and the long-term implications are not fully understood. Currently the majority of the offshore wind turbines are not coated in the submerged zone.

There are a number of metals released from sacrificial anodes into the marine environment as a result of their function for corrosion prevention. Predominantly comprised of aluminium they also often contain large quantities of zinc and other metals including lead gallium and indium. This has raised environmental concerns in the marine environment (Bell *et al.*, 2020: Caplat *et al.*, 2020: Kirchgeorg *et al.*, 2018: Reese *et al.*, 2020). Little information in the UK of the type and quantity of heavy metals in the marine environment as a result of the use of sacrificial anodes from these sectors are available, as the numbers used and replaced are not collected by regulators.

Few chemicals were seen to have a potential discharge pathway to the marine environment and, but little site-specific risk assessment for those chemicals were observed. Whilst many were used in small quantities some had the potential to contain chemicals that under the HMCS and HOCNF scheme, would require justification for use. Chemicals ranked for the oil and gas industry are modelled using the chemical hazard and risk model (CHARM) (Thatcher et al, 2005), later adapted to model pipeline discharges (Osborne and Adams 2005). The CHARM model uses generic platform parameters for the process in which the chemical is to be used (cementing, production, drilling etc.). The generic properties include a standard volume of water in a cylinder around the rig or platform (e.g., 40m of water in a cylinder). The model is not appropriate for use with ranking of chemicals for OWF.

There are no licence conditions for OWFs which encourage reduction of pollution similar to the requirements for the oil and gas annual returns data for OSPAR.

4.4.2 Corrosion protection

In Reese *et al.* (2020) the isotope ratios of heavy metals for use of individual tracer emission particularly Gallium and Indium are suggested as tracers due to the quantity used in aluminium-based anode corrosion prevention equipment (sacrificial anodes) compared to the low environmental background concentrations and the absence of other sources in the marine environment. Quantities of these corrosion protection measures are not notified and recorded for OWFs and comparison of use cannot be made, however, large quantities of heavy metals may have potential impact when consideration of the number of structures and future OWFs are considered.

Coatings with anti-fouling agents are not normally used for offshore wind turbines. There are new technologies like self-healing coatings or nano-coatings, but due to the harsh environmental conditions they are not applied offshore. Even aluminium based anodes can contain up to 26 different elements. Research has shown that there is potential impact in the marine environment from corrosion protection on the foundation of a single ‘monopile’, i.e., a foundation from a single steel pile, more than 80 kg of inorganic material are released into the marine environment every year. For other foundation structures, such ‘tripods’, the quantities emitted are even larger (Kirchgeorg *et al.*, 2018; Reese *et al.*, 2020). The cumulative impacts of future OWF construction using jacket foundations and sacrificial anodes have not been fully considered.

4.4.3 Oil and Gas similarities and Decommissioning

BEIS policy for decommissioning of offshore renewable energy is to; “*seek decommissioning solutions which are consistent with relevant international obligations, as well as UK legislation, and which have a proper regard for safety, the environment, other legitimate uses of the sea and economic considerations including protection of the taxpayer from liabilities relating to decommissioning. The Government will act in line with the principles of sustainable development*”.

The UK has obligations also in this regard to UNCLOS (1982) which requires abandoned or disused structures or installations to be removed. This is to ensure the safety of navigation and is adopted into regulation here by the IMO standards (1989). The IMO go further in suggesting that the infrastructure placed in the marine environment should be design with full removal in mind with full removal as the default.

To prevent duplication of effort on behalf of the operators BEIS and the Crown Estate only require one decommissioning programme to be prepared which is submitted to BEIS.

The annual tonnage used for a randomly selected oil and gas operator in 2019 was seen to be in the region of 1834.15 tonnes of chemicals, of which 165 tonnes were discharged by 12 assets. This equates to approximately 153 tonnes of chemicals used, and 14 tonnes discharged per asset during operation. By comparison the generic 50 monopile turbine offshore wind farm was observed to use an estimated 709 tonnes of chemicals for construction and likely much fewer during operation and maintenance, maybe only 3 tonnes (operation and repair quantities from Table 4).

Consideration at decommissioning from the oil and gas sector indicate that where piles are not ventilated hydrogen generation may risk explosions. Furthermore, the sediment and water inside the piles will be enriched with aluminium and zinc and other trace metals released from the galvanic anodes over a notional 25-year lifetime. The introduction of a high amount of low pH and highly metal-enriched water should be avoided, as it may have a negative impact on the marine environment. (Grabe, 2017; Topham and McMillan, 2017).

Decommissioning offshore wind farms

Topham and MacMillan (2017) describe the process' required and potential issues for decommissioning of an OWF. For offshore wind, repowering is also considered as a type of decommissioning. Repowering may consist of a partial refurbishment or full repowering where turbines are replaced with larger units that may require heavier or better foundations. For the purposes of this report, the scope is only to consider the chemicals used.

It is anticipated that piled foundations (monopiles or jackets) will be cut just below the seabed level; and then the foundation removed as a single lift including the transition piece. Gravity base foundations will be lifted out or floated to shore after de-ballasting. Suction bucket foundations would be entirely removed using overpressure to release them from the seabed in the reverse of their construction. Offshore substations would pose similar issues and process as that of a small oil platform.

The process and methodology for removal of the structures including mechanical gearing and removal of substructure will undoubtably use the same best available technology and best practices at the time of their removal. All chemicals like those within gears and such as motor oils would be either collected and removed or left with the nacelle to minimise spillage and acquired on shore.

OWFs also have to consider the decommissioning of their cables and the benefits of leaving them in situ with the mattressing and scour protection used or removal. The mattress and scour protection placed may be in are unlikely to be able to be retrieved safely, and from an ecology point of view preference might be to leave much of the cables situ until adequate technology is available. Due to the initial estimated lifetimes of 25-30 years, few OWFs similar to the oil and gas sector few have come to this point so far. Most of these OWFs are inshore and not in deep water. The oil and gas sector have over 30 years of experience which is transferable to many of the issues faced by the OWF sector.

WindEurope estimates offshore turbines will grow from approximately 1,300 offshore turbines (20GW) today to 20,000 in 2050 (300GW). The number of bases that will contain additional chemicals which can include chemicals of concern like biocides and corrosion inhibitors is currently not known. By 2035 it is estimated that 2 GW will be decommissioned each year, representing 500 turbines (Smith and Lamont 2017). Where the superstructure is removed the infrastructure must be cut 3 meters below the seabed surface such that no protruding elements remain that could cause snagging during seabed activities such as trawling. Pipelines can remain in situ if they are cleaned, flushed and remain buried with any ends buried.

Decommissioning of oil and gas platforms

There are many examples (>150 in the North Sea) of decommissioning structures however, in the North-East Atlantic region so far only seven concrete structures have been decommissioned. Two in shallow waters and five others granted derogation to leave them in place after removal of the topside. The difficulties largely surround the weight of the base its potentially buoyancy and instability thus the safety of lifting them.

For gravity base structures configured with oil storage cess withing the structure on the seabed in addition to oil these large cellular structures also contain ballast for stability and integrity. Accessing individual cells within these structures will be a complex task including removal of any chemicals. For jacket piles cutting and dredging is required. Offshore dredge operations particularly in deep water involve hard clay and the use of remotely operated tools. This work has the potential to disturb cutting piles that may have oil-based muds and so sampling and monitoring and detailed assessment is made on individual case by case basis.

Whilst there will be similar issues with offshore wind turbines due to the more recent drilling activity, less focus would be on the spread of oil in mud from this activity, as water-based muds are predominantly used. However, disturbance at decommissioning (e.g., excavating to allow cutting of pile) of the seabed of a platform whose footings may comprise of eight legs with four or more deep piles, might cause less disturbance than a 50-turbine offshore windfarm where pin piles are used. Therefore, this would require further consideration at that time and the sensitivity of any receptors present.

For the random oil and gas platform report it was noted that a total of 745.13 tonnes of chemicals were used for decommissioning operations during 2019. Of this 61.60 tonnes were discharged to sea (8.2%). There is no equivalent data for chemicals used for decommissioning offshore wind farms.

There was little evidence of chemical use for the decommissioning of MRE other than Environmental Statements. Published decommissioning plans as requirements of the DCOs were not considered to contain adequate information with regard to chemicals. For example, Dudgeon Offshore Windfarm Decommissioning plan prepared by Statoil in section 5.1.1, mentions “fluids to be cleared away before removal” and that “oil/resin filled transformers are sealed and removed separately and taken to shore complete, reducing the potential for offshore spillage risk and facilitating safe dismantling” (Section 5.1.2.2.) but no mention of specific types of chemicals or of biocides potentially within foundations or the quantities of such are mentioned. Therefore, a comprehensive audit of these documents was not conducted for this report. Although these documents may contain additional information with regard to the decommissioning process.

Radiation

Naturally occurring radiation is a risk that has to be well considered for oil and gas decommissioning, resulting in lengthy pugging and abandonment phases, this is not an issue for the offshore windfarm sector.

4.4.4 Future use

Little information is provided other than in the Environmental Statement regarding decommissioning chemicals in the OWF sector. The decommissioning plans provided little information (see above). Chemicals used within the turbines like corrosion inhibitors, dye and bactericide may all potentially be present at the time of decommissioning. To be able to remove these chemicals confidently the chemical types and quantities will be necessary to be known to be able to undertake an appropriate assessment at that time in case they are unable to be effectively contained within the works.

Chemicals used within machinery would likely be drained and shipped to shore unless an appropriate risk assessment is carried out and the activity approved by regulators. The generic OWF comprised 50 monopiles but some OWFs consist of over 300 structures. This together with the fact that jacket legs may use considerably more chemicals and potential for disturbance, together with the knowledge that there are a larger number of wind farms yet to be built, further estimation of future use is difficult without accurate operator chemical data for current designs of structures being used.

For OWF therefore where calculations are based on 50 turbines future OWF could use and or discharge six times as many chemicals in the construction with an annual use/discharge of around 18 tonnes (3 tonnes X 6 for a 300-turbine farm), which notably less than for the 2019 oil and gas random return selected approx. 1,834 tonnes of chemicals, of which 165 tonnes).

For OWF the improvement for knowledge regarding use and discharge is needed to be able to understand the issues for the scale that is to be used going forward, for example clarity of declaration of chemicals used in “closed” systems where periodic top up is required these still need to be declared and pathways to the marine environment if they are not used up within the assessment needs to be fully risk assessed. (It was noted that where constant topping up was required there was potential for some leak into sump tanks that are discharged that need to be fully accounted for).

4.4.5 Floating Offshore Wind

As space in the offshore becomes crowded, technology is being developed to use wind devices in far greater depths to help meet the policy drivers, ambitions and targets. Going further offshore and being able to be used in 40 to 1000m, floating wind is seen as an answer. There are various designs for floating wind since its introduction in 2009 including barge, semi-submersible spar or tension leg platforms secured to the seabed (James and Costa Ros, 2015). The French Floatgen project, as an example, features a 36m wide by 9.5m high floating base and will be built from steel and reinforced concrete. With various shapes and sizes and requirements for floats and ballast, these structures are also likely to require corrosion inhibitors and bactericide. It is also likely that dyes would be used for leak testing and lubricants greasers and rigwash/degreasers used by the tower and blade structure. These types of structure can be connected to the seabed by gravity or suction anchors or steel driven piles, but they are less likely to require drilling fluids and are made and then floated into position, so are less likely to use poured concrete at sea. However, these structures may have similar issues with regard to failing grout where the monopile foundation is joined to the tower due to the high stress levels imposed on the turbine above sea level (Stavrakakis and Sayigh, 2012). A single floating wind turbine is anticipated to produce 1000 times less energy in its operating life than a single offshore oil or gas platform (Gouvernec, 2020) and so to be able to produce sufficient energy a larger number will be required going forward.

Trends

Gas production and oil and gas extraction currently remains less costly than electricity production (figure 2) and the reliance on oil and gas production remain high.

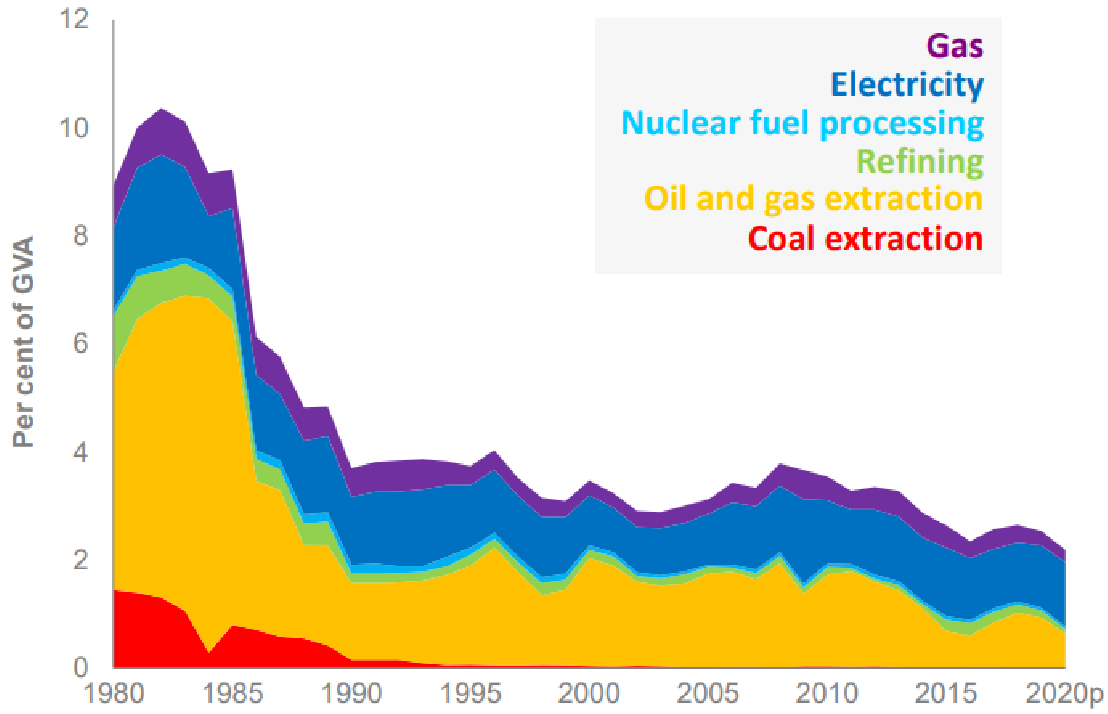

Figure 3. Taken from Office of National Statistics; UK Energy in Brief 2021 by BEIS. Contribution to Gross Value Added (GVA) by the energy industries 1980-2020

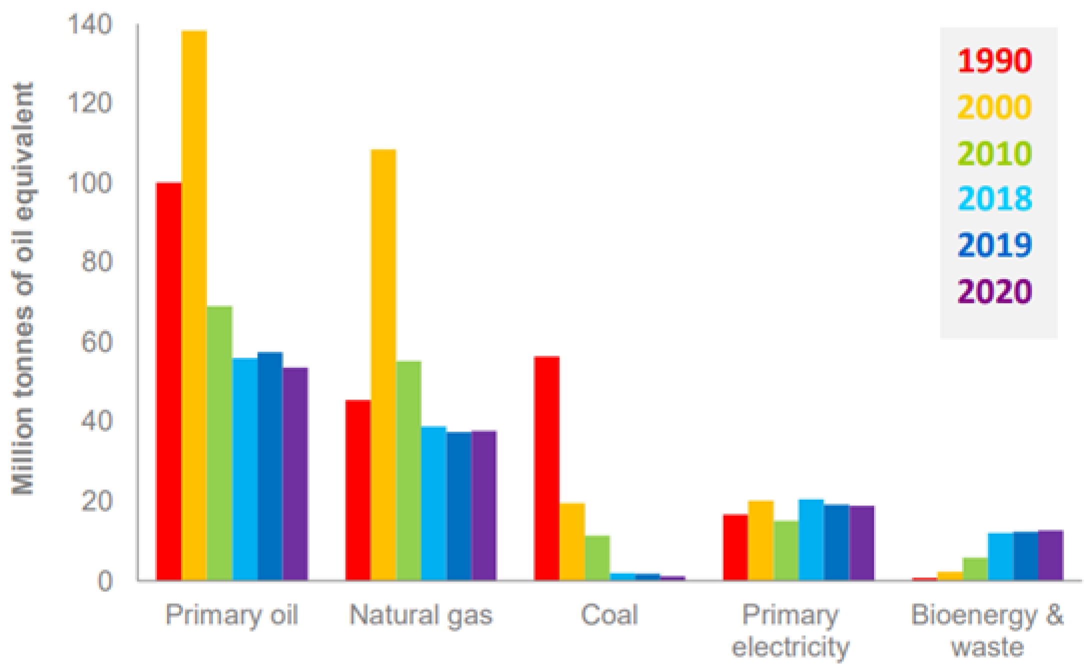

Figure 4. Taken from Office of National Statistics; UK Energy in Brief 2021 by BEIS. Primary production of fuels 1990-2020

Growth in renewable sources (bioenergy & waste, wind, solar & hydro) is seen to be increasing (figure 3) but not at the levels produced by the oil and gas sector. Outputs and emissions therefore will be comparatively higher.

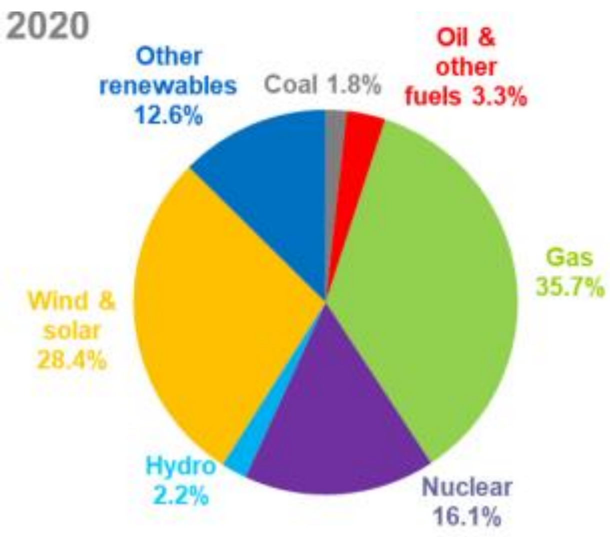

Figure 5. Taken from Office of National Statistics; UK Energy in Brief 2021 by BEIS. Electricity generated by fuel type

With wind and solar accounting for 28.4% and the size of OWF increasing to greater than 6 times the average this could outstrip that generated by oil and gas combined. Currently around 27% of our renewable energy source is from wind and marine provisions with 61% from bioenergy and solar and thermal and geothermal making up 5% and heat pumps the remaining 4%. This is a total of approximately 24 million tonnes of oil equivalent (ktoe). The random oil and gas platform selected for 2019 produced 51,400 barrels of oil equivalent per day (boepd) (2,886 tonnes).

5 Summary

There are over 5000 chemicals registered for use by the oil and gas sector. There are also hundreds of chemicals used by the OWF sector. There are some overlaps in the use and type of chemicals. Few used by OWFs however, are, or were, on the list of ranked chemicals and even fewer required to provide additional assessments for their use.

Most of the chemicals listed for use by both sectors are for use in closed systems. The difference arises in that for the OWF there is no consistent requirement from the licence conditions for notification of all the chemicals being used. With increasing numbers of OWFs being built, using generic estimated data the discharge of chemicals could be similar to some oil and gas platform assets. Without detailed information on pathways for fluids that have to be topped up and which may result in a discharge, it is not possible to predict the potential cumulative effects of chemical discharge in the marine environment.

Due to regulatory requirements to reduce pollution, the oil and gas industry annual statements provide information on the quantity of chemicals used and their potential environmental impact (e.g., substitution warnings). This is an objective under OSPAR NEAES 2030 to show how contracting parties' environmental impact is improving year on year and what they do with regard to spills and health and safety. As technology improves, rigs and platforms today are more efficient and there is opportunity for fewer chemicals that are more environmentally acceptable to be used, with publication of annual statements to support the information. It should be noted that as oil and gas installations age, volumes of produced water may increase, leading to greater use of chemicals of concern.

There are however information gaps for both the oil and gas and the OWF sectors. There is little information other than in the ES regarding how much anodic or cathodic corrosion inhibitors are being applied. Whilst new coating technology does suggest that there will be less of these sacrificial anodes type corrosion inhibitors likely to be used, and thus fundamentally fewer heavy metals entering the marine environment, little is known of the likely impacts of the new technology applied or the final fate and impacts of the sacrificial anodes in the UK due to the lack of information available, as well as that of the polymers and resulting plastic coatings being used instead.

For offshore wind a formalised process for providing information and what information is required including product components and their characteristics has led to some inconsistency with requests and assessments. Whilst the risk is considered small from the chemicals used this cannot be evidenced well.

With the move to alternative technologies in deeper water like floating wind, chemical needs may change although, there will still be chemicals used in the offshore substations, wind turbine generators, as well as the floating bases that will require hazard and risk assessment.

With the round four wind farms about to be built and the large number of structures to be installed, there is potential that the lack of detailed information available for these activities will result in poor impact assessments of chemicals and difficulty in predicting cumulative impacts. There are also questions regarding the quantity of heavy metals released from sacrificial anodes in the marine environment and how the advancements in new coating technologies will improve this. For decommissioning projects inclusion of information on likely use of chemicals to avoid legacy issues would be useful.

Without accurate environmental data for the chemicals used and discharged by OWF at the time of construction, during operation and for decommissioning, the appropriate hazard and risk assessment of the likely impacts are difficult to predict.

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7 Annex 1

Table A. Types of chemicals used in OWF construction and operation as identified from the advice retrieval.

Lubricants	Paints and coatings	Closed system chemicals	Hydraulic Fluids	Firefighting foam and other chemicals
Air compressor oils	Abrasive materials	Antifoulants	Antifreeze	Biocides
Anti-seize fluids	Adhesives	Antifreeze	Engine oils	Corrosion inhibitors
Brake fluids	Anticorrosive coatings	Battery acid	Gear oils	Fire extinguisher fluids
Engine oils	Coatings	Battery alkali	Hydraulic fluids	Firefighting foam (AFFF)
Gear oils	Curing agents	Coolants	Hydraulic oils	
Greases	Insulator agents	Corrosion inhibitors	Mineral oils	
Grinding paste	Paint strippers	Diesel biocides	Neutralisers	
Hydraulic oils	Paints	Engine water treatments	Scale removal agents	
Lube oils	Primers	Fuel stabilisers	Suppressants	
Mineral oils	Resins	Gas drying agents		
O' ring lubricants	Rust removers	Molecular sieve materials		
Pump lubricants	Sealants	Oxygen scavengers		
Releasing agents	Storage ('mothballing') treatments	Resins		
Sealants	Thinners	Sealants*		
Spindle oils				
Turbine oils				
Valve lubricants				
Wire rope lubricants				
Wireline lubricants				

**Sealants include grout and cementing compounds.*

Table B. Types of chemicals frequently used in oil and gas platforms construction (including wells installations and tie back pipelines) operation and decommissioning.

Chemicals used for Oil and gas platforms		
Construction	**Operational**	**Decommissioning**
Biocides	Asphaltene inhibitors	Biocides,
Corrosion inhibitors	Biocides	Corrosion inhibitors
Detergents	Detergents	Detergents
Drill muds	Corrosion inhibitor	Dyes
Dyes	Drill muds	Firefighting foams
Firefighting foams	Dyes	Gas migration suppressants
Gas migration suppressants	Firefighting foams	Hydraulic fluids
Hydraulic fluids	Flow improvers	Jacking greases
Jacking greases	Glycol boiler chemicals,	Lost circulation materials
Lost circulation materials	Hydrate inhibitors,	Milling fluids
Shale encapsulates	Hydraulic chemicals	Shale encapsulates
Sealants including Grout and Cement	Leak detection dyes	Surfactants/ defoamers,
Surfactants/ defoamers	Pigging chemicals	Viscosity modifiers
Rigwash	Rigwash	Weighted brines
Viscosity modifiers	Scale inhibitor	
	Water cooling system chemicals Wax inhibitors **Mature field chemicals: -**	
	Enhanced oil recovery surfactants Fracturing fluids	
	Chemical squeeze treatments	
	Defoamers	
	Flocculants	
	Formation tracer dyes	
	Proppants	

8 Annex 2

Table C. Summary of advice on chemicals provided from Cefas to the MMO.

Summary of Cefas Advice Provided to MMO					
Date	OWF	Specific to a Chemical	Specific chemical Name	Document reviewed	Relevant comments
09/11/2020	Dogger Bank	NO		PEMMP For Sofia OWF	Drill spoils with drilling muds will be left on the seabed. Only non water- based fluids will be notified to the MMO. Outline plans were fit for purpose. Clarification that chemicals not used within machinery and on vessels that have any potential for emission or discharge (even a one off), need to be notified to the MMO for approval. The information should include the quantity frequency and method of use, together with any relevant toxicity its potential to break down and or bioaccumulation data and justifications or risk assessments for use where there are associated warnings (i.e., substitution warning).
09/10/2020	Dogger Bank	YES	3 chemicals comprised of drilling fluids and additives	HDD EMMP, CRA	Products are not on the Cefas list of notified chemicals require suitable eco-toxicological risk assessment. The contractor/ applicant would need to be provide “quality” toxicity data to the MMO together with quantity, frequency, and purpose of use. The MMO depending on the type of chemical may also wish to see partitioning and persistency/biodegradation data (this together with toxicity is known as PBT criteria). It was noted that the information on the safety data sheet is not always sufficient to make an assessment and the chemical supplier’s data in the form of

					test reports may be requested. Further information on chemical specifications were provided final comments such that the assessment of risks of the chemicals for use during the horizontal directional drilling were fulfilled as requested in the dMLs conditions specified.
02/09/2020	Dogger Bank	YES	3 chemicals comprised of drilling fluids and additives	HDD EMMP	Whilst information provided for the other chemicals notified was satisfactory, the information supplied for one chemical did not address Cefas comments requested previously. Due to the potential of the chemical containing “substitutable” components justification for use offshore was required as well as a more detailed risk assessment.
20/07/2020	Dogger Bank	YES	3 chemicals comprised of drilling fluids and additives	LHDD EMMP, CRA	One or more chemicals were observed from the rank list to carry a “substitution” warning which would require further justification for use (a description of why it is necessary to use this chemical and why it cannot not be swapped for an alternative more environmentally friendly one). This justification prior to use would also need to be assessed. Therefore, it is recommended that this information would be required to be presented in good time to allow adequate assessment by consultation with specialist advisers to the MMO.
26/012015	Dudgeon	YES	1 Chemical Solvent	COSSH	Approval for proposal to provide details of the assessment for assessment
25/11/2019	East Anglia One	YES	1 Chemical; Acidic rust remover based on phosphoric	MSDS, Offshore protocol, technical sheet and	Due to the nature and quantity of the use of the chemical this was deemed acceptable to use offshore.

			acid- 25-50%	biodegradability data	
28/06/2019	East Anglia One	YES	1 Chemical: Wire Rope Lubricant		Chemical was not on the ranked list of chemicals comprised of petroleum distillate and contained components harmful to aquatic life and possibly contained substitutable components with potential for bioaccumulation and poor biodegradability, it was suggested that discharge into the marine environment should be avoided.
10/05/2016	East Anglia One	YES	3 Hydraulic Fluids	Chemical List	Chemicals used in closed system
24/05/2021	Galloper	YES	4 Chemicals: Rigwash, Grease, and Lubricants	O & M EMMP MPCP CMP and CRA.	Requested further information on chemicals outstanding from previous comments- required further PBT criteria.

17/04/2018	Galloper	YES	4 Chemicals: Rigwash, Grease, and Lubricants	CRA	One chemical with potential release to the marine environment had no justification for use although, it had a substitution warning and under UK national plan level 3: requiring justification for use and/or discharge. Assessment was difficult without justification for the use of the chemicals and risk assessments carried out for the operations. Information on whether quantities were for the wind farm as a whole, or per turbine, and over what period of time were omitted. Full descriptions of substitutable chemicals and the reasons for their use was deemed necessary, as well as a plan of replacement and a description of why the product used had any relevant substitution warning.
28/03/2017	Galloper	YES	Portland Cement	Email	Galloper requested use of a cement product not on the ranked list (although the main component chemical was) – the chemical was deemed PLONOR and appropriate for use.
29/04/2016	Galloper	YES	Chemical list provided.	Email with CRA	Unable to find relevant advice response
08/02/2012	Greater Gabbard	YES	1 Chemical: Tracer dye		Response used the definitive list on the intranet to confirm the chemical to be used was Gold-lowest hazard rank. Both this and the quantity suggested low volume and so acceptable for use.

23/06/2021	Gunfleet Demonstrator			Construction method statement, Emergency response plan, Scour protection management plan, Marine Mammal mitigation programme.	Comments were purely to do with Chemical spill response only.
22/02/2013	Gwynt y Mor	NO		Email of Risk of Chemical release	3 Chemicals were seen to possibly be leaked through the Yaw system which contained 3 fluids. The likelihood that chemicals would leak when the nacelle was lifted during operations was said to be unlikely, adequate contingency spill plans were provided.
10/10/2012	Gwynt y Mor	NO		Email on CRA	The chemical risk assessment provided for the transition pieces was acceptable. Recommendation was made for secondary containment (bunding) used for the fuel tank with a capacity of not less than 110% of the container's storage capacity.
20/04/2021	Hornsea Two	YES	4 Chemicals Paint coating, anti-seize lubricant and sealant	Consultation response to comments 11/01/2021 MSDS Installation documents	Further information on chemicals uses and ecotoxicology provided.

20/04/2021	Hornsea Two	YES	1 Chemical: Lubricant	Chemical List update and chemical requirements for Cable rollers, MSDS.	The chemical was required for cable laying operations with small quantity used, toxicity, bioaccumulation and biodegradation information provided as part of the assessment.
09/02/2021	Hornsea Two	NO		CRA	The CRA provided for 153 chemicals- 24 of which were described as paint/coatings. Further information requested on coatings and paints.
11/01/2021	Hornsea Two	YES	4 Chemicals Paint coating, anti-seize, lubricant, and sealant	Chemical compliance for Installation	Information on quantity and frequency of use not provided
20/08/2020	Hornsea Two	YES	3 Chemical Lubricants and adhesive	MSDSs, Promotional documentation ,	Chemicals to be used within machinery no intent of emission and demonstrated adequate spill provision, therefore no objection to use.
28/07/2020	Hornsea Two	NO		CRA	All chemicals listed in chemical inventory were exempt.
29/08/2014	Lynn	NO		Application	The materials for use were stated as plastic/synthetic, various chemicals that were to be taken from the Cefas list of notified chemicals (although none were specifically listed), used as corrosion inhibitors, electrical cables and paint. The applicant stated that it was unlikely that they would utilise chemicals for the removal of marine growth but would like to have it included on any licence granted. As it was not

					possible to stipulate at this time what chemicals and quantity would be used the advisor was content for the use of chemicals to be included, with the provision that the MMO was notified of any chemicals (and quantity) to be used to ensure that an impact assessment was undertaken. Due to the potential for the removal of paint from the structures, recommendation that a method statement for dealing with paint removal was submitted to the MMO prior to works commencing to ensure that contamination of the marine environment by paint flakes is kept to a minimum.
26/05/2016	Rampion	NO		CRA	No discharge of chemicals was planned but plan included likely spill impacts. No decommissioning plan was provided.
05/04/2013	Sheringham Shoal	YES	14 named chemicals: Corrosion inhibitors, Leak detection Dyes, and bactericide	Email	Chemicals listed were to treat the inside of the turbine structure - structures were leaking and therefore exposed to rusting and biofouling that could compromise the integrity of the structures long term. Most of the chemicals listed were observed to be biocides, corrosion inhibitors and buffers and looked like they had already been used in the oil and gas industry so no major concerns were observed. As any leakage were likely to be small and would be diluted quickly in the area outside the turbine. The use of the dye was seen as low risk.

30/04/2021	Triton Knoll	Yes	1 Chemical: Water based rust remover.	Chemical List Letter from BOWL Scotland, Cefas email, Cefas minute and MSDS for product.	Information provided was not complete additional ecotoxicological documentation prior to final assessment was required to provide a full assessment.
16/02/2021	Triton Knoll	YES	1 Chemical: Water based rust remover	Letter, technical documents for colour, MSDS.	More information was required regarding persistence and potential for bioaccumulation to be able to make an appropriate assessment.
26/11/2020	Triton Knoll	YES	1Chemical Transforme r oil		Transformer insulating fluid released via sump tank with rainwater was supported by appropriate ecotoxicological information although further risk assessment of dilution and impact was required.
01/06/2020	Triton Knoll	YES	1 Grouting/ cementing chemical	MSDS, Toxicology report and technical note	Although some additives within cement products may be of concern, as would large quantities of cement in the marine environment, given the purpose of this grouting product and the quantity and nature of its use, mostly PLONOR, it was regarded as unlikely to be of concern to the marine environment, in terms of the regulation of hazardous substances in offshore environments.

14/06/2019	Triton Knoll	Yes	3 Chemicals Polymer based sealant and grouting	MSDS	For one chemical although it contained substitutable components, there was no objection to use due to the very small quantities to be used. The other two chemicals reviewed were deemed to have too little information to be adequately assessed.
30/07/2013	Westermost Rough	YES	3 Chemicals for cement/grout and hydraulic oils.	Drilling method statement. Foundation grouting method statement. RA for drilling. RA for grouting. Job safety Analysis and Toolbox Talk MSDSs	The grouting method statement suggests that potential equipment malfunction of the digital water meter could result in too little water being added to the grout mix. If this could not be rectified the mix would be dumped. The quantity and potential frequency of this occurrence to be able to determine risk was not specified. It was determined that if the hydraulic fluids were to be used as lubricants for Jack-up barge legs etc. and not for use within equipment on deck (which are exempt) then the fluids to do this should also be used from the list of notified chemicals and information regarding quantity and reasons for use provided.

21/06/2016	Blyth Demo	NO		CRA	In summary the RA appeared to have appropriately assessed the risks of spillages of chemicals to the marine environment during the construction phase.
SCOTLAND					
09/11/2017	Beatrice	NO		Applicants concern such that approval process for chemicals used in closed system and those on OCNS list may cause unduly delay and disrupt OWF construction.	It was agreed that chemicals used in closed systems, where periodic refill is not needed, did not required that written approval. The regulator was content to accept that chemicals already listed on the OCNS list also would not require written approval. However, the developers were still required to provide written notification of all the chemicals to be utilised in the Works including those chemicals utilised in closed systems and those which are present on the OCNS list.
28/06/2017	Beatrice	NO			The chemicals were exempted chemicals as they were for use in closed systems and therefore did no needing to be from the ranked list.

9 Annex 3

Table D. Copy of the OSPAR ORED returns data for the 2020 UK submission (accurate as of December 2019) (wave and tidal energy installations have been excluded).

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK001	UK	Aberdeen Bay Demo	1.3	Aberdeen Offshore Wind Farm Limited	Wind Turbine	11	operational	92.4	jacket	20-30m	202	Yes
UK002	UK	Barrow Wind Farm	7.2	Barrow Offshore Wind Limited	Wind Turbine	30	operational	90	monopile	10-25m	165	Yes
UK003	UK	Beatrice	13.4	Beatrice Offshore Wind Farm Limited	Wind Turbine	84	authorised	588	jacket	25-50m	198.4	Yes
UK005	UK	Blyth Demo (Phase 1) Wind Farm	4.7	Blyth Offshore Demonstrator Limited	Wind Turbine	5	operational	41.5	gravity-based	25-50m	191.5	Yes
UK006	UK	Blyth Demo (Phase 2 & 3) Wind Farm	5.4	Blyth Offshore Demonstrator Limited	Wind Turbine	10	operational	58.4	TBC	50-100	0	Yes
UK007	UK	Blyth Wind Farm	0.5	E.ON C&R UK Blyth Limited	Wind Turbine	2	operational	3.8	monopile	0-10m	106	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK011	UK	Hywind Scotland Pilot Park	22.3	Hywind (Scotland) Limited	Wind Turbine	5	operational	30	other	100m+	178	Yes
UK012	UK	Burbo Bank Extension Wind Farm	6.8	Dong Energy Burbo Extension (UK) Limited	Wind Turbine	32	operational	259	monopile	10-25m	187	Yes
UK013	UK	Burbo Bank Wind Farm	6.0	DONG Energy Burbo (UK) Limited	Wind Turbine	25	operational	90	monopile	0-10m	190.5	Yes
UK014	UK	Creyke Beck A Wind Farm	131.0	Doggerbank Project 1 Bizco Limited	Wind Turbine	TBC	authorised	1200	TBC	25-50m	315	Yes
UK015	UK	Creyke Beck B Wind Farm	130.8	Doggerbank Project 4 Bizco Limited	Wind Turbine	TBC	authorised	1200	TBC	10-25m	315	Yes
UK019	UK	Dudgeon Wind Farm	32.0	Dudgeon Offshore Wind Limited	Wind Turbine	67	operational	402	monopile	10-25m	187	Yes
UK021	UK	East Anglia One North Wind Farm	36.1	ScottishPower Renewables (UK) Limited	Wind Turbine	TBC	authorised	800	TBC	25-50m	0	Yes
UK022	UK	East Anglia One Wind Farm	48.4	East Anglia One Limited	Wind Turbine	102	authorised	714	jacket	25-50m	197	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK024	UK	East Anglia Three Wind Farm	67.8	East Anglia Three Limited	Wind Turbine	100-172	authorised	1200	TBC	25-50m	247	Yes
UK025	UK	East Anglia Two Wind Farm	29.6	ScottishPower Renewables (UK) Limited	Wind Turbine	TBC	application	800	TBC	25-50m	0	Yes
UK034	UK	Galloper Wind Farm	28.2	Galloper Wind Farm Limited	Wind Turbine	56	operational	336	monopile	25-50m	180.5	Yes
UK036	UK	Greater Gabbard Wind Farm	24.8	Greater Gabbard Offshore Winds Limited	Wind Turbine	140	operational	504	monopile	25-50m	187	Yes
UK037	UK	Gunfleet Sands Demo Wind Farm	8.4	Dong Energy Gunfleet Sands Demo (UK) Limited	Wind Turbine	2	operational	12	monopile	10-25m	144	Yes
UK038	UK	Gunfleet Sands I Wind Farm	6.3	Gunfleet Sands Limited	Wind Turbine	30	operational	108	monopile	0-10m	183	Yes
UK039	UK	Gunfleet Sands II Wind Farm	8.3	Gunfleet Sands II Limited	Wind Turbine	18	operational	65	monopile	0-10m	183	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK040	UK	Gwynt y Mor Wind Farm	12.3	Gwynt y Mor Offshore Wind Farm Limited	Wind Turbine	160	operational	576	monopile	10-25m	191	Yes
UK043	UK	Hornsea 1 (East)	111.2	Hornsea 1 Limited	Wind Turbine	58	authorised	406	monopile	25-50m	200	Yes
UK044	UK	Hornsea 1 (West)	102.2	Hornsea 1 Limited	Wind Turbine	58	authorised	406	jacket	25-50m	200	Yes
UK045	UK	Hornsea 1 (Centre)	105.5	Hornsea 1 Limited	Wind Turbine	58	authorised	406	monopile	25-50m	200	Yes
UK046	UK	Hornsea Project 2 (HOW02) Wind Farm	89.5	Optimus Wind Ltd	Wind Turbine	300	authorised	1386	TBC	25-50m	276	Yes
UK047	UK	Hornsea Project 3 (HOW03) Wind Farm	120.8	Orsted Hornsea Project Three (UK) Limited	Wind Turbine	TBC	designated	1600	TBC	25-50m	0	Yes
UK048	UK	Hornsea Project 4 (HOW04) Wind Farm	65.1	Orsted Hornsea Project Four Limited	Wind Turbine	TBC	application	1200	TBC	25-50m	325	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK049	UK	Humber Gateway Wind Farm	7.9	E.ON C&R UK Humber Wind Limited	Wind Turbine	73	operational	219	monopile	10-25m	192	Yes
UK050	UK	Inch Cape Met Mast	22.6	Inch Cape Offshore Limited	Other	1	operational	TBC	gravity-based	25-50m	169	No
UK051	UK	Inch Cape Wind Farm	15.0	Inch Cape Offshore Limited	Wind Turbine	72	application	TBC	TBC	25-50m	215	Yes
UK052	UK	Inner Dowsing Wind Farm	5.1	Inner Dowsing Wind Farm Limited	Wind Turbine	27	operational	97	monopile	0-10m	189	Yes
UK056	UK	Kentish Flats Extension Wind Farm	7.5	Vattenfall Wind Power Limited	Wind Turbine	15	operational	49.5	monopile	0-10m	196	Yes
UK057	UK	Kentish Flats Wind Farm	8.3	Kentish Flats Limited	Wind Turbine	30	operational	90	monopile	0-10m	160	Yes
UK059	UK	Lincs Wind Farm	6.3	Lincs Wind Farm Limited	Wind Turbine	75	operational	270	monopile	10-25m	220	Yes
UK060	UK	London Array Wind Farm	20.4	London Array Limited	Wind Turbine	175	operational	630	monopile	10-25m	207	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK061	UK	Lynn Wind Farm	5.2	Lynn Wind Farm Limited	Wind Turbine	27	operational	97	monopile	0-10m	189	Yes
UK064	UK	Methil Demo Wind Farm	0.3	ORE Catapult Limited	Wind Turbine	1	operational	7	jacket	0-10m	196	Yes
UK068	UK	Neart na Gaoithe Wind Farm	15.5	Neart Na Gaoithe Offshore Wind	Wind Turbine	56	authorised	448	jacket	50-100	197	Yes
UK071	UK	Norfolk Boreas Wind Farm	73.3	Vattenfall Wind Power Limited	Wind Turbine	TBC	designated	1800	TBC	25-50m	0	Yes
UK074	UK	North Hoyle Wind Farm	7.2	North Hoyle Offshore Wind Farm Limited	Wind Turbine	30	operational	60	monopile	0-10m	147	Yes
UK076	UK	Ormonde Wind Farm	9.1	Ormonde Energy Limited	Wind Turbine	30	operational	150	other	10-25m	215	Yes
UK079	UK	Race Bank Wind Farm	26.7	Race Bank Wind Farm Limited	Wind Turbine	91	operational	573	monopile	10-25m	0	Yes
UK080	UK	Rampion Wind Farm	13.3	Rampion Offshore Wind Limited	Wind Turbine	116	operational	400	monopile	25-50m	140	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK082	UK	Rhyl Flats Wind Farm	7.7	Rhyl Flats Wind Farm Limited	Wind Turbine	25	operational	90	monopile	0-10m	187	Yes
UK083	UK	Robin Rigg East Wind Farm	8.6	RWE UK Renewables Operations	Wind Turbine	30	operational	90	monopile	0-10m	168	Yes
UK084	UK	Robin Rigg West Wind Farm	8.6	EON C&R UK Robin Rigg West Limited	Wind Turbine	30	operational	90	monopile	0-10m	168	Yes
UK087	UK	Scroby Sands Wind Farm	3.8	E.ON Climate & Renewables UK Limited	Wind Turbine	30	operational	60	monopile	0-10m	148	Yes
UK088	UK	SeaGreen Alpha Wind Farm	26.8	Seagreen Alpha Wind Energy Limited	Wind Turbine	114	authorised	1075	jacket	25-50m	210	Yes
UK089	UK	SeaGreen Bravo Wind Farm	38.0	Seagreen Bravo Wind Energy Limited	Wind Turbine	75	application	2300	TBC	50-100	210	Yes
UK092	UK	Sheringham Shoal Wind Farm	16.7	SCIRA Offshore Energy Limited	Wind Turbine	88	operational	317	monopile	10-25m	187	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK102	UK	Teesside Wind Farm	0.9	Teesside Wind Farm Limited	Wind Turbine	27	operational	62	monopile	10-25m	173	Yes
UK104	UK	Thanet Wind Farm	10.8	Thanet Offshore Wind Limited	Wind Turbine	100	operational	300	monopile	10-25m	160	Yes
UK106	UK	Triton Knoll Wind Farm	30.0	Triton Knoll Offshore Wind Farm	Wind Turbine	90	authorised	860	monopile	10-25m	187	Yes
UK107	UK	Walney 1 Wind Farm	14.3	Walney (UK) Offshore Wind Farms Limited	Wind	51	operational	184	monopile	10-25m	191	Yes
UK108	UK	Walney 2 Wind Farm	18.1	Walney (UK) Offshore Wind Farms Limited	Wind	51	operational	184	monopile	25-50m	210	Yes
UK109	UK	Walney Extension (WOW03) Wind Farm	26.8	Walney Extension Limited	Wind Turbine	40	operational	330	monopile	25-50m	0	Yes
UK110	UK	Walney Extension (WOW04) Wind Farm	20.0	Walney Extension Limited	Wind Turbine	47	operational	329	monopile	25-50m	0	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK113	UK	West of Duddon Sands Wind Farm	14.1	ScottishPower Renewables (WoDS) Limited and Orsted West of Duddon Sands (UK) Limited	Wind	108	operational	389	monopile	10-25m	210	Yes
UK114	UK	Westermost Rough Wind Farm	8.0	Westermost Rough Limited	Wind Turbine	35	operational	210	monopile	10-25m	256	Yes
UK123	UK	Kincardine Wind Farm	14.1	Pilot offshore renewables ltd	Wind Farm	5	authorised	50	floating	0	tbc	yes
UK124	UK	SeaGreen Charlie Wind Farm	42.9	Seagreen Charlie Wind Energy	Wind Farm	122	designated	610	TBC	50m	TBC	TBC
UK128	UK	Awel y Mor	10.4	Awel y Mor Offshore Wind Farm Limited	Wind Farm	TBC	application	TBC	TBC	TBC	TBC	TBC
UK129	UK	Dogger Bank - Teesside A	195.3	Doggerbank Offshore Wind Farm Project 3 Projco Limited	Wind Farm	tbc	authorised	tbc	tbc	tbc	tbc	tbc

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK130	UK	Dudgeon Extension	26.2	Dudgeon Extension Limited	Wind Farm	34	application	402	tbc	14-25m	326	Yes
UK131	UK	Erebus	30.1	Blue Gem Wind Limited	Wind Farm	tbc	application	96	tbc	tbc	tbc	tbc
UK132	UK	Five Estuaries	37.4	Five Estuaries Offshore Wind Farm Limited	Wind Farm	tbc	application	353	tbc	tbc	tbc	tbc
UK133	UK	Levenmouth Demonstrator Site	1.4	Offshore Renewable Energy Catapult	Wind Farm	tbc	authorised	7.4	tbc	tbc	tbc	tbc
UK135	UK	North Falls Wind Farm	22.2	North Falls Offshore Wind Farm Limited	Wind Farm	tbc	authorised	504	tbc	tbc	tbc	tbc
UK136	UK	Rampion Extension	12.4	Rampion Extension Development Limited	Wind Farm	116	designated	1200	tbc	tbc	325	tbc
UK137	UK	Sheringham Shoal Extension	15.7	SCIRA Extension Limited	Wind Farm	27	application	317	tbc	11-23m	326	Yes
UK138	UK	Sofia Wind Farm	164.4	Innogy	Wind Farm	100	authorised	1400	monopile	tbc	252	Yes

ID No	Country	Name	Distance to coast (km)	Operator	Device Type	No of Devices	Current Status	Capacity	Foundation type	Water depth	Height	EIA
UK139	UK	Thanet Extension	8.5	Vattenfall Wind Power Ltd	Wind Farm	34	refused	340	tbc	tbc	252	Yes
UK140	UK	Berwick and Marr Bank Wind Farm	30.9	Seagreen Delta Wind Energy	Wind Farm	tbc	application	3200	tbc	tbc	tbc	Yes
UK141	UK	Moray Offshore Wind Farm West	21.9	Moray Offshore Wind Farm (West)	Wind Farm	85	authorised	1500	tbc	tbc	tbc	Yes
UK142	UK	Moray Offshore Wind Farm (East)	22.2	Moray Offshore Wind Farm	Wind Farm	60	authorised	950	tbc	tbc	204	Yes

Centre for Environment Fisheries & Aquaculture Science

Cefas

World Class Science for the Marine and Freshwater Environment

We are the government's marine and freshwater science experts. We help keep our seas, oceans and rivers healthy and productive and our seafood safe and sustainable by providing data and advice to the UK Government and our overseas partners. We are passionate about what we do because our work helps tackle the serious global problems of climate change, marine litter, over-fishing and pollution in support of the UK's commitments to a better future (for example the UN Sustainable Development Goals and Defra's 25-year Environment Plan).

We work in partnership with our colleagues in Defra and across UK government, and with international governments, business, maritime and fishing industry, non-governmental organisations, research institutes, universities, civil society and schools to collate and share knowledge. Together we can understand and value our seas to secure a sustainable blue future for us all and help create a greater place for living.

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