Marine Scotland

Review of Approaches and Costs of Decommissioning Offshore Wind Installations

Public Report

Final | 13 April 2018

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Contents

Abbreviations

Acronym	Description
AACE	American Association of Cost Engineering
BEIS	Department of Business, Energy & Industrial Strategy
BOWL	Beatrice Offshore Windfarm Ltd
BPEO	Best Practicable Environmental Option
CfD	Contracts for Difference
DECC	Department of Energy and Climate Change
EIA	Environmental Impact Assessment
GFRP	Glass fibre reinforced plastics
HLV	Heavy lift vessel
HMRC	Her Majesty's Revenue and Customs
HMT	Her Majesty's Treasury
HSE	Health and Safety Executive
IMO	International Maritime Organization
JNCC	Joint Nature Conservation Committee
LCoE	Levelised Cost of Energy
LoC	Letter of Credit
MER	Maximising economic recovery
MSL	Mean sea level
MW	Megawatts
NLB	Northern Lighthouse Board
OFGEM	Office of Gas and Electricity Markets
OFTO	Offshore Transmission Owner
OGA	Oil and Gas Authority
OSPAR	OSlo PARis Convention (for the Protection of the Marine Environment of the North-East Atlantic)
OTM	Offshore transformer modules
OWF	Offshore Wind Farm
O&G	Oil and gas
PCG	Parent company guarantees
PMT	Project management team
PTV	Personnel transfer vessel
ROV	Remotely operated vehicle
RSPB	Royal Society for the Protection of Birds
SEPA	Scottish Environmental Protection Agency
SFF	Scottish Fishermen's Federation
SNH	Scottish National Heritage
SoS	Secretary of State
TCE	The Crown Estate
UKCS	UK Continental Shelf
UNCLOS	United Nation Convention on the Law of the Sea
WBS	Work Breakdown Structure
WTG	Wind turbine generator
WTIV	Wind turbine installation vessel

1 Executive Summary

In April 2017 (1), the decommissioning responsibilities and powers for Offshore Renewables Energy Installations in Scottish Waters, or in a Scottish part of a Renewable Energy Zone, transferred from the UK Government to the Scottish Government under The (Scotland) Act 2016, Section 62.

The scope of this report is to review existing approaches, cost estimates and guidance for decommissioning offshore wind installations with the aim of providing recommendations to inform future Scottish policies and procedures.

In examining the evidence, and as highlighted during the consultations, it was clear there are different definitions of decommissioning being used by regulators, developers and other stakeholders. Broadly speaking:

- The OWF developers assumed a clear sea-bed was sufficient, i.e. the removal of foundations and cables below the sea-bed was not required;
- Several other stakeholders (e.g. regulators and non-governmental organisations) considered decommissioning to be the removal of all infrastructure.

Establishing a definition of decommissioning is one of the key recommendations for the Scottish Government when producing their decommissioning guidance.

During the consultation a number of additional points were raised which are relevant to the Scottish Government (and to Marine Scotland) for policy development:

- Consistency between the regulations in Scotland and the rest of the UK - Any regulatory changes in Scotland should aim to ensure a level playing field with other UK projects and ensure the Scottish process is not more burdensome.
- Clarity is required in the guidelines around what is meant by a ‘clear’ seabed, or what the expected state of the seabed is post decommissioning.
- A coherent approach regarding securities for Scottish projects is required.
- Further guidance is required for the installation of assets e.g. recommended cable burial depth, recommendations for cable landfall etc. which have implications when decommissioning assets.
- The consultation process could be streamlined during the approval of the initial decommissioning plan.

As noted in the consultation feedback establishing the policy for decommissioning securities will be one of the Scottish Government’s key responsibilities. There are several issues which will require consideration, including:

- The level of security required, based on the decommissioning cost estimate and additional charges (such as VAT) that the Scottish Government may be liable for in the event of Government paying for decommissioning.

- The requirement for an allowance in the security for ongoing monitoring of the site post decommissioning.
- A definition of the appropriate timeframe for the accrual of securities.
- An understanding of the handling of securities throughout the life of the OWF, particularly to cater for changes in OWF ownership.
- A statement regarding the use of the accrued security, i.e. can the security be drawn down, by the developer, to pay for the decommissioning.

Following review of existing legislation, guidance and existing decommissioning programmes, as well as examining the lessons learned from the O&G industry, the recommendations for the Scottish Government in relation to the development of policy and guidance for OWF decommissioning are:

- Adopt an evidence based approach to define decommissioning policy;
- Define what is meant by decommissioning and the developers' obligations regarding decommissioning;
- Outline the expectations of decommissioning programmes, providing adequate guidance for developers;
- Define the requirements for decommissioning securities including appropriate level of security, based on robust cost estimates, type of security and basis of accrual; and
- Consider how a different approach to the rest of the UK may affect the development of Scotland's offshore wind market.

2 Introduction

Offshore wind is a relatively recent contributor to the electricity mix, with the first European offshore wind farms (OWFs) installed in the early 2000s. Despite this relatively new nature of the technology, offshore wind decommissioning is already becoming a feature in the industry and projects of increasing size and scope are reaching end of life.

Until April 2017, all UK OWF operators were required to submit a decommissioning plan to the UK Government Department for Business, Energy and Industrial Strategy (BEIS) as part of the construction consenting process. These plans provide the regulator with insight into how developers see decommissioning being carried out and what range of vessels, contractors, methodologies and equipment are likely to be employed. Cost estimates provided ensure that appropriate provisioning for decommissioning can be made by both the developer and the regulator.

In April 2017 (1), the decommissioning responsibilities and powers for Offshore Renewables Energy Installations in Scottish Waters, or in a Scottish part of a Renewable Energy Zone, transferred from the UK Government to Scottish Government under The (Scotland) Act 2016, Section 62.

The scope of this report is to review existing approaches, cost estimates and guidance for decommissioning offshore wind installations with the aim of providing recommendations to inform future Scottish policies and procedures.

The report draws on the review of existing decommissioning plans submitted by operators, UK government and international offshore wind regulation and guidance, UK government and international oil & gas (O&G) regulations and best practice from industry bodies. Findings from these have been supplemented with the outputs from a consultation event held at Scottish Government facilities, attended by representatives from OWF developers, the supply chain and relevant government bodies and stakeholders.

This report focuses on the offshore aspects of OWF projects and does not specifically address onshore infrastructure including substations or grid connections. Also of note is that offshore transmission assets (principally offshore substations and export cables) are subject to additional regulation under OFGEM. The scope of these regulations and how they relate to decommissioning has not been examined in detail.

Structure of the report

The report is structured as follows;

Section 2. The market context to provide relevant background to the offshore wind market.

Section 3. An introduction to OWF decommissioning to provide context for the assets being considered and the offshore operations required to decommission them.

Section 4. Existing OWF decommissioning regulation to summarise the existing regulatory framework

Section 5. Experience from decommissioning O&G infrastructure to illustrate how the regulatory framework in the O&G industry works, and highlight learning from this industry.

Section 6. Experience from decommissioning OWFs to provide a record of experience to date, and lessons learned.

Section 7. Costs and securities to illustrate the current state of cost estimation for future decommissioning and the options for financial securities.

Section 8. Recommendations and feedback to Scottish Ministers for considering when developing future guidance and regulation.

Consultations

Consultations with industry, regulators and non-governmental organisations was undertaken to gain feedback on their views and experience regarding offshore wind decommissioning approaches and regulation. The consultees included OWF developers, government organisations and representatives from the oil and gas (O&G) industry. The organisations represented during the consultations are listed in the table below. Feedback from the consultations has informed the report and where relevant, specific stakeholder views are described, with key points highlighted in each section.

Table 1: Organisations that attended the consultations

Organisation
Marine Scotland
Scottish Government
Crown Estate Scotland
Scottish National Heritage (SNH)
Transport Scotland
Joint Nature Conservation Committee (JNCC)
Northern Lighthouse Board (NLB)
EDP Renewables (EDPR)
Scottish and Southern Energy (SSE)
Red Rock Power
Orsted
Scottish Fishermen's Federation (SFF)
Royal Society for the Protection of Birds (RSPB)
Oil and Gas Authority (OGA)
Decom North Sea

3 The market context

This section introduces the offshore wind market in the UK and Scotland. It also provides an overview of an OWF's infrastructure, including a brief description of the various elements.

3.1 Offshore wind in Scotland

The UK currently has 30 operational OWFs, more than any other country around the world (2). According to The Crown Estate, Offshore wind currently delivers around 5% of the UK's annual electricity (2). The majority of the commercial OWF projects are located offshore England and Wales. Barrow was the first commercial OWF to be commissioned in UK waters, becoming fully operational in 2006 with a capacity of 90 MW.

Scotland currently has two operational OWFs, Robin Rigg, Scotland's first OWF, which started operating in April 2010, and Hywind, the world's first floating OWF which started generating electricity in October 2017 (3). Additionally, SSE and Talisman Energy installed two demonstration wind turbine generators (WTGs) in 2007 in the Beatrice oil field in the Moray Firth. These WTGs are due to be decommissioned, with the rest of the oil field infrastructure, in the next few years. However, SSE, Red Rock Power and Copenhagen Infrastructure Partners are currently constructing the much larger Beatrice Offshore Wind Ltd (BOWL) project nearby.

As well as the BOWL project which began construction in 2017, there are a number of other Scottish OWF projects at various stages of development. Several OWFs have received planning consents and two have received revenue support in the form of Contracts for Difference (CfD) which gives the developer a guaranteed price per unit of electricity generated. Scotland's existing and consented OWFs are outlined in the table below. There are several more OWFs in the early planning stages.

Table 2: Scotland's offshore wind developments

OWF	Status	Capacity (MW)	WTGs & Foundations	Operational information
Robin Rigg	Operating	180	60 x 3MW Vestas Monopile foundations	Began operating April 2010
Levenmouth Demonstrator	Operating	7	1 x 7MW Samsung Jacket foundation	Began operating December 2014
Hywind	Operating	30	5 x 6MW Siemens Floating foundations	Began operating October 2017
Aberdeen Offshore Wind Farm	Construction	92.4	11 x 8MW Vestas Suction bucket foundations	European Offshore Wind Development Centre (EOWDC), operation expected in Summer 2018
Beatrice Offshore Wind Limited	Construction	588	84 x 7MW Siemens Jacket foundations	CfD at £140/MWh, operation expected in 2019, estimated construction cost £2.6bn

Kincardine Offshore Wind Farm Project	Consented	49.6	8 x 6.2MW Senvion Semi-spar floating foundations	Construction expected to start in 2018.
Forthwind Offshore Wind Demonstrator	Consented	12	2 x 6MW 2-B Energy (two blade WTGs) Jacket foundation	Demonstrator site with operation planned for 2020
Moray East	Consented	950		CfD at 57.50/MWh awarded in 2017, commissioning is scheduled for 2022/23
Neart na Gaoithe	Consented	448	New application for 54 WTGs (compared to 75 in current application)	CfD at £114.39/MWh awarded in 2015, generation expected in 2020
Inch Cape Offshore Ltd	Consented	784	Up to 72 WTGs	Expected to enter construction in 2020
Seagreen Alpha	Consented	525		Construction could begin in 2022
Seagreen Bravo	Consented	525		

3.2 OWF overview

The diagram below shows the main components of an OWF. Each component is described in more detail in the text that follows.

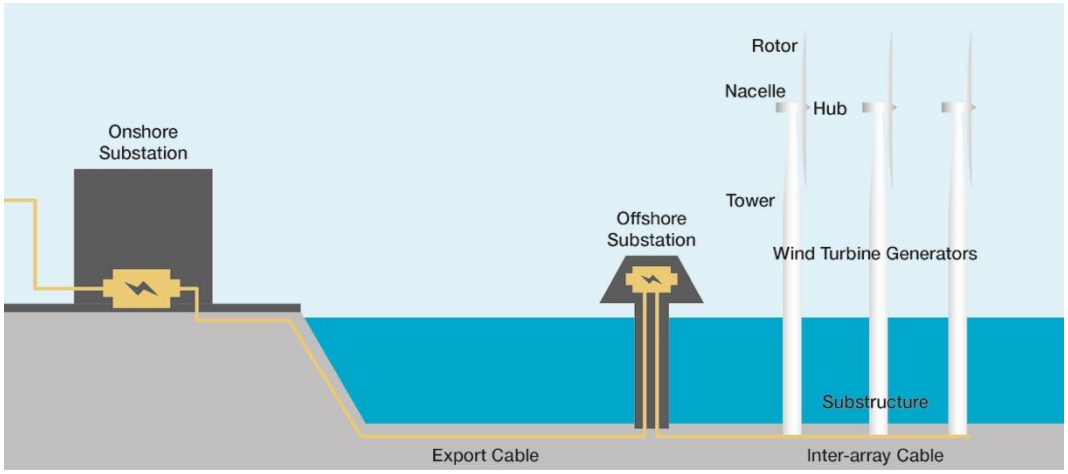


Figure 1: OWF. Source: Adapted from Ofgem

Wind turbine generators (WTG)

The WTG are the electricity generating hub of the OWF. Historically, the most common offshore WTG was rated 3.6 MW, but WTG ratings and dimensions have grown dramatically over the last five years. The largest installed offshore WTG is currently 8 MW, installed at the Burbo Bank and Walney extension OWFs in England in 2017 (4), but WTG of 9 – 10 MW are scheduled for installation on future projects (5). The main components are:

- Blades which rotate, capturing kinetic energy from the wind using the energy to turn a shaft. Most modern WTGs have three blades which are between 44m (3MW WTG) and 80m (8MW WTG) long. The blades are connected to a hub at the front of the nacelle.

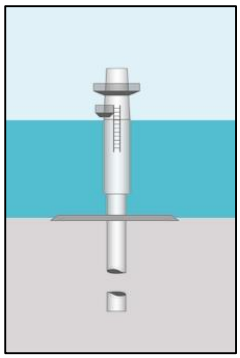
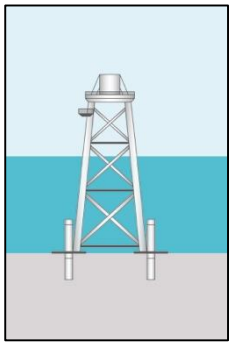
- A nacelle mounted at the top of the WTG tower, which houses the main power take off equipment including the shaft, gearbox and generator, where kinetic energy is converted into electrical energy. The nacelle's hub height is typically between 75 and 120m above the mean sea level.
- A tower supports the nacelle, enabling the blades to be elevated to an area of higher wind speed. These contain high voltage cables, distributing power from the nacelle to the base of the WTG.

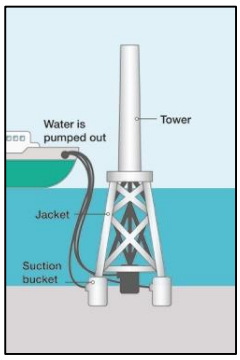
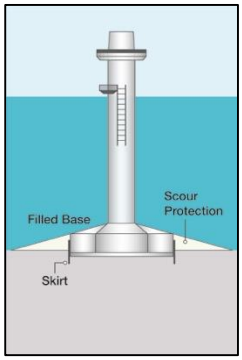
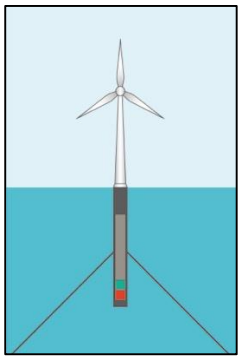
Substructures

The WTG towers are supported on a substructure, which sits in the water column and elevates the tower above sea level. The substructure typically consists of a foundation which fixes the structure to the seabed and the transition piece (TP) which connects the foundation to the WTG tower. Historically the most common substructures have been monopiles with steel jackets utilised in deeper water (as illustrated in Table 3 below).

However, there are a number of more innovative foundation types in development, some of which have been proposed and/or installed in Scotland including suction bucket jackets, concrete gravity bases (CGB) and floating foundations (see Table 3 below).

Table 3: OWF foundations

Monopile 	Monopiles are by far the most common foundation utilised for OWF projects, and are preferred in areas of shallow water (up to 25 to 30m) with a firm seabed. A monopile is a cylindrical steel tube that penetrates around 40 to 50m into the seabed. The monopile is generally installed into the seabed by 'pile driving,' using a hammer to force the foundation into the seabed, providing it with stability to withstand wave and wind loading.
Jacket 	Steel jacket foundations are historically less common and mainly utilised in deeper waters (of 30 to 60m). A jacket foundation is generally a three or four legged structure with piles at each corner to secure the structure to the seabed, and a lattice structure providing strength and stability. The piles utilised are similar to those utilised in monopiles, but are generally of a smaller diameter. Scotland's comparatively deeper waters means that jacket foundations are more likely to be considered as suitable.

Suction bucket jacket 	Suction bucket jackets (also known as suction caissons/piles or anchors) are similar to jacket foundations, with similar lattice design within the water column. However, instead of piles being driven into the seabed, the suction buckets are embedded into the seabed by creating negative pressure inside the bucket. This is usually done by sucking water from the bucket which creates a downward force on the seabed. The foundations currently being installed at the EOWDC are three legged jacket foundations with a suction bucket (instead of a pile) at the end of each leg (6).
CGB 	CGB foundations are hollow concrete structures that are ballasted with materials such as sand or rock that anchors the foundation to the seabed. The width of the CGB is designed to suit the OWF soil conditions. CGB structures have a flat base and usually require some preparation of the seabed prior to installation, in many locations CGB will also require some scour protection. CGB foundations not been widely used in the UK, although they are under consideration for projects in Scotland, e.g. Inch Cape OWF where a CGB foundation met mast was installed in 2014 (7).
Floating spar foundation 	There are several floating foundation design concepts that are being developed for OWF. Design concepts include semi-submersible, spar-buoy and tension leg platforms, all concepts borrowed from the O&G industry. The first floating OWF, Hywind, has a floating spar foundation that is secured to the seabed via three suction bucket anchors. The Hywind foundation consists of a cylindrical buoy that was floated to location horizontally before being ballasted vertically using water and aggregates to a draft of 75m.

Cabling

OWF cabling consists of:

- intra-array cabling which collects power from each WTG and distributes it to one or more offshore substation; and
- one or more export cables which transmits electricity from the offshore substation(s) to shore.

Intra-array cables are typically run at Alternating Current (AC) at 33 kV, although this is moving to 66 kV on the latest projects. The WTG towers or nacelles contain a transformer to convert the generated electricity to the array cable

voltage. The cables typically run between several WTGs, in either a string or loop, see Figure 2, before connecting to the offshore substation. These cables are usually buried below the seabed, and/or may be covered by protection such as rocks or concrete mattresses, to minimise hazards for other users of the sea, and to protect the cables from damage.

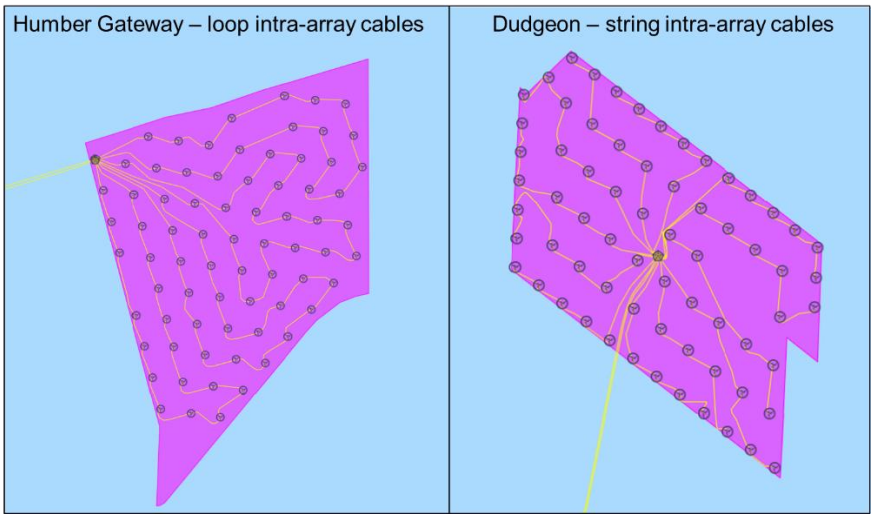


Figure 2: Inter array cable configurations. Source: adapted from (8)

The export cable is a higher voltage cable that transmits the electricity generated by the OWF to a grid connection point on the onshore transmission network. Export cables for OWF projects in the UK have utilised AC technology, but Direct Current (DC) is being considered for longer distances to shore. In the UK 132 kV or 275 kV are the commonly utilised voltages. The cable consists of an offshore and onshore portion, connecting the offshore substation to the onshore substation where electricity is fed into the transmission network.

Depending on the size of the OWF, there may be two or more export cables to connect multiple offshore substations and to provide redundancy. As is the case with intra-array cables, the cable will usually be buried or otherwise protected so as not to pose a hazard, and to reduce the risk of damage.

Offshore substation platform

The offshore substation (OSP) receives the electricity produced by the WTGs and uses transformers and other power electronics to step up the voltage from the intra-array cable voltage to the export cable voltage. It can also be utilised as a convertor station, which changes the AC power to DC. Depending on the operations strategy the platform may have accommodation or refuge to all operational staff to remain on the platform for extended periods. It is likely to have a helipad to allow access for operations and maintenance.

The OSP is similar to an O&G platform with a topside that contains the electrical equipment and other plant, as well as any accommodation and other systems. The topside will be mounted on a substructure, which are typically steel jackets with piled or suction bucket foundations.

Figure 3: Robin Rigg OSP. Source: Arup

With the aim of reducing the cost of OWF, Siemens has developed a substation alternative known as an Offshore Transform Module (OTM). The OTM has a simplified design that weighs one third less compared to conventional OSPs. The first OTMs will be installed on the Beatrice OWF in early 2018 (9).

Onshore substation

The onshore substation typically provides the connection to the electrical grid transmission system. There will also be an additional voltage step-up to the onshore substation to the grid transmission voltage.

Offshore Transmission Operator (OFTO)

Since 2009, in the UK, the offshore transmission assets including OSP, export cable and onshore substation are known collectively as the offshore transmission operator (OFTO) assets. These assets may be constructed by the OWF developer but they must be transferred to an OFTO through a competitive tendering process within 18 months of commissioning (10). Prior to 2009 the offshore transmission assets remained within the ownership of the OWF developer.

4 Introduction to offshore wind decommissioning

In this section we describe what is meant by offshore wind decommissioning and the effects it may have on the marine environment. We describe the potential methodologies for offshore wind decommissioning. We also propose a suggested offshore wind decommissioning work breakdown structure (WBS) that may be used when considering decommissioning activities, providing a common terminology to discuss the various stages of decommissioning.

4.1 Offshore wind decommissioning

Offshore wind decommissioning is the dismantlement, removal or abandonment of infrastructure related to inoperative offshore wind renewable energy generation and transmission facilities. The decommissioning activity should consider all of the offshore infrastructure described in section 3.2 above, including the buried cables.

The majority of decommissioning programmes are expected to take 2 to 3 years to deliver, with additional time for planning prior to the offshore decommissioning operations. The time taken will vary depending on the size and location of the OWF, and how many activities can be completed in favourable weather windows.

4.1.1 What does decommissioning mean

There are several interpretations of decommissioning that will be used throughout this report and have been discussed during the consultations. For the purposes of this report the following decommissioning definitions will be used:

- Complete removal - removal of all infrastructure above and below the seabed
- Clear seabed - removal of infrastructure to leave a clear seabed that is over trawlable
- Partial removal – some infrastructure left in place on the seabed

Note these definitions are defined here for the purposes of this report. In existing standards and guidance ‘removed in whole’ or ‘removing the whole’ is used but it may only be in reference to infrastructure on the seabed, as opposed to under the seabed, this is discussed further in section 5.

A key discussion during the consultation was how different parties interpret decommissioning. There was a variety of opinions which are summarised in the consultation feedback below. When submitting decommissioning plans, the majority of operators have assumed that they are required to leave a clear seabed, meaning they are able to decommission foundations by cutting them below the seabed and that buried cables can remain in place.

Consultation feedback

During the consultations conducted for this project there was some debate as to whether decommissioning should mean returning the seabed to its original condition. Some consultees noted the seabed would change naturally over the operation of the OWF, others commented there should be a consistent 'baseline' condition which the seabed returns to following decommissioning.

The current UK government (BEIS) guidelines state that the site must be cleared of debris following decommissioning. Most stakeholders agreed that decommissioning must make the site safe for other users of the sea, be environmentally acceptable and protect public finances. Several stakeholders assumed that all infrastructure should be removed during decommissioning.

The developers assume that decommissioning does not include complete removal of foundations and buried cables, instead assuming a clear seabed is sufficient.

Several consultees mentioned the 'Polluter Pays' principle, recognising that those who make money from the OWF development should pay for the decommissioning.

It was also highlighted throughout the consultation that decommissioning should fit in with the National Marine Plan and that any decommissioning activity should support the overall direction of the Marine Plan.

4.2 Offshore wind decommissioning methodology

The methodologies for offshore wind decommissioning, are described below. The options based on the various decommissioning definitions above (Complete removal, clear seabed, partial removal) have been described in the relevant sections. It should be noted that limited decommissioning activities have taken place to date in the offshore wind industry and that the methodologies described are based on the current assumptions and available technologies. It is likely that approaches will be refined through experience and novel approaches and methodologies which are potentially disruptive, may develop. There is also potential for reuse or recycling of material or components.

Consultation feedback

During the consultations the work breakdown structure (WBS) for O&G decommissioning was discussed. The WBS is an outline of the decommissioning tasks that is now widely used within the O&G industry providing common terminology for operators and the supply chain. The consultees from the O&G industry said the WBS had helped facilitate discussion with the supply chain and was also used as the basis of decommissioning cost estimates. The WBS has allowed comparisons across projects, operators and suppliers and is helping to drive down the decommissioning costs in the O&G industry.

4.2.1 OWF decommissioning work breakdown structure

The phases of a decommissioning project can be broken down into several work packages, each using a specific set of tools and skills. Below is a suggested work breakdown structure (WBS) for offshore wind decommissioning (informed by O&G UK's WBS for offshore O&G decommissioning (11).)

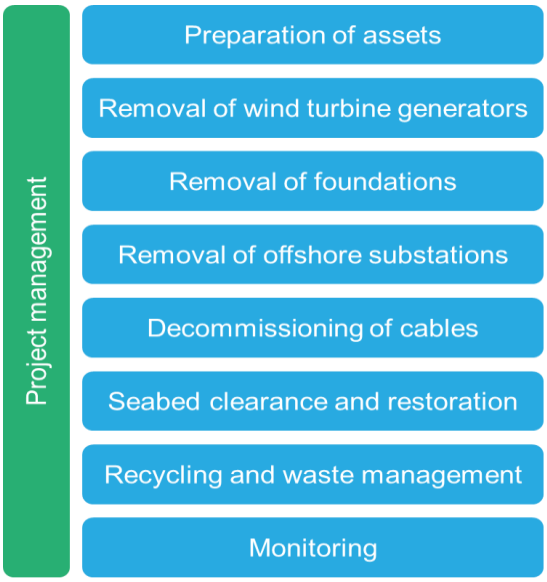


Figure 4: Suggested Work Breakdown Structure (WBS) for OWF decommissioning

4.2.2 Project management

Throughout the decommissioning process management of the different work streams and regulatory approvals is required. This is likely to be best executed by a project management team (PMT) from the OWF operating company, with the support of someone, e.g. a contractor, with experience in decommissioning projects. The PMT will be responsible for designing, procuring and managing the decommissioning works, gaining regulatory approvals and liaising with contractors, regulators and stakeholders as required.

4.2.3 Preparation of assets

The first stage of decommissioning an OWF is to prepare the site and WTGs for dismantlement and removal. This will include the following tasks:

- De-energise and isolate the electrical systems from the national grid.
- Remove loose items from structures.
- Installation of lifting points and lifting equipment.
- Cutting wiring at separation points e.g. between tower and nacelle.
- Removal of fluids e.g. lubricants from the WTG.

An initial preparation stage allows works to be carried out from a smaller vessel, such as a personnel transfer vessel (PTV), maximising the efficiency of operations when the lift vessel required for removal of the WTG is brought on site.

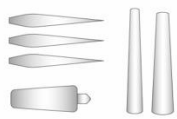
This stage is likely to require the use of standard tools, similar to those used during OWF operations and maintenance throughout the life of the OWF.

4.2.4 Removal of WTG

Removal of the WTG is currently assumed to be a reversal of the installation process. This assumption is consistent across all decommissioning programmes submitted to BEIS. This operation involves dismantling and removing the WTG section by section before transferring the component parts to shore.

The WTG can be dismantled in several configurations, each configuration producing a differing number of component parts and requiring a differing number of lifts. Some examples of configurations, based on typical installation configurations, are shown in the table below.

Table 4: WTG dismantlement configurations

Configuration	Lift 1	Lift 2	Lift 3	Lift 4	Lift 5	Lift 6
Six separate components 	Blade 1	Blade 2	Blade 3	Nacelle and hub 	Tower 1 	Tower 2 
Complete rotor 	Rotor and hub 	Nacelle 	Tower 1 	Tower 2 		
Bunny ears 	Blade 1	Nacelle, hub and two blades 	Tower 1 	Tower 2 		

The tower may also be removed as a single component if vessel capabilities and health and safety assessments allow.

The removal of a WTG is assumed to be carried out by a vessel similar to that used for installation e.g. a wind turbine installation vessel (WTIV) or similar jack up vessel. Crucially the chosen vessel requires a crane capable of lifting high

loads (typically 400 tonnes plus, depending on the size of the WTG) at a sufficiently high hook height (typically 80m plus above MSL, depending on WTG hub height) and at sufficient radius to access the WTG (30m plus, depending on crane location, seabed conditions etc.).

To separate components, cutting tools such as plasma cutters and angle grinders may be required to undo bolts and other connections that cannot be undone with standard tools.

Once the WTGs are removed they are transported back to shore. This may be undertaken using the same vessel as for removal. Alternatively, the components may be loaded on to a transport barge and taken ashore while the removal vessel stays on site and continues WTG removals. The economics of each option will depend on the distance between the OWF and the preferred port, the available deck space on the vessel and the speed of each vessel.

4.2.5 Removal of substructures and foundations

The approach to removing the substructures and foundations will vary depending on the definition of decommissioning being applied.

Clear seabed

For substructures and foundations that extend some distance below the seabed, e.g. monopiles or jacket piles, developers generally assume that these will be cut below the seabed to allow removal of the substructure. The developers generally assume removing the foundations to 1m below the seabed, leaving the pile in place below this depth. The regulations and international obligations with respect to this assumption are discussed in section 5.

To remove the foundations to 1m below the seabed, monopile and jacket foundations can be cut using diamond wire cutting or abrasive water jet cutting. Both techniques are applied in the O&G industry for cutting similar structures.

To remove to 1m below the seabed, monopiles may be cut externally or internally. For internal cutting, internal manipulator tools of sufficient diameter will be required. To remove jacket structures it is considered likely that first their legs will be cut above the piles, allowing removal of the steel jacket. Following that the piles would then be cut and removed separately.

Depending on the combined weight of the substructure and transition piece both pieces may be removed as a single lift, or detached and removed separately. If the foundation is connected to the transition piece with a grouted connection, then the transition piece will need to be cut from the foundation. The cut can be made using the same cutting equipment used to cut the foundation.

If carrying out an external cut of the pile, prior to cutting an excavation around the pile below the seabed will be required to provide access for the cutting tools. For internal cuts material will need to be pumped out of the monopile to allow access for cutting tools. Before the foundation can be removed J-tubes, cable connections and other external structures need to be detached.

The cutting and removal operation will require a similar vessel to that used for WTG removal, one with sufficient crane capacity to lift the foundation. This could be a WTIV, other jack up vessel or a heavy lift vessel (HLV).

Consultation feedback

During the consultation, cutting of foundations was discussed. It is assumed by the developers that if they have a deep piled foundation such as a monopile that decommissioning these foundations will involve cutting the monopile at some depth below the seabed (to date BEIS have approved decommissioning programmes with this assumption).

It was understood that required depth of cut below the seabed is based on seabed conditions and is currently assessed on a case by case basis. The regulatory requirements and guidance are discussed more in section 5. There were concerns amongst some developers that BEIS had been discussing removal of the whole foundation. Developers were concerned that for the majority of installed monopile foundations this would be technically challenging and would have a significant impact on costs.

Complete removal

Foundations that do not extend below the seabed, such as CGB foundations are assumed to be completely removed by reverse installation, i.e. removing the ballast, refloating the entire structure and towing or lifting it to a vessel for transport back to shore. Suction bucket foundations could also be removed completely by reverse installation, by pumping water into the suction bucket to release it from the seabed and then removing it to shore. Any grout that may have been used to install the foundation will likely need removing before a CGB or suction bucket could be removed.

To remove foundations that extend below the seabed, e.g. monopiles and steel jackets with piles, would require a hydraulic or vibratory hammer to aid in pulling out the pile as well as excavation around the piles to allow removal. Section 7.1.3 describes the use of a vibratory hammer to remove monopiles at the Lely OWF.

4.2.6 Removal of offshore substations

The OSP must be removed as part of the OWF decommissioning. OSPs typically include a large topside (up to 2000 tonnes or more), installed on a monopile or jacket foundation.

It is currently considered that the substation topside is likely to be removed as one piece and transferred to shore for dismantling. Carrying out a single lift will reduce the amount of offshore operations, which has the potential to be safer and more cost effective. Certain components may be isolated or removed prior to the main lift to reduce the risk of offshore spills, this includes any oil filled transformers and cutting intra-array and export cable connections.

A HLV or crane barge will be required to lift the topside structure. The main requirement is that the vessel has sufficient crane capacity to lift the substation

topside. The same HLV or a similar vessel can also be utilised to remove the foundation which will be removed in the same way as described above for the WTG foundations.

4.2.7 Decommissioning of cables

OWF cables include both intra-array cables and export cables that extend from the OWF to the shore. For both of these cables there is the choice of decommissioning the cables in situ or removing them.

Clear seabed

For decommissioning in situ, the cable ends are located and buried at an acceptable depth below the seabed. This is likely to require the use of a remotely operated vehicle (ROV) equipped with suitable trenching and burial equipment and accompanying support vessel. It is assumed that to decommission the cables in situ the cable is already buried along its length and so limited activity is required along the length of the cable. Exposed sections of cable will most likely be cut and removed or subjected to rock placement to ensure they are over-trawlable.

Complete removal

The alternative to decommissioning the cable in situ is to remove the cables. In this case the cable end must be located and lifted to the cable removal vessel. The lifting operation can be performed using a grapnel deployed by the vessel, or using an ROV to fit a lifting attachment to the cable. Once the end of the cable has been recovered the rest of the cable is 'peeled out' using winches on the recovery vessel. If the seabed has challenging features then additional tools and vessels may be required to lift the cable from the seabed before it can be removed.

Consultation feedback

Several developers did not believe that the industry currently views the removal of all infrastructure as the baseline for decommissioning. These developers felt that BEIS should continue to assess decommissioning plans on a case by case basis regarding the removal of cables, scour protection and the depth to which the foundations must be cut. This was contrary to some organisations (regulators and other stakeholders) who viewed decommissioning as the complete removal of all infrastructure.

The developers and other organisations raised concerns about precedents being set, such as the removal of all scour protection, without appropriate consideration for the environmental impact.

4.2.8 Seabed clearance and restoration

Once all the infrastructure has been removed or suitably buried the seabed must be restored to a state that minimises risks to maritime users. This may involve several activities and will depend on the location and conditions of a particular OWF, and the decommissioning definition being applied.

Scour protection - Clear seabed

Existing scour protection may be left in place and additional scour protection placed if required to ensure over-trawlability. For example, additional protection may be required at the WTG foundation locations to fill in the excavated seabed and cover any remaining infrastructure. Additional scour protection may be placed by a rock dumping vessel or a crane vessel depending on the nature of the scour protection.

Scour protection - Complete removal

All existing scour protection would be removed which could be carried out with a grab dredger but may also require diver intervention for smaller / more difficult to access scour protection.

Debris removal

Following the removal of the OWF infrastructure a seabed survey is usually conducted to ensure that all debris associated with the OWF has been removed. The survey is required to provide assurances that the seabed is free from anything that could pose a risk to other maritime users. Any identified debris should be removed, if removal is not possible it should be communicated to the relevant authorities and marked on navigational charts.

Seabed restoration

In most cases, it is likely, the seabed will be allowed to naturally settle following the decommissioning works, this presents the least risk to personnel and limits further disruption to the seabed.

4.2.9 Recycling and waste management

The material removed from the OWF will be taken ashore for reuse, recycling or disposal. The steel components including the tower and foundations can be readily recycled through existing waste management channels. The fibre reinforced plastic blades are less readily recyclable and may causes challenges in the future unless suitable reuse or recycling routes can be identified.

Currently the options for recycling glass fibre reinforced plastics (GFRP) is limited, a handful of recycled WTG blades have been used in construction projects in Europe. Neocomp, a German company recycles GFRP into raw material (cement clinker) and substitute fuel for the cement industry (12). Their business is specifically targeted at recycling WTG blades following the ban in Germany of sending the blades to landfill.

Other waste streams, including the copper from any cables removed and any used lubricants extracted from the WTG, will occur in much lower volumes than the steel or fibre reinforced plastic components and can be recycled through existing channels.

When discussing waste handling, the waste hierarchy is used to rank waste management options according to what is best for the environment (13). The

waste hierarchy, illustrated in Figure 5, should be used during decommissioning projects with the aim of handling the waste in the most environmentally responsible way. The waste hierarchy was discussed by SEPA during the consultation, their feedback can be found below.

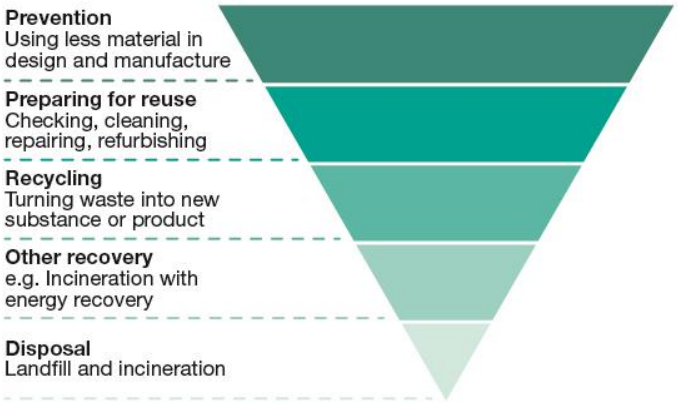


Figure 5: Waste hierarchy

Consultation feedback

SEPA was consulted regarding recycling and waste handling in relation to OWF. SEPA has produced guidance for onshore wind farms that includes a hierarchical framework to support decision-making relating to life extension and potential decommissioning of onshore wind sites. The guidance states that the hierarchy (outlined below) should be applied in extension and decommissioning proposals taking into account site specific circumstances:

1. Life extension – extend life of existing development
2. Re-use max – replant turbines on existing bases
3. Repower – new turbine bases installed
4. Decommission – cessation of use of part or whole of site

There is currently no specific guidance on OWF but the onshore guidance will likely be applicable. This has implications for repowering discussed in section 4.5.

Most of the waste e.g. steel is assumed to be recyclable. It was noted that OWF components may be easier to deal with, compared to offshore O&G decommissioning. 100,000 tonnes of steel per OWF is comparable to a single O&G platform but as the wind farm components are smaller and maybe more easily broken down at sea they should be able to be handled by a wider range of facilities.

SEPA also noted that there may be more value in some OWF components than in O&G platforms. Rare earth metals will likely be more valuable in the future and so people should be thinking about how these could be extracted at the end of the OWF's life.

With regard to WTG blades, these may be used for energy from waste but moving higher up the waste hierarchy is preferable (see Figure 5). SEPA presented several examples of waste streams where there is a targeted effort to find recycling and reuse solutions e.g. tyres and paper cups. A similar programme could be undertaken for turbine blades. An organisation such as the Scottish Institute for Remanufacturing may be able to provide some creative thinking around what could be done with blades. Part of managing the blade waste should be putting pressure on the OWF

owners to plan for the blade's end of life. There may be opportunities to manufacture the blades with reuse and remanufacture in mind. This should be explored with owners and manufacturers.

4.2.10 Monitoring

Following completion of decommissioning, if any infrastructure such as foundations and cables remain in place below the seabed, an ongoing monitoring program will be required to ensure that the infrastructure does not become exposed and pose a risk to maritime users.

The timeframe for monitoring will be agreed between the operator and the regulator following an initial baseline post decommissioning survey upon the completion of decommissioning activities. The timeline for subsequent decommissioning surveys will be based on:

- The scale and nature of remaining infrastructure.
- The risk of any remaining infrastructure becoming exposed (considering seabed conditions, depth of burial etc.).
- The degree of risk to marine users.
- The residual environmental risk given the sensitivities in the OWF local area.

4.3 Effects of decommissioning

The effects of decommissioning are assessed as part of the initial Environmental Impact Assessment (EIA) prior to the OWF construction. It is generally assumed that the construction will have a greater effect on the environment than the decommissioning. A further EIA may be required prior to decommissioning and this EIA should consider the residual impacts of decommissioning on the marine and terrestrial environments as well as the impact of the decommissioning activities themselves.

Consideration should be given to the point in time at which the baseline for the decommissioning of projects is considered. The baseline could be either prior to any construction of the OWF or a baseline of the state of the environment of an operational OWF.

Consultation feedback

Many consultees, both developers and others, stated that decommissioning should be viewed as another aspect of OWF development lifecycle and is subjected to all the same requirements as any other stage in the life of the OWF, and that impacts on the environment should be minimised during the decommissioning.

The decommissioning plan should consider the impacts during any decommissioning activity as well as any residual impact once the decommissioning activities are completed. Both short term and long term impacts should be considered when determining the most appropriate approach to decommission.

A key decision in decommissioning will be if infrastructure should be wholly or partially left in situ or if it should be removed. It is possible that in some circumstances it may be less disruptive for the environment to leave infrastructure in situ provided the long term impact of doing so is acceptable.

The effects that decommissioning activities have on the environment and any residual environmental effects can be considered in terms of human, physical and biological impacts.

Human impacts

The main impact on human activities during and post decommissioning will be the infrastructure left in place, which could pose a risk to other marine users such as fishing vessels, commercial ships and leisure users.

- During decommissioning activities, there will be restrictions on vessels entering the area where activities are ongoing. This may impact upon the fishing and shipping activities in the local area.
- Any infrastructure left in place, e.g. cables or foundations could pose a snagging risk to fishing or other vessels, this infrastructure may also limit the potential future use of the site for other uses e.g. new OWF development or aggregate extraction.
- Radar adaptions – Any devices installed to reduce the radar interference from the OWFs may need to be removed during decommissioning process, this will need handling with the appropriate aviation authorities to ensure that there is no disruption to their radar systems.

Consultation feedback

Several consultees mentioned the health and safety risk associated with offshore wind decommissioning, both for workers during the decommissioning activity and other users of the sea once decommissioning was completed. Particular attention should be paid to the health and safety of workers during the decommissioning activities as the risk are considered higher than the installation risk due to the activities taking place on structures that were often built many years prior.

It was also noted that any infrastructure left in place should be clearly marked so that other users of the sea are aware of the potential snagging risk. This included physical lighting of any obstructions at sea and marking on navigation charts.

Physical

The main physical impact from decommissioning will be changes to the seabed as a result of the removal of infrastructure and the activities of removal equipment and vessels.

- Decommissioning may result in seabed excavations which change the seabed topology and result in the removal or discharge of material, this topology

change could have impacts on humans (e.g. navigation) and organisms (changes to habitat)

- The decommissioning program should consider whether remedial works are required to restore the seabed or whether the seabed should be allowed to naturally settle. The choice will depend on the local seabed conditions and the extent of the work required to restore the site (as much as possible and desirable) to the condition it was in prior to construction.
- The requirement for remedial works is particularly relevant for cable removal – the decision to remove or leave or partially remove cables in place will be one of the key assessments for all decommissioning plans.

Biological

The impact on the biological environment from decommissioning will be similar to that of construction. There is potential for impact on:

- Benthos associated with seabed disturbance and removal of hard substrate and associated marine growth
- Fish – through removal of Fish Aggregate Devices (FADs) and changes to the benthos, local habitat and removal of marine growth
- Seabirds – increased risk of oil spill due to increased vessel traffic, and indirect impacts from benthos and fish change
- Marine mammals through the production of underwater noise, other disturbance and possible increase in risk of vessel strike

4.4 Decommissioning consideration in OWF design

The requirement for OWF developers to consider decommissioning during EIA assessments and to complete a decommissioning plan prior to construction encourages the developers to consider decommissioning the assets during the design phase of the project. This discourages any radical design changes in OWF infrastructure that may cause problems with decommissioning later in the project's life.

Decommissioning considerations also encourage developers to consider options for extending the life of infrastructure to delay decommissioning costs. This includes designing components of the OWF that will last as long as the seabed lease, for example the foundations or electrical infrastructure, so that these components could be reused with the installation of new WTGs if the initially installed WTGs have a shorter operational life.

Thinking about decommissioning in the design phase may lead to designs that allow for easier decommissioning such as foundations that do not penetrate the seabed or modular reusable components. Currently there are no examples of designs that have been specifically influenced by decommissioning considerations however specific designs may become more prevalent as decommissioning programmes are carried out and issues and potential solutions identified.

Consultation feedback

Feedback from the consultation, specifically from representatives of the O&G industry, highlighted the value in considering decommissioning from an early stage. Appropriate pre-planning would mitigate against unforeseen events which may lead to very high outturn costs. Not only this, but decommissioning should be seen as a wider programme encompassing the late life of the asset, how plant is safely run down and ultimately the removal activities themselves and any post-removal monitoring.

4.5 Reusing OWF infrastructure

As part of the decommissioning programme the operators should investigate whether parts of the OWF infrastructure may be reused as an alternative to full decommissioning. The options for use may include continuing use as an OWF or an alternative purpose.

OWF repowering

As noted in section 4.3 it is likely that the electrical infrastructure and possibly the OWF foundations have a lifetime that exceeds the WTG life and may even extend to the full lease period (50 years). If at the end of the technical life of the WTG it is economical to replace the WTG with newer models, then the electrical infrastructure and the foundations could be reused in creating the repowered OWF. This represents a significant saving for the developer compared to developing a completely new OWF, it also delays the decommissioning costs for the reused elements.

As well as having a sound economic basis for repowering, the developer would also need approval from the relevant regulatory body, i.e. Marine Scotland in Scottish waters. Approval would be required to extend the life of the OWF and reuse the existing infrastructure. This may require extensions to the leasing agreement and the marine licence.

Consultation feedback

During consultations repowering was discussed noting that longer consents of 40 to 50 years are being sought and this could imply that repowering is being considered. The terms of the leasing agreement were considered as key to the ability to repower, as well as the economics. The developers noted that as the WTG is the most expensive part of the OWF, extending its life should be the goal instead of repowering. However, it was also mentioned that, as with most decommissioning issues, it is difficult to know at this stage what the future scenario will be.

Artificial reefs

In some areas of the world, offshore infrastructure has been abandoned on the seabed as an artificial reef, known as ‘rigs to reef’ programmes. This has been the case for abandoned O&G platforms in Gulf of Mexico, many of which have created artificial reef sites off the coast of Louisiana and Texas, with Louisiana

having over 60 sites (14). The practice has also been extended to the Asia Pacific region. Brunei's rigs to reef policy has resulted in Shell abandoning several jackets in artificial reef areas (15). This is currently not an option for O&G in the North Sea due to the Oslo Paris Convention (OSPAR) Decision 98/3 however there is ongoing research into the benefits of artificial reefs around the world which could lead to changes in legislation in the future. More information on this is included in Section 5.

Consultation feedback

An equivalent to 'Rigs to reefs' for OWF infrastructure was discussed as an option during the workshop, it was mentioned that in Argyll a sunk ship is being used as a conservation area and could provide value to the fishing industry. The consultees thought a 'rigs to reef' equivalent programme for OWF foundations could work in theory if correctly marked up on navigational charts.

Regarding the viability of an OWF equivalent 'rigs to reefs' under international obligations, it is understood that this would be viable given the International Maritime Organisation (IMO) standard states that 'A coastal State may determine that an installation or structure may be left wholly or partially in place where it will serve a new use, such as enhancement of a living resource'. As OSPAR Decision 98/3 does not apply to OWF this would not prevent a 'rigs to reef' equivalent being a potential option. Research would be required to determine if leaving some OWF infrastructure in place as a marine habitat would be beneficial and desirable for the marine environment.

Aquaculture

There has been some research into reusing offshore O&G platforms as structures to support offshore aquaculture. Although there is little practical experience of this application, it is something that is gaining momentum. Earlier this year a Norwegian company, Roxel (16), began offering a service to temporarily convert jack up drilling rigs into ocean fish farms. Further investigation is required to confirm if OWF assets could be used as aquaculture sites.

5 Existing OWF decommissioning regulation

In this section, we review the international and national policy, legislation and overall regulatory framework which governs OWF decommissioning.

5.1 International obligations

5.1.1 UNCLOS

The international obligations that the UK's decommissioning policies have been developed from are primarily The United Nation Convention on the Law of the Sea (UNCLOS). Held in 1982, the convention was implemented in 1994 with the UK formally entering in 1997.

With regards to decommissioning, article 60 of the convention states that:

> *"Any installations or structures which are abandoned or disused shall be removed to ensure safety of navigation, taking into account any generally accepted international standards established in this regard by the competent international organization. Such removal shall also have due regard to fishing, the protection of the marine environment and the rights and duties of other States. Appropriate publicity shall be given to the depth, position and dimensions of any installations or structures not entirely removed."*

These requirements were formally implemented into the 'Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone' by the International Maritime Organisation (IMO) in 1989. This integration into IMO Standards meant that the UK is required to follow the requirements when carrying out decommissioning activities in the exclusive economic zone.

5.1.2 IMO criteria for removal

The IMO Standard refers to installation of structures on the sea-bed. With regards to the general requirement for removal the Standard states:

> *"The coastal State having jurisdiction over the installation or structure should ensure that it is removed in whole or in part in conformity with these guidelines and standards once it is no longer serving the primary purpose for which it was originally designed and installed, or serving a subsequent new use, or where no other reasonable justification cited in these guidelines and standards exists for allowing the installation or structure or parts thereof to remain on the sea-bed. Such removal should be performed as soon as reasonably practicable after abandonment or permanent disuse of such installation or structure."*

The IMO Standard then goes on to discuss that decisions to:

> *"allow an offshore installation, structure, or parts thereof, to remain on the sea-bed should be based, in particular, on a case-by-case evaluation, by the coastal State with jurisdiction over the installation or structure".*

The Standard refers to structures on the sea-bed and does not explicitly reference structures below the sea-bed.

The Standard also notes that under certain circumstances, installations do not necessarily need to be completely removed from the site. The installation may be permitted to be safely abandoned if it meets any of the following criteria:

- If the installation (excluding the deck and superstructure) weighs more than 4,000 tonnes in air or is standing in more than 100m of water, a coastal State may determine that it may be left wholly or partially in place where this would not cause unjustifiable interference with other uses of the sea;
- If the installation or structure will serve a new use, such as enhancement of a living resource; or
- Installation or structure need not be entirely removed where entire removal is not technically feasible, removal would involve extreme cost or would pose unacceptable risk to personnel or the environment.

If the installation is located within 'approaches to or in straits used for international navigation or routes used for international navigation through archipelagic waters, in customary deep-draught sea lanes, or in, or immediately adjacent to, routeing systems which have been adopted by the Organisation' then the installation must be entirely removed without exception.

Installations or components associated with installations may remain on the sea-bed under certain circumstances and will be judged on a case by case basis. Before any partial removal or abandonment is considered a case must be put forward confirming that any infrastructure left in place will not be transported under the influence of storms, tidal and wave movement. This is essential to ensure that components will not become future hazards for navigation. The following factors will be considered:

- Any potential effect on the safety of surface or subsurface navigation or other uses of the sea;
- The rate of deterioration of the material and its present and possible future effect on the marine environment;
- The potential effect on the marine environment, including living resources;
- The risk that the material will shift from its position at some future time;
- The costs, technical feasibility and risks of injury to personnel associated with removal;
- The determination of a new use or other reasonable justification for allowing some or all of the installation or structure to remain on the sea-bed.

In the event that all or a portion of an installation is left in place, written authorisation detailing the condition of the components and a specific monitoring plan must be developed as soon as possible. Notifications to mariners and hydrographic services detailing the dimensions, depths and specific position of the components must also be provided in a timely manner.

The government should ensure that the responsibility of monitoring the abandoned installation is stated clearly and the responsible party are aware of their monitoring obligations.

The IMO Standard is not clear about infrastructure below the sea-bed, and allows for circumstances where infrastructure on the sea-bed may be left in place for consideration by the coastal State.

5.1.3 OSPAR Convention

The UK is one of 15 members of The 1992 OSPAR Convention, a guide for international cooperation on the protection of the marine environment of the North-East Atlantic. Specifically, OSPAR Decision 98/3 (17) sets out binding requirements for the disposal of disused offshore O&G installations. It states:

> *"The dumping, and the leaving wholly or partly in place, of disused offshore installations within the maritime area is prohibited."*

Although OSPAR Decision 98/3 does not cover offshore renewable energy installations it is worth noting that the decision does not apply to "any part of an offshore installation which is located below the surface of the sea-bed". So O&G operators are not required to remove jacket piles below the sea-bed.

Nonetheless, OSPAR published 'Problems and Benefits Associated with the Development of Offshore Wind-Farms, Biodiversity Series, OSPAR Commission 2004' to provide guidance regarding offshore renewable decommissioning. The paper provides considerations for developing guidance for the removal/disposal of offshore wind-farms. With regards to decommissioning, it states:

> *"when decommissioning wind energy installations (end of operational life-time use or premature termination of the project), the wind energy installations (including foundation) and cables should be removed completely and disposed of (recycling) on land. In order to avoid hindrances for e.g. fisheries, the piles should at least be cut off far enough beneath the seabed to ensure that the remaining parts will not be exposed by natural sediment dynamics."*

And the method used to remove installations should implement:

> *"techniques which minimise impacts on the environment (e.g. benthos, fish) including re-suspension of the sediment should be applied for the removal."*

5.2 Domestic legislation

5.2.1 Energy Act 2004

Part 2, Chapter 3 of the Energy Act 2004 (18) (as amended by the Energy Act 2008 (19)) is focused on decommissioning activities associated with offshore renewable energy installations located in British waters. The Act states that the Secretary of State may request that the owner of the installation produce and submit a decommissioning programme. This request is also a product of section 36 of the Electricity Act 1989 where the Secretary of State may request a decommissioning plan be provided as a factor in deciding to give a project generating consent. If the project is a joint venture, the Secretary of State may place the requirement on all parties involved.

The request for a decommissioning programme may be submitted at any stage after one of the statutory consents is granted to the project. If deemed necessary, the Secretary of State may also request consultations to be carried out in tandem with the development of the programme.

Once the programme draft is submitted to the authority, the secretary of state may choose to either;

- Approve the programme as it is;
- Approve the programme on the condition of some changes to be made or the provision of financial security;
- Reject the programme and require a new one;
- Decide to develop the programme themselves and recover the cost from the responsible party

It is the responsibility of the Secretary of State to review the decommissioning programmes in a timeframe they deem appropriate. During these reviews either the responsible party or the Secretary of State may suggest changes to the programme to be made and the party responsible of fulfilling the decommissioning programme may be transferred subject to the approval of the Secretary of State.

Sections of the Energy Act which are relevant to decommissioning are illustrated in Figure 6 below.

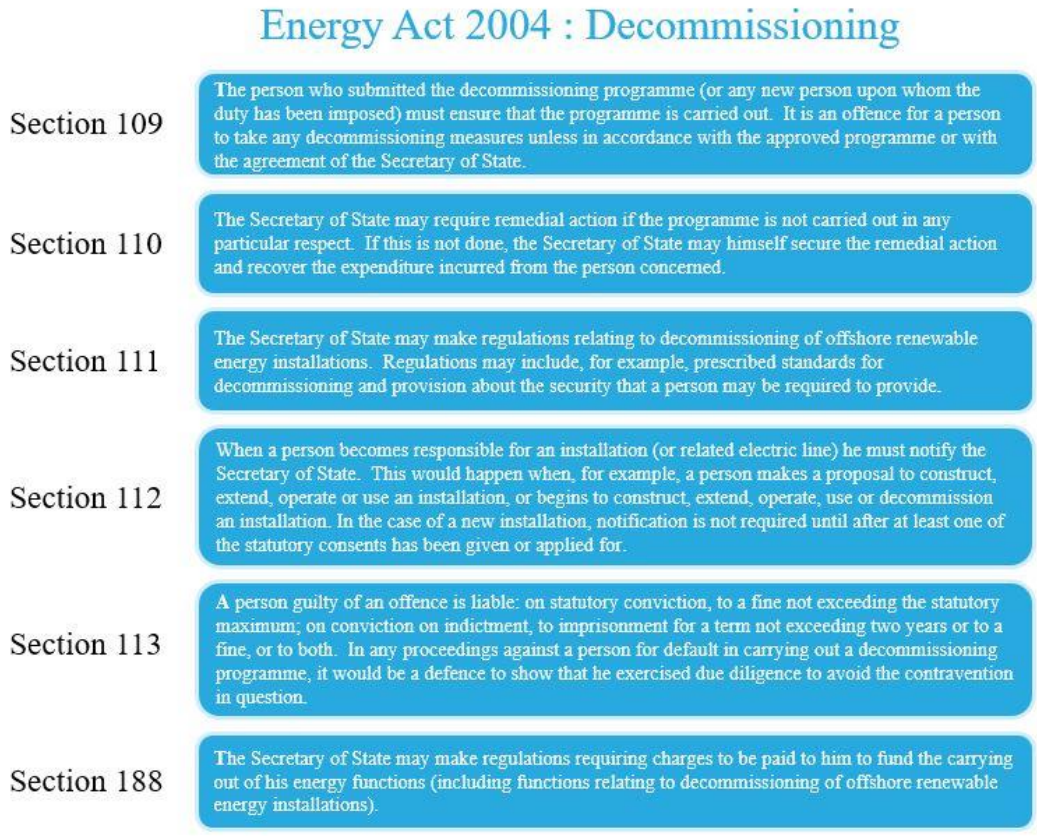


Figure 6. Relevant aspects of Energy Act 2004

5.2.2 Scotland Act 2016

Section 62 of The Scotland Act 2016 (20) transfers the UK Secretary of State's (SoS's) Energy Act 2004 functions in relation to the decommissioning of offshore renewable energy installations, including wind installations, from the UK wide Department of Business, Energy and Industrial Strategy (BEIS) to Scottish Ministers and their appointed staff members. This transition formally occurred on April 1st 2017.

Specifically, such powers include:

- The authority to request decommissioning programmes;
- The authority to request financial securities;
- To review decommissioning programmes and financial securities and requests appropriate actions; and
- Ultimately ensure that decommissioning is carried out by either the responsible party or by other means if the responsible party is unable to fulfil their obligations.

Concordat on the decommissioning of offshore renewable installations

The concordat (1) sets out the practical arrangements for the transfer of powers regarding the decommissioning of offshore renewable energy installations. The

concordat sets out the arrangements prior to transfer, i.e. BEIS are responsible for carrying out their functions in respect of decommissioning programmes. The responsibilities after the transfer of power are for Scottish Minister to set or amend and collect the required securities and enforce any defaults. The concordat also states that any securities held by BEIS in relation to the Scottish projects will be transferred to Scottish Ministers.

The concordat sets out that BEIS and the Scottish Government will support each other in efforts to enforce decommissioning programmes, particularly in relation to ensuring that decommissioning is paid for by the operator in compliance with the polluter pays principle. The concordat also states that both BEIS and the Scottish Government should seek to implement a coherent UK-wide approach to decommissioning whilst noting that there is the right to exercise discretion as appropriate. Specifically, the concordat mentions that if either administration is considering a more risk-averse approach this would likely result in increasing the costs of a development and that the impact on investment and subsidies should be considered.

Transfer of functions of specific sites

With regard to the transfer of responsibilities for specific projects, the concordat sets out several categories of projects and how the transfer of responsibilities will be handled. The categories and transfer process are outlined below:

- **Category 1**: New site, a new project or a new part of an existing OREI that;
    1. was/ is constructed on or after 1st April 2017.
    2. had/ has a marine licence/ consent issued or varied on or after 1st April 2017.

  Energy Act functions transferred to Scottish Ministers from 1st April 2017
- **Category 2**: Infrastructure due to decommission on or after 1 January 2023 where infrastructure to which a consent relates has not been constructed as at 1st April 2017.
  Energy Act functions transferred to Scottish Ministers from 1st April 2017
- **Category 3**: Infrastructure due to decommission on or after 1 January 2023 and partly or fully constructed at 1st April 2017.
    1. If an approved decommissioning programme and associated financial securities, as required by the decommissioning programme, are in place at 1st April 2017, then Energy Act functions transferred to Scottish Ministers from 1st April 2017.
    2. If an approved decommissioning programme and associated financial securities are not in place on 1st April 2017, then BEIS will retain Energy Act functions until they are in place at which point the Energy Act functions will be transferred to Scottish Ministers.
       Note: The requirement for securities to be in place before transfer will only be applicable if in the approved decommissioning there is a requirement for securities to be provided before the date of transfer. E.g. where an approved decommissioning plan sets out that financial securities should start to accrue mid-way through a 15 to 20 subsidy period, Energy Act functions for such a project would transfer to

Scottish Ministers once the decommissioning programme has been approved by the SoS. The provisional level of, and timetable of accrual for, financial securities would have been agreed as part of that approval.

- **Category 4**: Existing infrastructure due to decommission before 1st January 2023
  These sites will stay with BEIS until decommissioning is complete, unless both the following conditions are met:
  1. a decommissioning programme approved by the SoS is in place and;
  2. a new marine licence/ consent is or has been issued for the site to become a new/ extended project and there is the issue of a notice under section 108 of the Energy Act requesting a modified decommissioning program that covers both the old and the new sites.

  Once a section 108 notice is issued Energy Act functions for the old site will transfer to Scottish Ministers.

Based on the above categorisation it is understood that the Energy Act functions for the following OWF projects have transferred to Scottish Ministers:

- Beatrice OWF
- Aberdeen OWF (EOWDC)
- Inch Cape OWF
- Neart Na Gaoithe OWF
- Seagreen Alpha and Bravo OWFs
- Moray East OWF sites (MacColl, Stevenson and Telford)
- Hywind (subject to an approved decommissioning programme being in place)
- Kincardine OWF
- Dounreay Tri Floating Wind Demonstration Project
- Forthwind OWF

5.2.3 Other relevant legislation

Decommissioning activities will need to comply with other relevant UK legislation at the time of decommissioning, this legislation is relevant to environmental protection, waste management, health and safety and construction and much of it would have been relevant during the construction and operation of the OWF.

For example, a marine licence will likely be required to decommission the OWF as it is required for construction and remedial works throughout the life of the OWF. The applicable legislation is the Marine and Coastal Act 2009 which covers marine licencing.

An Environmental Impact Assessment (EIA) undertaken prior to the decommissioning of the OWF will need to meet the requirements in the relevant EIA legislation, this is currently the Electricity Works (Environmental Impact

Assessment) (Scotland) Regulations 2017. Additionally, an Appropriate Assessment will be carried out where a project is likely to affect any Natura 2000 site as defined under the EU Habitats and Birds Directive and protected under domestic legislation such as the Offshore Marine Conservation (Natural Habitats etc.) Regulations.

Waste management is governed by a series of waste and environmental legislation to ensure the UK is compliant with the EU Waste Framework Directive. Waste management licencing is governed by the Environmental Protection Act 1990 and the Waste Management Licensing (Scotland) Regulations 2011. Depending on how the waste is to be handled will determine which legislation is applicable.

The decommissioning works will be subjected to health and safety and construction related legislation. This legislation (e.g. Health and Safety at Work Act 1974) places duties on the employer for the health and safety of workers, ensuring equipment is suitable and the preparation of emergency procedures and health and safety plan. These duties will apply throughout the decommissioning programme.

It is likely that the legislation will change between the writing of the initial decommissioning programme and carrying out the decommissioning. Therefore, Marine Scotland should ensure legislative changes that will affect the decommissioning programmes are addressed during reviews of the programmes throughout the life of the OWF.

5.3 BEIS guidance notes

The Department of Business, Energy and Industrial Strategy (BEIS), provide the Decommissioning of offshore renewable energy installation under the Energy Act 2004 (21) guidance notes for industry. This document is for developers and other responsible bodies involved in the decommissioning of offshore renewable energy installations.

Originally published in 2006 and revised in 2011 by the Department of Energy and Climate Change (DECC)[1], the guidance notes provide information regarding decommissioning legislation, the structure of the required decommissioning plan, the required securities and the ongoing project liabilities. BEIS are currently revising the guidelines and have a draft version out for consultation (22). Where there are significant changes in this new draft guidance these are discussed.

The guidance notes have been prepared to help developers and owners of offshore renewable energy installations meet their decommissioning obligations under the Energy Act 2004. The guidance notes set out that the Act and therefore the guidance applies to territorial waters in or adjacent to England, Scotland and Wales. The guidance also outlines that Act applies to all offshore wind installations consented after June 2006, and wave and tidal installations that were consented or became operational after June 2006. The Act and therefore the guidance applies to both commercial or demonstration installations.

[1] DECC was the government department with responsibilities for offshore renewable energy decommissioning prior to the formation of BEIS in 2016.

As well as covering the process for submission, approval and review of the decommissioning programmes, see section 5.3.4 below, the guidance also covers the expected content of the decommissioning programme, the decommissioning standards, expectations for financial security (see section 8.3) and the residual liability post decommissioning.

5.3.1 Decommissioning programme

The BEIS guidance notes set out the suggested contents of the decommissioning programme, including a description of the material to be included under each heading. The guidance notes that the level of information provided will reflect the level of uncertainty associated with that particular issue at the time of writing the decommissioning programme.

Although the guidance notes acknowledge there will be more uncertainty within the decommissioning programme earlier in the development timeline, the guidance also states that the programme should be sufficiently detailed. The level of detail in the programme, from the outset, should demonstrate that decommissioning has been fully considered and factored into design decisions. It is also requested that the decommissioning strategy being considered is viable given the knowledge at the time of writing.

The guidance notes also state that the decommissioning programme should be informed by an EIA. Stating that the EIA should assess the potential effects of the proposed decommissioning measures on the environment, and describe the measures envisaged to avoid, reduce and, if possible, remedy any significant adverse effects indicated.

For the initial programme the EIA is expected to use the analysis already completed for the wider EIA prior to the consent of the OWF. The decommissioning EIA will be reviewed, and if necessary updated with more detailed assessment, towards the end of the life of the installation. The guidance notes are not clear as to how the changes to the environment throughout the life of the OWF should be handled. They do not provide clarity as to whether the baseline for the decommissioning EIA should be the condition prior to decommissioning or the condition prior to installation of the OWF.

5.3.2 Decommissioning standards

The BEIS guidance notes provide a series of decommissioning standards which will inform the decisions regarding the submitted decommissioning programmes. The standards are used to guide the decisions made by BEIS but decisions are made on a case-by-case basis and so different solutions may be proposed for different installations. The guidelines cover several areas as described below.

General requirement to remove installations

Taking into account UNCLOS, IMO and OSPAR discussed in Section 5.1, the guidelines state that the generally accepted ‘ideal’ decommissioning programme would involve the removal of all disused installations and structures, although this does not explicitly apply to infrastructure below the seabed. Therefore, the

guidance starts from the general presumption that the whole of all disused OWFs are removed and taken back to land for reuse, recycling, incineration or disposal.

Exceptions from general presumption in favour of removing the whole of an installation

The guidelines acknowledge that in some circumstances removing all of a disused installation is not the best solution. The guidelines state that deciding whether infrastructure can remain in place will be considered on a case-by-case basis. The situations where leaving a structure in place may be considered are:

- The installation or structure will serve a new use, whether for renewable energy generation or for another purpose, such as enhancement of a living resource (provided it would not be detrimental to other aims, such as conservation). In this case the eventual decommissioning programme when the installation eventually becomes 'disused' should be set out.
- Entire removal would involve extreme cost. It is considered that design decisions should, as far as possible, result in installations which are affordable to remove, but it is recognised that some elements, such as deep foundations, may be costly to remove.
- Entire removal would involve an unacceptable risk to personnel.
- Entire removal would involve an unacceptable risk to the marine environment.
- The structure weighs more than 4000 tonnes in air (excluding any deck and superstructure) or is standing in more than 100 m of water and could be left wholly or partially in place without causing unjustifiable interference with other uses of the sea.

The BEIS guidance also states that the IMO standards specify certain circumstances where a structure must be removed without exception. This is when the structure is located in *'approaches to or in straits used for international navigation or routes used for international navigation through archipelagic waters, in customary deep-draught sea lanes, or in, or immediately adjacent to, routeing systems which have been adopted by the Organization [IMO]'.*

The BEIS guidance gives a number of examples for which it might be possible to consider alternative solutions to complete removal.

- Structures which will be reused for renewable energy generation – a decommissioning programme should be set out for when the infrastructure eventually becomes 'disused'.
- Structures which serve a purpose beyond renewable energy generation – such as a breakwater with integrated wave energy device – a decommissioning programme should set out the eventual decommissioning of the structure.
- Foundations and structures below seabed level – i.e. cut foundations below the seabed – the decommissioning programme should include contingency plans which describe the action should the foundations become exposed.
- Scour protection materials.

Seabed clearance

The guidelines state that it is important for the developer to confirm that the site has been cleared following decommissioning. The guidelines suggest that proposals for ensuring this should include carrying out surveys, and debris clearance. The area to be covered by the surveys will be assessed on a case-by-case basis but the guidelines mention that post decommissioning survey for O&G installations covers a radius of 500m from the installation. The guidelines also state that an element of independent third party verification would be required in the survey results.

Method of removal

The guidance is not prescriptive about the method of removal, instead stating that when deciding the method the following should be considered:

- The Best Practicable Environmental Option (BPEO), informed by an EIA and consideration of costs;
- Safety of surface and subsurface navigation;
- Other users of the sea; and
- Health and safety considerations.

Management of waste

The guidance is not prescriptive about the choice of waste management solution, however the guidance references the waste hierarchy and that reuse should be considered first followed by recycling, incineration with energy recovery and lastly disposal. The guidance notes waste management must be carried out in line with all relevant legislation at the time of decommissioning.

Post decommissioning monitoring, maintenance and management of the site

The guidance states that some post decommissioning will be expected where an installation is not completely removed. The decommissioning programmes should include a description of the proposed post decommissioning monitoring and an appropriate regime will be determined on a case-by-case basis taking account of the nature and condition of the remaining infrastructure, the seabed conditions and the risk that the infrastructure may be come exposed and pose a risk to other users of the sea.

The guidance states that in general the monitoring regime may be adapted over time, the frequency of monitoring to reduce over time. Monitoring reports are expected to be submitted to the Government and published by appropriate means.

5.3.3 Residual liability

The guidance states that the person who owns the installation at the time of decommissioning will normally remain the owners of any residues. An exception would be in the case where the owner proposes complete removal of an object but the Government decides the object should be left in situ. In this case the owner would not be expected to maintain liability for the object.

The guidelines states that BEIS would not expect any problems following completion of the post decommissioning monitoring regime, however, if problems did arise they would expect to require the owner to take the appropriate action. Additionally, any claims from third parties arising from damage caused by remaining infrastructure would need to be dealt with by the owners.

5.3.4 Decommissioning approvals process

The BEIS guidance notes outline a process for the decommissioning programme approval. This process is outlined in Figure 7 below.

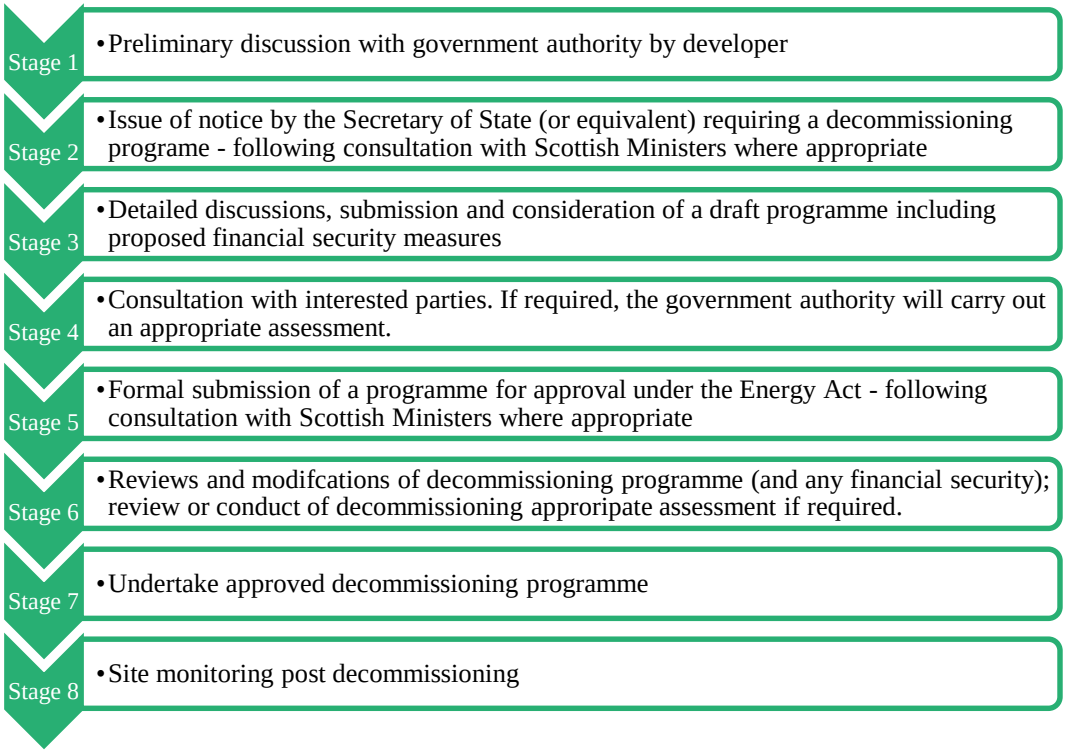


Figure 7: Decommissioning approval and completion process

It is expected that Stages 1 to 5 would take place during the development of an OWF. The Energy Act 2004 states that a decommissioning plan can be requested as soon as a statutory consent for a proposed offshore renewable energy installation is received or has been applied for and is likely to be received. According to the guidelines it is likely that consents for the OWF development will include a condition that construction cannot begin until a decommissioning programme has been submitted. Therefore, it is assumed that the initial decommissioning plan will be written and submitted prior to the OWF construction.

BEIS's consultation documentation (22) on the updates to the guidance, states that '[BEIS] would like to ensure that all future offshore renewable energy installations have an approved decommissioning programme in place prior to construction', although it is not currently the practice that decommissioning programmes are approved prior to consultation.

Throughout the operation of the OWF it is assumed the decommissioning plan will be revised and updated based on the latest information. The Energy Act 2004 states that the SoS (amended by the Scotland Act 2016 to Scottish Ministers for projects transferred – see section 5.2.2) 'must, from time to time, conduct reviews of a decommissioning programme approved by him as he considers appropriate'. The reviews are likely to depend on project life, financial security provisions, market conditions and technical performance.

The existing BEIS guidelines suggest the following for a commercial scale OWF:

- A final review that might start 2 years prior to the planned decommissioning program, allowing enough time to carry out any surveys required for the final EIA;
- After 2 years of operation;
- 2 years prior to provision of financial security;
- and half way through period of financial security provision.

However, in BEIS's draft updated guidance, the suggested review schedule has updated to include the reviews below which 'should be assumed as standard':

- A post construction report within 1 year of construction completion which highlights any issues during construction which may impact on decommissioning;
- High level of the decommissioning programme every 3 years thereafter until 12 to 18 months before security is due;
- A comprehensive review at this point (12 to 18 months before security is due) to identify any changes in assumptions on costs and risks that might affect the size or timing of financial securities;
- Annual reviews of the decommissioning programme by the developer to make sure the security provision is on track to meet the expected cost of decommission. Any changes as a result of these reviews would need to be submitted to BEIS for approval, written confirmation that the review has taken place, even if there are no changes, would need to be sent to BEIS.

The expectation is that most reviews, except the final review, would be completed between the Government and the developer without the need for additional consultation.

5.3.5 Decommissioning programme consultations

Stage 4 in Figure 7 refers to the decommissioning plan consultation process. The developer is required to consult with a number of statutory consultees as detailed on the request to submit a decommissioning programme. The statutory consultees are determined by the location and circumstances of the OWF development.

The guidelines state that the developers will be expected to consult with affected parties including the fishing industry and other users of the sea and relevant local stakeholders. The list of expected consultees given in the guidelines (specific to Scotland) includes: the Joint Nature Conservation Committee; Scottish Natural

Heritage; the Scottish Environment Protection Agency (as the case may be); Historic Scotland; the Maritime and Coastguard Agency; the appropriate General Lighthouse Authority; and the relevant harbour authority (if any).

The guidance notes state that developers may wish to include their decommissioning proposals in the consultations conducted as part of the process of securing development consents to avoid a separate consultation process prior to the OWF construction. It is expected that the final review of the decommissioning program, approximately 2 years prior to the start of decommissioning operations, may require further consultation with external stakeholders.

5.4 Lessons learned and feedback

The current guidance and legislative framework were topics of discussion during the consultations. There was a variety of feedback on the current guidelines and the role of BEIS during the submission and approval of the decommissioning plans, this led to discussions around the role for Marine Scotland in the development of future legislation and administration of decommissioning plans related to Scottish projects.

Consultation feedback

Regarding the current guidelines and legislation the following feedback was received:

- When reviewing and approving the decommissioning plans there is a lot of discussion on 'case-by-case' issues. This takes up a lot of time, some documented decisions should be made around certain common aspects and reviews should focus on the unique aspects of each case.
- The multitude and variety of consultee comments received make submitting initial decommissioning plans complex, it can take a long time and many iterations.
- In the experience of developers BEIS has been supportive throughout the review and approval process, although what they are asking for and approving does not necessarily reflect their guidance.
- Improved guidance regarding the installation of OWFs may help in the decommissioning phases, for example guidance on cable burial and protection could help with determining whether it is acceptable to decommission a buried cable in situ.
- BEIS guidance changing from a clean seabed to a clear seabed, what is meant by this should be made apparent in the guidelines.

In terms of Marine Scotland's future role in taking responsibility for the decommissioning of offshore renewable installations the following feedback was received:

- The transfer of powers is viewed positively providing Marine Scotland continues to work along the same lines as BEIS.
- Marine Scotland should maintain a strategic overview across all offshore renewable decommissioning projects, managing the risks as a whole and looking for opportunities to build the supply chain in Scotland.

- Marine Scotland should ensure there is consistency between the regulations in Scotland and the rest of the UK, any regulatory changes in Scotland should not make the process more burdensome
- A clear approach regarding securities for Scottish projects is required

The feedback implies the current regulatory framework is broadly acceptable, however there is the opportunity for the Marine Scotland to make some improvements. Such improvements include:

- Developing a consistent approach across projects rather than assessing everything on a case-by-case basis
- More clarity in the guidelines around what is meant by a 'clear' seabed, or what the expected state of the seabed is post decommissioning
- Further guidelines on the installation of assets that could be beneficial at the time of decommissioning, e.g. cable burial, cable landfall etc.
- Changes to the consultation process to streamline the approval of the initial decommissioning plan

Whilst it is important to maintain consistency between the regulations and guidance in Scotland and the rest of the UK the concordat acknowledges the right to discretion on the details. The Scottish Government has the opportunity to improve the decommissioning programme review and approvals process.

6 Experience from decommissioning O&G infrastructure in the North Sea (planning and delivery)

In this section we review the regulatory framework which applies to the decommissioning of UK O&G infrastructure. A comparison between this and the OWF specific regulation is valuable, to consider how best practice from both can provide guidance to Marine Scotland. Decommissioning practitioners from the O&G industry were consulted during the consultation process, with their feedback in section 6.2 below.

6.1 O&G decommissioning legislation

6.1.1 Introduction

In the UK, O&G decommissioning regulation reflects requirements from international bodies as well as those stipulated by relevant UK regulatory bodies. BEIS, OGA, The Treasury and Revenue and Customs (HMT/HMRC) and the Health and Safety Executive (HSE).

BEIS and the OGA act as the primary regulators, with responsibility for executing legislation and for providing the key policy drivers taking into account commercial, technical and operational criteria as well as regulation to promote policy objectives on environmental and occupational safety issues. Recent changes in the approach to UK regulation have involved increasing the scope for consultation with regulators. The OGA in particular has the responsibility to foster co-operation in the industry in order to maximise economic recovery (MER).

Key legislation which has a significant and marked influence on O&G decommissioning regulation is highlighted in Figure 8.

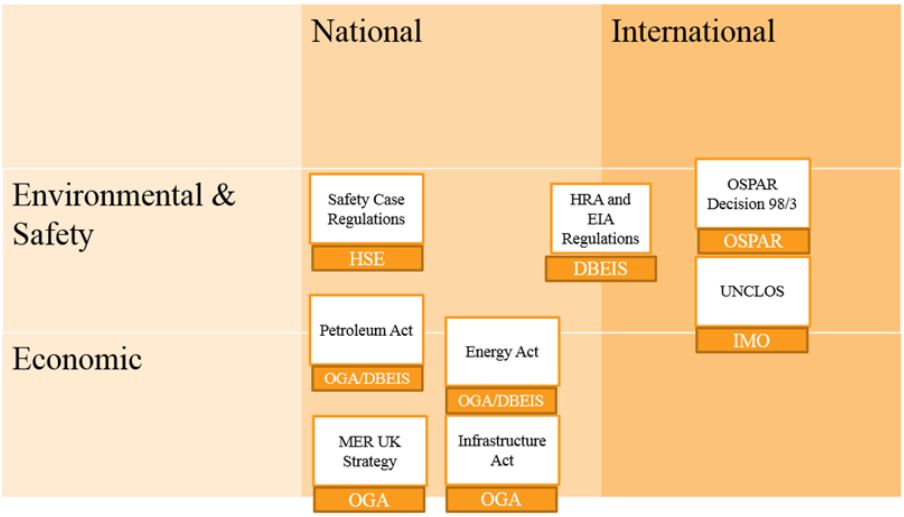


Figure 8: Breakdown of national and international decommissioning legislation

6.1.2 International context for UK regulation

As illustrated above and discussed in section 5.1, the UK is subject to UNCLOS and IMO regulations. These apply equally to O&G installations. OSPAR, also introduced in section 5.1, applies more specifically to O&G and is described in more detail below.

OSPAR Decision 98/3

OSPAR Decision 98/3 and the accompanying ministerial 'Sintra' statement prohibits dumping offshore installations or leaving them in place (either partly or wholly). A competent authority (i.e. a UK regulatory body) may give an operator an exemption from this requirement (a so-called "derogation") if there are significant reasons why an alternative approach to disposal is preferable. This includes substructures for the following offshore installations:

- all or part of the footings of a steel installation weighing more than 10,000 tonnes placed in the maritime area before 9 February 1999
- a concrete installation or a concrete anchor base
- any other disused offshore installation to be dumped or left wholly or partly in place, when exceptional and unforeseen circumstances resulting from structural damage or deterioration, or from some other cause presenting equivalent difficulties, can be demonstrated

Eligibility for a derogation does not mean that a derogation will automatically be granted. The operator must put forward the case for a derogation using a Comparative Assessment (CA) and this is considered on a case-by-case basis by the competent authority following consultation.

Comparative Assessments

The CA assesses the disposal options against a number of criteria outlined in the OSPAR decision. The aim of the CA is to consider the potential impacts of the proposed disposal option on the environment and on other legitimate users of the sea. The assessment criteria includes, but is not limited to, the following:

- technical and engineering aspects of the options;
- timing of decommissioning;
- safety considerations;
- impacts on the marine environment;
- consumption of natural resources and energy associated with reuse or recycling;
- other consequences to the physical environment;
- impacts on amenities, and the activities of other users of the environment; and
- economic aspects.

The operator is required to assess the impact of each of the proposed disposal options, including compete removal, against each of the proposed criteria using established methodologies.

Consultation feedback

Feedback from consultees was consistent in that extending OSPAR to cover marine renewables to an equal extent was not of interest. However, the objective that assets should be removed in their entirety, but with scope for case-by-case specific exemptions, was accepted as a generally appropriate principle.

As noted in section 5.1.3 OSPAR Decision 98/3 excludes infrastructure below the seabed. Therefore, under OSPAR, O&G developers are not required to remove any infrastructure below the seabed.

6.1.3 Domestic O&G decommissioning regulation

Petroleum Act 1998

The Petroleum Act 1998 (23) vests all rights to the UK's petroleum resources in the Crown, but the Government can grant licenses that confer exclusive rights to 'search and bore for and get' petroleum. These powers were originally vested to the Secretary of State for the Department Energy and Climate Change (DECC). A number of the powers have been transferred to the OGA by the Energy Act 2016 (24).

Decommissioning of disused offshore installations and pipelines is the focus of Part IV of the act. The principal provisions relate to serving a Section 29 notice. These perform the following functions:

- Enable the Secretary of State, by written notice, to require the submission of a costed decommissioning programme for each offshore installation and submarine pipeline. Those persons given notices are jointly liable to submit a programme.
- Where a decommissioning programme is approved by the Secretary of State, make it the (joint and several) duty of the persons who submitted it to secure that it is carried out.
- Provide the Secretary of State with means to satisfy himself that any person who has a duty to secure that an approved decommissioning programme is carried out will be capable of discharging that duty and, where he is not so satisfied, require that person, by notice, to take such action as may be specified.
- In the event of failure by those given notice to submit a programme or secure that it is carried out, enable the Secretary of State to do the work and recover the cost from those given notice.
- Provide penalties for failure to comply with notices.

- Enable the Secretary of State to make regulations relating to decommissioning.

MER UK Strategy

The OGA is responsible for defining and implementing maximising economic recovery (MER) for O&G activities.

The MER UK Strategy is legally binding on "relevant persons" which include the OGA and licensees. The "Central Obligation" of the Strategy requires that "relevant persons must, in the exercise of their relevant functions, take the steps necessary to secure that the maximum value of economically recoverable petroleum is recovered from the strata beneath relevant UK waters."

The following principles, relevant to decommissioning, are incorporated in the Strategy:

- All stakeholders should be obliged to maximise the expected net value of economically recoverable petroleum from relevant UK waters, not the volume expected to be produced.
- Compliance with the Strategy is intended to lead to investment and
- Compliance with the Strategy may oblige individual companies to allocate value between them, matching risk to reward. However, while the net result should deliver greater value overall, it will not be the case that all companies will always be individually better off.
- Compliance with the Strategy will not lead to any individual company investing in a project or operating existing assets where there is not a satisfactory expected commercial return on that investment or activity. Such a return does not necessarily mean a return commensurate with the overall corporate return on their portfolio of investment, e.g. a low risk investment could give low returns.
- In determining whether something is consistent with the principal objective the OGA will need to balance the benefit of economic recovery of petroleum with the need to maintain the confidence of new and current investors to invest in exploration and production of petroleum from relevant UK waters, taking into account market conditions at the time of making its determination.

There is further guidance by way of "Supporting Obligations", which clarify how the Central Obligation applies to certain circumstances, for example, exploration, development, asset stewardship, technology, decommissioning and OGA Plans. Supporting Obligations relating to decommissioning include the following considerations:

- Before commencing the planning of decommissioning of any infrastructure in relevant UK waters, owners of such infrastructure must ensure that all viable options for their continued use have been suitably explored, including those which are not directly relevant to the recovery of petroleum such as the transport and storage of carbon dioxide.

- Relevant persons must decommission infrastructure located in relevant UK waters in the most cost effective way that does not prejudice the maximising of the recovery of economically recoverable petroleum from a region.
- Where the OGA produces a plan on how the obligations of the Strategy may be met, it may identify particular pieces of infrastructure the decommissioning of which would prejudice the maximising of the recovery of economically recoverable petroleum in a region.

UK Energy Act 2008 and 2016

This legislation amended some aspects of the original Petroleum Act 1998. The Energy Act 2008 (25) made a number of adjustments due to the changing nature of business practices in the O&G industry. Since the introduction of the legislation there has been increased participation by smaller companies which have fewer assets, hence increasing the risk that decommissioning liabilities could not be met.

In summary, the 2008 Act amended the regime by:

- Enabling the Secretary of State to make all the relevant parties liable for the decommissioning of an installation or pipeline and, where a licence covers multiple sub-areas, clarifying which licensees will be liable.
- Giving the Secretary of State power to require decommissioning security at any time during the life of an oil or gas field if the risks to the taxpayer are assessed as unacceptable.
- Protecting the funds put aside for decommissioning, so in the event of insolvency of the relevant party, the funds remain available to pay for decommissioning and the taxpayers' exposure is minimised.

The Energy Act 2016 (24) received Royal Assent in May 2016. This Act formally established the OGA as an independent Government Company, with the intention that it would be as independent from Government as possible.

BEIS guidance notes for O&G decommissioning

Similar to the guidance notes issued by DECC for offshore renewable energy installation decommissioning, DECC also produced guidance notes for O&G installation decommissioning under the Petroleum Act (26). These guidance notes are currently being updated by BEIS and are due to be released in April 2018 (27). There are some interesting aspects of these guidance notes that may be relevant for OWF decommissioning including;

- For pipeline decommissioning, which is not covered by OSPAR Decision 98/3, BEIS requires a CA to be completed if the proposal is to leave the pipeline in place.
- The draft version of the latest guidance includes more clarity around specific requirements including:
    - For pipelines, mattresses and related items left in situ the operator should aim to achieve a burial depth of 0.6m below the seabed.

- For any piles being severed below the seabed the operator should aim to achieve a depth of 3m.
- As a minimum, the area covered for debris clearance should include a 500m radius around any installation and a 100m corridor (50m either side) along the length of any pipelines.
- Any infrastructure left in situ will be subject to a risk based monitoring regime agreed with BEIS as part of the decommissioning programme.

6.2 Learning from O&G regulation & practice

In this section we consider the learning from O&G decommissioning regulation and practices that may be beneficial for offshore wind decommissioning. Firstly, we consider the main differences in the offshore wind / renewables and O&G decommissioning regulations. We then examine the lessons from O&G decommissioning that may be applicable to offshore wind decommissioning. Finally, we examine the options and current practice from the O&G decommissioning industry for the reuse of infrastructure and the handling of waste to identify practices that may be adopted by the offshore wind industry.

Consultation feedback

Several consultees pointed out that there are significant differences between offshore wind and O&G infrastructure to be decommissioned, including that OWFs consist of many structures whereas O&G installations are usually only a couple of structures and the risk of hydrocarbon release from failure of well containment. However, whilst it is important to bare these differences in mind there are many useful lessons learned from the O&G industry, these are discussed in section 6.2.2 below.

6.2.1 Differences between the OWF and O&G decommissioning framework

The diagram below sets out the main differences in the process of submitting, approving and conducting the decommissioning programmes between O&G and offshore wind. Although the process is broadly similar, the main difference is the timing of submission of the initial decommissioning plan. For OWF there is much more focus on considering decommissioning earlier in the life of the project. OWF developers are required to submit the decommissioning programme prior to construction, whereas for O&G installations the decommissioning programme is only required 3 to 5 years prior to decommissioning.

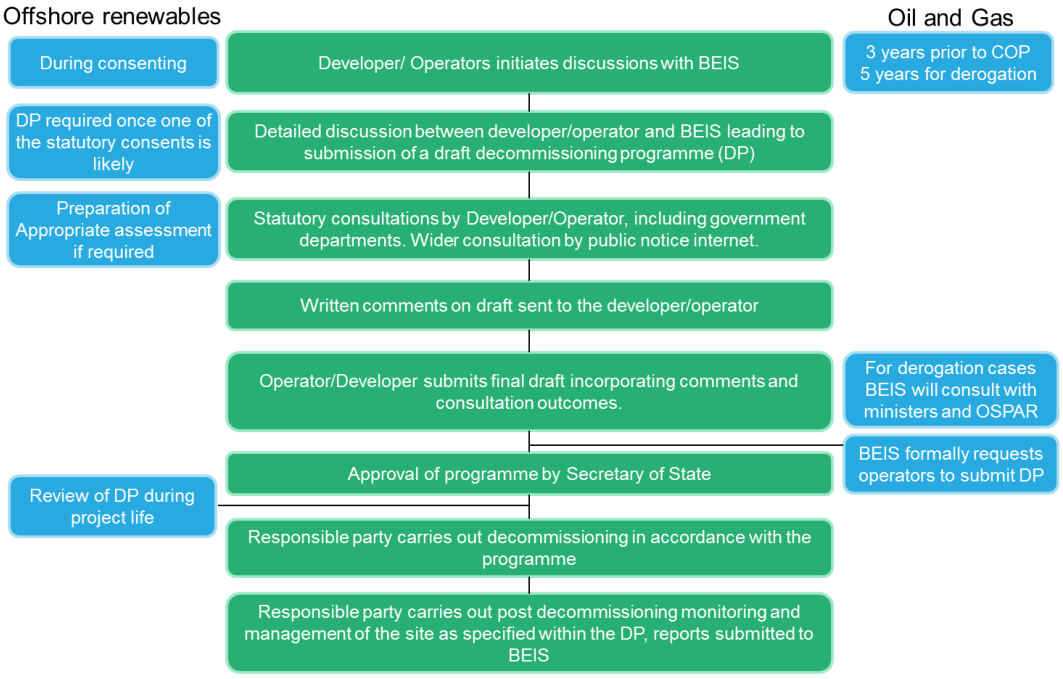


Figure 9: Comparison of decommissioning programme process in offshore renewables and O&G.

The differences in the timing of the decommissioning programme submission and approvals leads to differences in the management of securities for the two types of decommissioning. The Energy Act 2008 gives the Secretary of State powers to determine the type and level of security which must be held by the party responsible for decommissioning the OWF. The BEIS guidance outlines the acceptable security measures, and as part of the decommissioning programming the level of financial security must be set out by the developer. In contrast offshore O&G decommissioning has no established security process in place, although the Energy Act 2008 awards powers to the Secretary of State to request a security be put in place, a consistent process is yet to be established. Although there is a process in the BEIS guidance on decommissioning O&G installations (26) for reviewing the financial stability of a company in relation to their decommissioning obligations. BEIS is in the process of updating this guidance and is yet to release updated financial guidance (27).

As well as the differences in the timing of submission of the initial decommissioning programme and the way financial securities are managed, there are also differences in the legislation that governs the decommissioning proposals. O&G decommissioning is governed by the OSPAR 98/3 decision which stipulates that disused O&G installations must be removed. Whilst this decision does not apply to offshore renewable installations, OSPAR has provided guidance in relation to OWFs that references UNCLOS Article 60, and IMO 1989 Guidelines stating that abandoned or disused offshore installations have to be removed. Therefore, the governing principle is that the disused infrastructure is required to be removed, which is the same for both O&G and offshore renewables.

As the OSPAR 98/3 decision does not apply to pipelines, the situation of pipelines for O&G installations is similar to the situation for cables for offshore wind

installations. The baseline assumption in both cases is that the infrastructure will be removed, however UK legislation, based on the IMO 1989 Guidelines considers arguments for leaving suitably buried infrastructure in place. Decisions as to whether the infrastructure (pipelines or cables) can remain in place are made on a case by case basis for both O&G and offshore wind infrastructure.

6.2.2 Lessons learned from O&G decommissioning

The main lesson learnt from O&G decommissioning is to plan the decommissioning early. This was reiterated throughout the consultations conducted as part of this study. The current process of requesting a decommissioning plan prior to construction is taking on board this lesson and should lead to improvements compared to the situation where O&G infrastructure was installed with no thought regarding the decommissioning.

Although progress on upfront planning has already been made it is essential that the drafting of the decommissioning programme is given the correct consideration and it does not become a box ticking exercise. Unlike in O&G it is expected that OWF decommissioning plans are reviewed throughout the operational period of the OWF and updated according to the latest information available. This will maintain the relevance of the decommissioning programme, ensuring it contains the correct information as the project approaches decommissioning.

Another lesson is ensuring that the responsible party has enough funds to meet their decommissioning obligations. Again this has been addressed to some extent within the existing framework by requiring the developers to provide securities but this relies on accurate cost estimation. A security will only fulfil its purpose if it provides enough funds for the decommissioning. The O&G industry has found that operators, particularly during the early decommissioning programmes underestimated the cost (and the time) of the decommissioning programme, e.g. the North West Hutton platform which cost 50% more to decommission compared to the original estimate and the offshore operations took two years longer than planned (28).

Discrepancies between estimates and outturn costs can be caused by vessel constraints, e.g. the assumed vessel not being available and so a more expensive vessel must be used, or high demand for vessels generally pushing up the vessel cost. In some O&G projects the lack of vessel availability has significantly affected the project cost. To avoid this situation in offshore wind, developers stated during consultation that they would like to see flexibility in the decommissioning schedule, allowing them to take advantage of lower vessel rates in periods of low vessel demand. However, this request must be balanced with the needs of the regulator and ensuring that the developer will be able to meet their decommissioning obligation. There may be a higher chance of the developer defaulting if the decommissioning is allowed to be delayed for a long period of time.

The O&G industry has refined cost estimations through the use of the Work Breakdown Structure (WBS), and the OGA has completed cost benchmarking across the operators in recent years (conversations during consultations) in an effort to understand and reduce the decommissioning costs. Ensuring a consistent

baseline for cost estimates through the use of a suitable WBS (see section 0) and then benchmarking costs across developers should help improve cost estimations ensuring adequate securities are being held. The role of the OGA encouraging dialogue and fostering collaboration across decommissioning projects generally has been valuable and allowed cost reduction on projects that have been able to learn lessons from others.

One issue that has become apparent during the decommissioning of O&G assets in the North Sea is understanding the nature of all the infrastructure that needs to be removed. This includes what the infrastructure is and where it is located. Due to the age of some of the assets, data about components is not always available or has not been recorded correctly. Recording the as installed data for OWFs should be a priority during the development in order to simplify decommissioning. The data should also be stored so that it is accessible when required later in the life of the project. This should be easier than it has been in the past (for older O&G assets) through the use of digital technology, but capturing high quality data is key to aiding the decommissioning process.

Recent experiences from O&G decommissioning include operations which have been executed with little reasoning or evidence to support the choice of methodology. To minimise this occurring in OWF decommissioning and allow for review, the reasoning and evidence for OWF decommissioning methodology should be recorded. It was also noted during the consultation that agreeing on practices too early, based on limited evidence, can cause problems. Hence it is reasonable to recommend retaining flexibility in practices and decisions if new evidence becomes apparent.

Consultation feedback

The key feedback regarding the lessons learned from O&G decommissioning is:

- Plan for decommissioning early
- Ensure the responsible party has enough funds to meet the decommissioning obligation
- Consistent cost estimations and cost benchmarking can be a tool for cost reduction
- Allow flexibility in decommissioning programme to take advantage of lower vessel rates
- An industry body championing a decommissioning work stream has led to effective collaboration
- It is crucial to understand the nature of all installed infrastructure and any changes to this infrastructure throughout the life of the project need to be documented
- Keep a comprehensive record of decisions and reasoning behind the development of guidelines, recommendations and practices, with the potential to revisit them if new evidence emerges

6.2.3 Waste handling and reuse

When discussing waste handling, the waste hierarchy is used to rank waste management options according to what is best for the environment (13). The waste hierarchy, illustrated previously in Figure 5, should be applied in all

decommissioning projects with the aim of handling the waste in the most environmentally responsible way.

O&G decommissioning projects have to handle large amounts of waste that is brought to shore for reuse, recycling and disposal. The industry is reporting achievement of a high level of recycling of their waste streams at approximately 97% per weight. However, they have been much less successful at reuse of materials and components. The largest volume and weight of waste is steel and that is largely recycled.

Opportunities for reuse are being explored, with the preferred options being reused offshore including reuse of infrastructure at another field, for offshore wind installations and carbon capture and storage. In reality, the applications have been limited and there are a number of technical constraints that have limited widespread applications. Reuse of plant, equipment and materials in other applications are also being considered, such as reuse of steel rather than recycling, or recondition of pumps and valves for lower demand applications. Again, success has been limited to date, despite industry interest and activity to support these applications.

The O&G industry also have a number of hazardous waste streams to managing including Naturally Occurring Radioactive Material (NORM) as well as hydrocarbons and associated contaminants. Regulations are developed in order to ensure that impacts to health and the environment are considered appropriately in the handling and management of these waste streams.

Much interest has been given to the socio-economic opportunities associated with job creation through onshore waste management jobs. It should be noted that for O&G decommissioning it is estimated that onshore recycling will account for only a few percent of the overall decommissioning costs, a relatively limited opportunity in the scale of the overall expenditure. Waste management will be an important factor in offshore wind decommissioning and so there are lessons that can be learned from the O&G industry. Although it is worth noting that the O&G industry have a much higher level of hazardous waste than is contained within an OWF, as such not all regulation will be directly applicable.

Consideration will need to be given to any waste streams that cannot be reused or recycled. The handling of the WTG blade material is uncertain, as discussed in section 4.2.9. It is generally assumed that the onshore industry will come up with a solution and that there will be options at the time of decommissioning. However, without industry efforts, and regulatory signals, in this space a solution is unlikely to materialise and this may be an area where some government intervention is required to prevent material ending up in landfill. For example, in Germany there is a ban on composite material being sent to landfill (29).

Consultation feedback

During the consultations it was discussed that because the O&G industry has adopted a single lift approach to decommissioning some of the potential dismantlement and onshore works has been lost to Norway, where deepwater ports capable of handling the large vessels used to lift the structures. For offshore wind decommissioning it was suggested there may be an opportunity for the Scottish Government to help shape the type of removal and dismantlement carried out and therefore the facilities required.

Regarding the handling of steel waste, the consultees believed there is enough capacity in the UK to handle the current scrap steel and other waste from O&G decommissioning and that the steel waste from OWFs could also be handled. For offshore wind the waste handling should be easier as there is no NORM to deal with, and less contaminated or hazardous material, although bioaccumulation may need to be dealt with.

SEPA mentioned that there are concerns over whether the market will be able to accept the large volume of scrap steel that will come to market as a result of O&G decommissioning. This could affect the price of steel and makes it very difficult to predict the price in the future.

To exploit the potential opportunities presented by waste management for the Scottish supply chain, Marine Scotland and the Scottish Government need to consider what sort of work they would like to see in Scotland. There may be competition from international markets, the consultees stated this would depend on the cost, especially after Brexit, the cheapest and most technically competent option will be chosen.

Marine Scotland could consider whether Scotland would be willing to accept, handle, reuse and recycle the waste, and what sort of profitable industry could be built around these activities. Currently the feeling is that the UK cannot compete with Germany and Denmark where waste is processed very quickly after landing onshore. Additionally, for Scotland to exploit such opportunities there may need to better consider the handling and tracking of waste. SEPA has found waste from the O&G industry ending up in unauthorised sites and are currently working with BEIS to improve the process, particularly through implementation of Active Waste Management Plans.

In agreement with many of the comments from other consultees, SEPA highlighted the following experience gained from early O&G decommissioning:

- Difficulties in handling NORM, asbestos and transformers
- Operators not having a good understanding of the type & quantity of material they have offshore
- Operators attempting to abdicate responsibility for waste once it had been passed to contractors
- Waste ending up in facilities without the proper infrastructure or authorisation to handle that waste stream
- Only 2% of decommissioning spend is onshore so waste handling has thus far had limited attention by industry
- There is good industry collaboration around the topic of decommissioning. Collaborations include operators sharing experiences and improving the supply chains, including specific companies e.g. Peterson and Veolia working together to provide decommissioning services effectively. Similar collaborations should be encouraged.

7 Experience from decommissioning OWFs

Few offshore wind projects have been decommissioned to date but several early OWFs have reached the end of their design life and more are expected to be decommissioned in the near future. In this section we review several OWFs where decommissioning activities have taken place to date or are planned in the near future including the technical approaches and any reported lessons learned. We then go on to review the existing decommissioning programmes for UK OWF projects and examine the available Scottish decommissioning programmes in more detail.

7.1 Decommissioning experience to date

The table below lists the OWFs that have been decommissioned partly or wholly, or are planned to be decommissioned in the near future. The decommissioning activity that took place, or is planned to take place in each case is outlined in the sections below followed by any lessons learned on the projects.

Table 5: Offshore wind decommissioning activity

OFW name	Location	Operator	WTGs	Foundations	Nameplate capacity	Status
Vindeby	Denmark	Dong Energy	11 x Bonus B35/450 kW	CGB	4.95 MW	Decommissioned 2017
Yttre Stengrund	Sweden	Vattenfall	5 x Neg Micon 2MW	Monopile	10 MW	Decommissioned 2016
Lely	Netherlands	Nuon (Vattenfall)	4 x NedWind 40/500kW	Monopile	2 MW	Decommissioned 2016
Hooksiel	Germany	Offshore Wind Solutions	1 x Bard 5.0MW	Tripile	5 MW	Decommissioned 2016
Robin Rigg	Scotland	E.ON	60 x Vestas V90-3MW	Monopile	180 MW	2 turbines decommissioned 2015
Beatrice demonstrator	Scotland	Repsol Sinopec Resources UK (RSRUK) and Scottish and Southern Energy (SSE)	2 x Senvion 5MW	Steel jackets	10 MW	In decom planning

7.1.1 Vindeby – Demark, Dong Energy

Decommissioning overview

Vindeby was one of the world's first OWFs and began operating in 1991, with relatively small WTs rated at 450kW. Dong announced decommissioning in 2016 following 25 years of operation. Dong completed the decommissioning of Vindeby in September 2017.

Dong decommissioned Vindeby using reverse installation techniques. The blades, nacelles and towers were dismantled and taken down using a mobile crane on a jack up vessel. The concrete gravity bases were broken up on site using hydraulic demolition shears, hydraulic hammers and milling tools, then shipped to shore along with the blades, nacelles and towers.

All wind turbine components and foundations were sent ashore following decommissioning. Dong intended to reuse the parts as much as possible for other wind turbines. Some of the blades were sent to DTU Riso for a research project and others are being reused in noise barriers along major roads in Denmark.

7.1.2 Yttre Stengrund – Sweden, Vattenfall

Decommissioning overview

Yttre Stengrund began operating in 2001, with five NEG Micon WTGs rated at 2 MW each, and in 2015 it became the first OWF in the world to be decommissioned. Decommissioning of the WTGs began in November 2015 and was completed in January 2016. The cables were removed in September 2016.

The decision to decommission the site was taken because it was too costly to repair and maintain the Neg Micon WTGs. These WTGs were an early model and relatively few of them were installed (only around 50) meaning it was difficult to obtain spare parts. The cost of upgrading the WTGs and gearboxes was found to be too great and so Vattenfall decided to decommission the site.

The rotors and blades were removed in one piece followed by the nacelle and the towers. The monopile foundations were cut level with the seabed using a diamond wire saw (30). The general philosophy was to dismantle the WTGs in the reverse order of installation.

Prior to the decommissioning taking place, the cost was estimated to be SEK 10 million (31) (approximately £0.88m). The final decommissioning cost was not publicly reported.

Lessons learned

Cutting the monopile foundations at the seabed proved to be the most complex task. The first foundation took 29 hours to cut with the diamond wire saw, however lessons learned from this first operation and refinement of the process meant that subsequent cutting operations took 13 hours to complete (30).

7.1.3 Lely – Netherlands, Nuon (Vattenfall)

Decommissioning overview

Lely began operating their 500kW Nedwind WTS in 1992 and Nuon decommissioned the WTGs in 2016, after 24 years of operation, following the failure of one of the WTGs in 2014.

The WTGs were removed in three sections; the nacelle and the blades removed as one section and the tower as two sections. It took three days to remove all four of the WTG structures. The full 27m length, 3.7m diameter, 84 tons, monopile foundations were removed using a vibratory hammer. Within three weeks all wind turbines, monopiles and cables were removed (32).

7.1.4 Hooksiel – Germany, OWS (Offshore Wind Solutions)

Decommissioning overview

The Hooksiel 5 MW Bard demonstrator WTG was installed in 2008 and decommissioned eight years later in 2016 following a number of failures of the gearbox and transmission failures. Regulatory approval for the project expired in 2017 which meant repairing the WTG was not economically viable (33). The rotor and hub were removed in a single lift. The tripile foundation (similar to a monopile, but with three legs) was cut at each leg and removed before the three piles were removed.

7.1.5 Robin Rigg – Scotland, E.ON

Figure 10: Robin Rigg OWF. Source: Arup

Decommissioning overview

The Robin Rigg OWF was commissioned in 2010 operating with 3 MW Vestas WTs. Two WTGs at the Robin Rigg OWF were removed in October 2015. E.ON stated that the decision to remove these WTGs was due to seabed erosion around the base of the WTGs reducing the embedment depth to unacceptable levels (34).

As a result, two of the WTGs were found to be at risk of collapse and the decision was made to remove them.

During the planning of the decommissioning the E.ON team found that as decommissioning was only envisaged at the end of life there was no established methodologies and no consents or licences in place to allow the completion of works.

The Robin Rigg monopile diameter was greater than any decommissioning undertaken in O&G and so a specific methodology had to be devised. The grouted connection between the monopile and the transition piece caused additional complications as the connection was not easy to dismantle. The solution was to cut the monopile in two places, 1m below the grout connection and 2m above the current seabed and remove the monopile in two sections. This leaves the monopile stub protruding 2m above the current seabed depth.

Each WTG was removed in six lifting operations. Each blade was removed separately in order to be stacked on the deck. The nacelle and hub were lifted as one unit and the tower removed in two sections.

Lessons learned

The E.ON team (34) identified a number of lessons learned mainly as a result of having to complete the decommissioning much earlier than expected. The team noted that the decommissioning strategy (produced prior to construction) should have been reviewed and updated by the operation and maintenance (O&M) team post construction when all the information about the OWF's construction was available. The team also noted that the OWF's design should consider the potential need for disconnection points within the electrical system.

There were several lessons learned regarding the writing and updating of the decommissioning plan, noting the plan should:

- Identify restrictions and constraints of a potential decommissioning project, including consents/ licences, access, available techniques etc.
- Contain clear decommissioning method options rather than 'let's figure it out later'.
- List the assumptions around the equipment that will be used during decommissioning.
- List the vessel capability requirements.
- Use methods that minimise diving.

Finally, there were several lessons learned relating to conducting regular bathymetric surveys, some of these suggested actions may have helped to avoid the early decommissioning of the two WTGs. The suggestions included:

- Bathymetric surveys should be planned annually as a minimum.
- After major storm and tidal surge events additional surveys should be considered particularly at high risk locations.

- Surveys should extend out of the wind WTG site at a reasonable distance to consider wider seabed movements in the vicinity, this will provide early indication of threats to site areas.
- Sites in close proximity should consider sharing survey data.

7.1.6 Beatrice Demonstration – Scotland, Repsol Sinopec Resources UK and Scottish and Southern Energy

Figure 11: Installation of the complete Beatrice Demonstration WTGs. Source: Repsol Sinopec (35)

Decommissioning overview

The Beatrice Demonstration consists of two, five MW Senvion, WTGs placed on steel jackets within the Beatrice oilfield. At the time of installation, in 2007 it was the world's first deep water project, installed in waters over 40m, and the first demonstration of jacket substructures for an OWF. The project was unusual in that it was consented under the O&G regulatory framework, through DECC, because it was part of the operating oil field.

The Beatrice oil field has now ceased production of hydrocarbons, and planning for decommissioning has commenced. The WTGs are planned to be decommissioned along with the rest of the O&G infrastructure during 2024 to 2027. As for construction, it is likely that they will be included in the decommissioning approvals process for the O&G infrastructure.

The plan for decommissioning is using a reverse installation method, removing the whole WTG (blade, nacelle and tower) as a single unit and transferring the whole structure to shore for reuse or recycling. The jacket piles will be cut 3m below the seabed. The current plan is to lift the jackets as a single unit, however a series of smaller lifts is still an option

RSRUK have stated in their EIA that BEIS have suggested that cables should be treated in the same manner as pipelines, i.e. subject to a CA as described in section 6.1.2. As such they will consider the safety, environmental, technical, commercial and societal impacts or the options, and make recommendations on a preferred option. (35).

7.2 Summary of decommissioning experience

Limited decommissioning of OWFs has been undertaken to date, with only 23 WTGs removed to date. The vast majority of these were WTGs rated below 2 MW, and therefore compared to contemporary technology they are much smaller both in terms of weight and height. The associated substructures and foundations have mainly been smaller diameter monopiles, alongside some relatively unique concrete and tripile foundations.

All of the OWFs decommissioned to date have been completed using reverse installation methods for WTG removal. The activities required the use of large vessels, similar to those used for installation, for the removal of blades, rotor hubs, nacelles and towers. Although reverse installation is relatively straight forward it is very costly, requiring highly specialised vessels.

Removing substructures and foundations has required specialist equipment and often unique methodologies to handle monopiles, which are larger than O&G versions, but small compared to contemporary projects. The approach to concrete structures also required a novel approach, noting that there are currently limited proposals for concrete substructures in UK waters. No jacket substructure removals have been undertaken to date.

Removing the foundations has proved to be the most technically challenging aspect of decommissioning to date, and is likely to offer more challenges as larger diameter cuts and heavier lifts are required. Considering the projects completed to date it is understood that two projects completely removed the foundations (Vindeby - Dong, CGB and Lely - Nuon, monopiles) and two other projects cut the monopiles at or above the seabed (Robin Rigg - E.ON and Yttre Stengrund - Vattenfall).

There are several lessons learned identified from these projects for future decommissioning plans and programmes, these are:

- Having a good understanding of the installation methods and updating the decommissioning plans following installation to take account of the installation methods would improve the decommissioning plans.
- Including the vessel requirements and tools / technology requirements in the decommissioning plan. If the vessels, tools, technologies are not available then consideration as to how to these requirements may be fulfilled by the time the OWF is decommissioned should be included e.g. technology development programs, alternative removal method to make use of other vessels etc.
- Consideration for phased decommissioning or removal of some WTGs but not all, and how this would affect the ongoing operation of the OWF.

- Identifying options for recycling the plastic and fibre glass components (e.g. blades) will require some thought and investigation prior to decommissioning, recycling markets for these materials are not as established as for metals.
- Developing methods of removal, other than reverse installation may help reduce costs.

7.3 Experience from approval of OWF decommissioning programmes

Prior to construction each UK OWF developer will submit a decommissioning programme to BEIS. BEIS then review and approve the decommissioning programme. Over 20 decommissioning programmes have been reviewed during the course of this work. This review found that each of the decommissioning programmes follows the same broad structure as outlined in the BEIS guidance notes. The programmes cover:

- Background information
- Description of items to be decommissioned
- Proposed decommissioning measures
- Environmental Impact Assessment
- Consultations
- Project management and schedule
- Seabed clearance, site restoration and post decommissioning monitoring

Each of the programmes contains a similar level detail on the following areas:

- site characteristics including the OWF layout,
- physical conditions including seabed and metocean conditions,
- offshore biological environment, and
- offshore human environment including shipping, fishing, O&G, other OWFs, aggregate extraction etc.

Generally, the background information is not discussed specifically in the context of decommissioning activities and the programmes do not put forward mitigations regarding the points raised.

The plans describe the items to be decommissioned including the WTGs, foundations and cabling, some also include the OFTO assets. There are varying levels of detail, some include the equipment sizes and weights, others provide a generic description of the OWF structures. Plans written further in advance of construction may not be able to provide the final details of the equipment as this was unknown at the time of writing.

The proposed decommissioning measures generally state that a reverse installation process will be used. The plans vary in the level of detail regarding

the actual process that will be completed and specific details of this process, some examples of the varying levels of detail are listed below:

- WTG removal: Some decommissioning plans state that each blade will be removed separately, in most cases the approach is not explicit.
- Vessels: The type of vessel used for the WTG and foundation removal is not described in detail, some plans mention this is likely to be a jack-up or HLV.
- Removal process: Most of the plans are not clear about whether the process will be to remove all the WTGs, followed by all the foundations or remove each WTG and then it substructure/foundation before moving to the next location.
- Substructure/Foundation removal: The depth of removal below the seabed is only stated in some of the decommissioning plans, usually 1 to 2m below the seabed.
- Substructure/Foundation removal: Some of the plans state that the transition piece and foundation will be removed in one or two lifts but several plans are not explicit.
- Cable removal: The plans state whether the cables will be removed or left in situ, with the majority assuming cables are left in situ. However, many are not clear on the required burial depth of cables left in situ.

Each of the decommissioning plans has a section on the EIA as suggested in the guidance. Each of the plans considers the requirements for an additional EIA prior to decommissioning, and how this may be decided nearer the time of decommissioning. The decommissioning plans do not discuss in detail the environmental issues and mitigations, generally stating reviews will take place throughout the OWF operation and a final review prior to decommissioning.

Many of the plans include responses from consultees, and many also state the measures undertaken to address the consultees concerns. There is generally a good level of detail regarding the consultations and their responses.

The final sections on schedule, project management, seabed clearance, site restoration and post decommissioning monitoring are broadly similar and generic across the decommissioning plans. Some plans give a timeframe for decommissioning and the expected length, but with little detail on how this was calculated.

Overall many of the plans contain similar (if not the same) statements on the approach to decommissioning, there are few specific details on exactly how the decommissioning will be carried out and what equipment will be required.

Consultation feedback

The consultees were asked about the writing and review of decommissioning plans for new projects, they noted that the level of detail and scrutiny of the plans is particularly subject to the experience level of the staff involved in the writing and review process. It was also acknowledged that although the decommissioning programme was necessary at the start of the development, the level of effort may not be proportional to the issues arising. It was also mentioned that some O&G decommissioning plans assumed certain technology would be

available at the time of decommissioning and now that is proving not to be the case. The development of adequate technology is something that should be considered during the review of the decommissioning plans throughout the OWF's life.

7.4 Review of current Scottish OWF decommissioning plans

In this section a more detailed review of the available Scottish OWF decommissioning plans has been undertaken. This outlines the information within the decommissioning plan and provides comments on the level of information within the decommissioning plan and any outstanding questions.

7.4.1 Beatrice OWF

Introduction

Beatrice Offshore Wind Limited (BOWL) received consent in 2014 and construction began in 2017 of 588 MWs. The development consists of 84 7MW WTGs and is located in the Outer Moray Firth.

Decommissioning philosophy

The decommissioning plan (36) states that BOWL will decommission the Beatrice OWF in accordance with the following guiding principles:

- No harm to people
- Consider the rights and needs of legitimate users of the sea
- Minimise environmental impact
- Promote sustainable development
- Adhere to the Polluter Pays Principle
- Maximise re-use of materials
- Ensure commercial viability
- Ensure practical integrity

A number of options for decommissioning have been considered in the decommissioning plan. The following options are set out as possible alternatives for the OWF at the end of its life:

- Decommissioning and construction of a new OWF
  Assumes that wind power is still commercially attractive and that the technical integrity of the OWF is declining and the most economical approach is to replace the aging infrastructure rather than increase O&M effort to keep the OWF running.
- Repowering
  Assumes the electrical infrastructure and the foundations remain sound. It

could be possible to re-use these parts of the OWF, replacing the WTGs with new models and potentially replacing substructures at an appropriate scale.

- Step-down
  Assumes it is not economical to invest in new technology but that the WTGs will continue to operate beyond their 25 year design life. The OWF would be decommissioned under a controlled step down, where WTGs are gradually shut down as their technical integrity declines.

Methodology

The current option for decommissioning proposed in the decommissioning plan considers the removal or disposal in situ of each element in turn. The proposed decommissioning program for each element is outlined below

WTGs

WTGs will be removed in full and will be a reversal of the installation process. The decommissioning plan sets out a methodology using suitable HLVs. The plan also states the blades and nacelle will be removed separately.

Regarding the waste material handling, the decommissioning plan states that any hazardous material will be removed from the WTGs and disposed of in line with relevant regulations. The intention is to sell the steel components for scrap to be recycled. The WTG blades will be disposed of in accordance with the relevant regulations in force at the time of decommissioning.

Foundations - Jackets

The jackets will be removed in full and will be the reversal of the installation process. The decommissioning plan states the jacket will be 'separated' from the piles. The plan also states a HLV will recover the jacket and take it to shore for re-use or recycling.

Foundations – Pin pile

The Beatrice OWF uses pin pile foundations for the WTGs and the OTM, these will be decommissioned in the same way. The approach will be to cut the piles at or below the seabed. The proposed cutting method is diamond wire cutting, but the decommissioning plan notes that other methods may be preferred at the time of decommissioning. The plan also states the material removed will be taken ashore for recycling.

The decommissioning plan compares the options of complete pile removal and the preferred option to cut the pile at the seabed. The decommissioning plan states the cutting method is consistent with the guiding principles for the following reasons:

- Fewer offshore activities and no requirement for excavation undertaken by divers, reduces risk of harm to people.
- Negligible risk presented to other sea users providing adequate notification of activities, the cut is at a sufficient depth and post decommissioning monitoring

is carried out. The alternative of complete removal would cause more disruption during the activities and leave a scour hole from excavation.

- Cutting minimises environmental impact as the works are considerably reduced compared to complete removal and reduced seabed recovery time compared to complete removal which would cause extensive evacuation pits and require dumping of evacuation material.
- BOWL assumes seabed recovery is highly likely in the case of cutting the piles at the seabed and state that there would be considerable impacts to the site over the short and medium term if the piles were to be completely removed.
- Piles will remain buried and so the plan is consistent with the polluter pays principle as far as is reasonably practicable. BOWL states that although complete removal adheres in principle the excavated waste will have to be disposed of and the seabed restored.
- Cutting is considered more economically viable than complete removal, and considered a more practical solution.

The complete removal of foundations would provide more material for re-use than the cutting method and so the methodology is not consistent with the guiding principle of 'maximise re-use of materials'.

Offshore transformer module

The OTM topside structure will be removed in a single lift and taken by a suitable vessel to an onshore facility for dismantling and re-use, recycling and disposal of component parts. The jackets substructures will be removed as outlined above in a similar methodology to the WTG substructures.

Intra-array and export cables

The decommissioning plan proposes leaving the buried subsea intra-array and export cables in situ having cut and sealed the ends of the cables and subsequently buried them below the seabed. The loose ends of cables that remain where the cables are cut at the WTGs and OTMs will be recovered to shore for recycling.

The decommissioning plan compares the options of complete cable removal and leaving the cables buried in situ. The decommissioning plan states that leaving the cables buried is consistent with the guiding principles for the following reasons:

- Burial below the seabed will not pose a risk to marine users, post decommissioning monitoring will identify any cable exposure.
- There is no associated environmental impact of buried cables and no residual pollution risk
- More economical than complete cable removal

The decommissioning plan acknowledges that there is not potential for material re-use if the cables remain buried and that some future activities e.g. extraction may be limited along the cable corridor and so the methodology is not consistent

with the guiding principles of maximising material re-use and promoting sustainable development.

Post decommissioning monitoring

The decommissioning plan states that, where considered necessary, post decommissioning monitoring of the seabed will be carried out following the decommissioning works. The details of post-decommissioning monitoring, maintenance and management will be discussed with stakeholders close to the point of decommissioning.

Comments

The decommissioning methodology is fairly standard compared with other decommissioning plans in the UK. Leaving piles and cables in situ provide economic benefits and reduces the risk to workers involved in the decommissioning programme but leaves a potential hazard in place that will require future monitoring. The consideration of the future monitoring requirements is not covered in detail within the decommissioning plan.

The cable burial depth and cutting depth of the piles is not stated. The burial/ cutting depth will have an effect on the likelihood of future exposure and therefore risk to other marine users and as such an adequate burial/ cutting depth should be established.

As with most other decommissioning plans there is a lack of information around the specification of the HLV required for each task and whether the same vessel would be needed to remove the WTGs, jackets, piles and OTM or if different vessels could be utilised and what features the vessel/ vessels require for each task.

There is no indication of the cutting method used to separate the jackets from the piles. As this is a grouted joint then cutting will be required, diamond wire or abrasive water cutting are the available alternatives that would be suitable.

The blades will result in a significant amount of waste material that is currently not widely recycled. The decommissioning plan states that this material will be disposed of in accordance with the relevant regulations, the decommissioning plan makes no suggestions as to how this material may be recycled or an alternative use found.

Environmental concerns

The decommissioning plan outlines the physical and biological environment in the vicinity of the OWF and does not raise any specific concerns relating to the environment. The decommissioning methodology makes reference to the measures that will be taken to reduce environmental impact. Measures include removing the nacelle in one complete piece to reduce the risk of spills and dismantling equipment onshore to reduce the risk of spills or material discharge.

The decommissioning plan states that the EIA for Beatrice will be updated, if necessary, prior to decommissioning. The decision to update the EIA will include consideration of:

- The understanding of the baseline environment at the time just prior to decommissioning, informed by the findings of the environmental monitoring of the development and engineering/ asset surveys such as cable burial monitoring.
- A review of other marine use (fishing, navigation, etc.) with potential to be affected by decommissioning.
- Amenities, the activities of communities and on future uses of the environment.
- Historic environment interests.

7.4.2 Other OWF decommissioning plans

The following Scottish OWF have been consented but at the time of writing decommissioning programmes have not been submitted, or were not available for review:

- Inch Cape Offshore Ltd
- Neart Na Gaoithe
- SeaGreen Alpha & Bravo
- Moray East
- Kincardine (Decommissioning plan submitted)
- Forthwind (Decommissioning plan submitted)
- Dounreay Tri

8 Cost and securities

In this section we examine the decommissioning costs and the driving factors behind these costs, as well as how they may change between first estimation and the time of actual decommissioning. We also consider the different types of securities available and what these offer in terms of relative benefit versus the potential impact on the levelised cost of energy.

Consultation feedback

When discussing decommissioning cost estimates during the consultation it was noted that the cost estimates are based on many assumptions and that variation in costs may be down to experience, early OWFs having many unknowns, different risk profiles, different decommissioning philosophy and different attitudes towards future liabilities.

8.1 Cost drivers across the WBS

It is helpful to consider the costs for OWF decommissioning in terms of the decommissioning WBS suggested in section 0. The cost drivers, and expected costs, for each element will vary across different sizes and location of assets. The main driver for the majority of costs is the day rate of the vessel required for each offshore task. This rate is highly dependent on the vessel market at the time of decommissioning and can make the costs difficult to estimate with a high degree of certainty. The sections below give an indication of the day rates associated with each activity. All costs reflect the 2017 market for operations in UK waters.

Preparation of assets

The cost driver will be the cost of the vessel and crew required to carry out the preparatory works on the WTGs and the foundations. This work is likely to involve a PTV. The expected day rate would be in the order of £10,000 - £20,000 per day. The time taken for the works would be several days per WTG depending on the size of the team used. Multiple WTGs could be worked on simultaneously by different teams sharing vessels and reducing the amount of time vessels needs to be on site.

Removal of WTGs

Along with removing the foundations, removing the WTGs is one of the most expensive decommissioning tasks as it will require the largest vessel. The vessel required will likely be similar to the vessel used for installation and may cost in the region of £200,000 per day for a large jack-up WTIV. The vessel may also be used to transporting the WTGs back to port, or a separate vessel may be used for this task. The duration of the removal operations and the amount of time taken for the vessel to move WTGs to shore will determine the total cost of the operation. The use of a separate vessel, such as a transport barge may appear to be an attractive option as it would allow the jack up to stay on site and potentially reduce the duration for which the jack up vessel is required. However, the use of

a barge requires benign weather conditions and low sea states which make this option impractical for many OWF locations.

Removal of foundations

As with removing the WTGs this task will require a large vessel capable of lifting the foundations as well as supporting the cutting operation required to cut the monopile or jacket piles below the seabed. Again this will be a large vessel with a day rate likely in the region of £150,000 - £200,000 per day. These vessels may be capable of removing several foundations per day and transporting several back to shore at a time. Jacket foundations are likely to take longer to remove, require more area on deck and require more vessel trips to transport back to shore.

Removal of offshore substations

To remove the offshore substations a large HLV is likely to be required. This operation will require several heavy lifts to remove the substation topside and the substation foundation. Although the operation will be much shorter in duration than the WTG and foundation removal, the HLV required may cost £350,000 - £400,000 per day. Together with the mobilisation rate for such vessels this operation will likely cost around £2m per substation.

Decommissioning of cables

Whether the cables are decommissioned and left in situ or removed will dramatically affect the cost of the operation. If the cables are left in situ, then some work will be required to ensure the cable ends are buried. This is likely to require an ROV support vessel with ROVs equipped with cable burial equipment, likely to cost between £20,000 - £40,000 per day. If the cables are to be removed then it is likely a cable installation vessel, equipped with the required cable lifting equipment and winches will be required. This may cost in the order of £40,000 to £50,000 per day and require weeks or even months to remove all cables from a typical OWF. Hence the removal of intra-array and export cables could significantly increase the costs of completing the decommissioning programme.

Seabed clearance

The seabed clearance activities may require additional scour protection placements, where foundations have been removed, or may require the removal of scour, depending what materials were in place initially, and what is agreed in the decommissioning plan. Scour removal, as with cable removal, will be a costly process, requiring large vessels with costs upwards of £50,000 per day for scour removal. Post decommissioning surveys will be required with a survey vessel costing in the region of £30,000 per day and require several days or weeks to complete full surveys of the site.

Recycling and waste management

The scrap value of decommissioned WTG and foundation components may bring a small amount of revenue to the developers as part of the decommissioning programme. However, there will also likely to be a cost involved with the onshore dismantlement and waste handling that should not be neglected when

considering the overall decommissioning costs. There may also be a cost associated with the disposal of the blades as it is not currently known how this material may be recycled. The worst case scenario is that this material will be landfilled at a cost to the developer. All scrap values are highly market-dependant, but 2017 scrap steel (e.g. cars) can be traded for £55-95 per tonne (37). 2018 landfill costs for GRP are in the region of £89 per tonne (38).

Consultation feedback

It was noted that recycling or disposal of blades is a growing issue for onshore OWFs, and it is likely that a market for recycling or reuse of materials may develop for these blades well in advance of the needs of large-scale OWF decommissioning.

Monitoring

Ongoing monitoring may be required after decommissioning to confirm the seabed status. It is likely that this monitoring will be in the form of a number of subsea surveys that are carried out at agreed intervals following the decommissioning programme. For the purposes of cost estimating a similar vessel and duration as for the post decommissioning survey can be assumed. This would be a vessel costing in the region of £30,000 per day requiring several days to weeks to complete each survey.

Project management

There will be some additional costs in addition to the vessel costs throughout the decommissioning programme. These costs will be for project management, planning and engineering work require prior to the offshore operations, for example developing bespoke lifting equipment, port charges and costs associated with guard vessels and other support vessels that may be required during the decommissioning. Some operators have suggested costs for these overheads in their decommissioning programmes. This cost is likely to be between 10 to 20% of the cost of the marine operations as outlined above.

Total decommissioning cost estimate

As the decommissioning cost is driven by vessel rates and specific features of the OWF (number of WTGs, water depth, distance from port etc.) it can be challenging to provide headline metrics at a farm level. However, following analysis of a number of OWFs, it is possible to estimate a cost of £800,000 to £900,000 per WTG for smaller WTGs in shallower waters (typically Round 1 OWFs) and between £1m to £1.2m per WTG for the larger WTG models in deeper waters (typically Round 3 OWFs). This analysis was based on the vessel rates mentioned above and is highly sensitive to assumptions. These are considered to be central estimates of the potential decommissioning costs and that until firm quotes are received from the supply chain, high levels of uncertainty remain. From this analysis it is clear that metrics which have previously been suggested by industry stakeholders, e.g. £40,000 per MW (39), can be misleading.

In addition to the assumptions and costs described above, when calculating the decommissioning cost estimate for a specific OWF for procuring securities developers should include Value Added Tax (VAT), a sufficient contingency (to cover uncertainty and to allow for optimism bias) at a level agreed with the regulator.

Consultation feedback

Feedback received on cost estimating included the following recommendations:

- Develop and provide a consistent format for estimating and presenting costs
- The regulator should have a cost model to generate benchmarks
- AACE or similar accounting principles should be used to highlight uncertainties
- Identify a review cycle for cost estimates

8.2 Cost estimating uncertainty

Estimating the costs of decommissioning activity due to take place 25 to 30 years in the future has a high level of uncertainty, discussed below.

Vessel rates

As noted above the cost estimations are highly dependent on a forecast of the vessel's day rate. Clearly there is a risk that using today's spot market rates may not give an accurate future estimate. Vessel rate does not typically rise in line with inflation, instead the rates for vessels used today may be expected to reduce over time as more sophisticated vessels are brought to market. However, there could also be constraints within the vessel market i.e. high demand for installation and decommissioning work using the same pool of vessels that may drive up the price.

Decommissioning process and new technology

The decommissioning process is currently assumed to be a reverse of the installation process based on known technologies, generally those used in O&G decommissioning, such as abrasive water jet or diamond wire cutting. Some adaptation to these technologies may be required so they are able to handle foundations but it is assumed by many operators that technological developments will come to market. These technologies could be new cutting technologies, vessel or lifting based technologies that may change how offshore operations are carried out. It is challenging to predict what these specific advancements will be but it is reasonable to expect that cost reduction would be the overall impact.

Regulatory changes

The base case in the BEIS offshore renewables guidance (21) assumes that all infrastructure, including buried cables is removed. However, most decommissioning cost estimates from current UK operators do not include a cost for cable removal (or where these costs are included, they tend to be too low). If

the regulations were to change so that all cables absolutely had to be removed, the impact would be to increase the decommissioning cost greatly, particularly if the cables needed to be removed in a way that minimized damage to the seabed.

Similarly, for foundations, it is the accepted convention that the piles will be cut at some depth below the seabed and the lower portion left in place. If this practice was to be challenged and a requirement for the whole foundation to be removed this would increase the decommissioning cost well beyond the point of reasonableness, and may not even be technically possible with some of the largest foundations currently being installed.

Residual infrastructure

As mentioned above some cost needs to be factored in for monitoring the decommissioned site following the operations, particularly if infrastructure such as buried cables or elements of foundations are left in place. Whilst the cost of additional surveys can be estimated using current vessel rates, the additional cost of remediation of highlighted issues is challenging to forecast. The main concern would be infrastructure becoming exposed and resulting in a snagging risk for other users of the sea. The cost of dealing with such an issue depends on how much of a risk the infrastructure is and what is the likelihood of exposure occurring again.

If, sometime after the decommissioning programme, the remaining infrastructure needs to be removed, this will incur a high cost of offshore intervention. At this point it is likely that all the decommissioning securities will have been used to fund the decommissioning activities. It is unlikely there will be remaining securities to cover the additional removal works. This could result in the costs being transferred to government if the developer is not able to meet the costs of the additional work.

8.3 Decommissioning securities

In this section we outline the different securities available to build up decommissioning funds and compare their costs and their impact on the levelised cost of energy.

The cost of securities is not currently taken into account in the LCoE used by BEIS (based on the 2016 Arup study (40)). However, operators ultimately have the obligation to pay for decommissioning at the end of the project and it is a cost that they take into account in their business plan analysis, which flows into their pricing and is eventually born by consumers.

As noted earlier BEIS are currently consulting on the updated guidance notes for offshore renewable energy installations (22), these updated guidance notes provide more clarity on the acceptable forms of security. The following types of securities are available and are deemed acceptable by BEIS (21) to be used for decommissioning costs. (Parent Company Guarantees are currently not accepted by BEIS but as they were raised during the consultation for this report, and during BEIS's consultation on their guidance notes they have been included.) Some securities are funded securities – essentially setting aside funds for future use,

whereas others purely provide security that the operator will make funds available in the future at the point of decommissioning.

- Cash: this is cash set aside up front to cover expected decommissioning liabilities.
- Letter of credits: An irrevocable letter of credit issued by a Prime Bank (banks established in an OECD country which have an AA, Aa2 or equivalent rating). This is essentially a promise by the Bank that they will pay the amount at the agreed date in the future if the operator does not.
- Bonds: whereby an underwriter (either an appropriate Prime Bank or insurance company) guarantees an amount equal to the decommissioning sum in return for an arrangement fee and premium, assuming they can be relinquished in a similar manner to letters of credit.
- Early/Mid-life and continuous accrual funds: a secure, segregated decommissioning fund that accrues early in, during the middle of, or over the life of an installation, provided the fund is completed ahead of the end of life of the installation (39).
- Insurance: Insurance, for example, to cover the uncertainty element of decommissioning costs. Could be used but it is unlikely as a security given the long-term nature.
- Parent company guarantee: Guarantees where a parent company is called upon if the defaulter themselves cannot cover the costs.

Each of these securities carry a different cost. They also vary in terms of trade-offs between ease of access, ring-fencing, certainty of funds and cost. The table below assesses at a high level the securities against our selected criteria. The selection of a preferred security depends on the weight Marine Scotland would like to place on each criterion.

Table 6: Comparison of securities

Security	Cost of financial security (Interest Rate or Opportunity Cost)	Cash Flow Impact	Counterparty Default Risk	Ease of Access to Security/ Ring-Fencing of Financial Assets	Provision for Cost Escalation	Provision for Asset Transfer	Risk rating for Government	Likely impact on LCoE*
Cash	Opportunity cost = Cost of capital of the operator (high as it includes both cost of equity and debt) and provided at the outset therefore cost incurred through the duration of the project	Upfront cash impact (Day 1)	Counterparty: Bank holding the deposited cash	Typically not ring-fenced (if retained in project) In case of operator default, creditors may be able to draw on it before Marine Scotland. Potential to restrict account for Marine Scotland use in decommissioning in operator insolvency	Amount set upfront (and not varied) Need additional mechanism to add cash when reforecasting decommissioning costs	No need as cash held by the project or Marine Scotland, not by parent	Low (if ring fenced)	5
Early/ Mid-life & Continuous Accruals	Cost of capital of operator (like 'cash') on deferred basis as only provisioned through the life of the project, therefore cost is minimised compared to 'cash'	Regular payments to accrual fund (lower NPV than 'cash')	Counterparty: Bank holding the deposited funds	Accruals are secure and segregated, ring-fenced from the project and there is potential to restrict account for Marine Scotland similar to 'cash'	Provisions need to be made for adjustments in case of cost escalations Easier to adjust for reforecast than 'cash' given the annual nature of accrual	No need as cash held by the project or Marine Scotland, not by parent	Low/ Medium (if ring fenced)	4 (deferred 'cash')

Security	Cost of financial security (Interest Rate or Opportunity Cost)	Cash Flow Impact	Counterparty Default Risk	Ease of Access to Security/ Ring-Fencing of Financial Assets	Provision for Cost Escalation	Provision for Asset Transfer	Risk rating for Government	Likely impact on LCoE*
Parent Company Guarantee	Typically limited cost passed to the project. Cost of capital of Parent Company If risk cannot be absorbed into parent company's current portfolio without changing its risk profile Parent Company can borrow at corporate level - cheaper than at project level	No impact on operator cash flow for specific security	Counterparty: Parent Company These companies usually have a portfolio of similar assets, geographically diversified Dependent on credit rating of parent may carry the highest risk. Difficulty enforcing if the parent is liquidated or out with the UK/EU	Ring-fenced from project Likely no ring-fenced funds in the parent company	Can include headroom at start or adjust the guaranteed amount when reforecast closer to the date of decommissioning	As asset transfer assumes change of parent company, the sale needs to be contingent on a similar guarantee provided by the new parent	High	1 (no security cost but decommissioning cost still incurred)

Security	Cost of financial security (Interest Rate or Opportunity Cost)	Cash Flow Impact	Counterparty Default Risk	Ease of Access to Security/ Ring-Fencing of Financial Assets	Provision for Cost Escalation	Provision for Asset Transfer	Risk rating for Government	Likely impact on LCoE*
Letter of Credit (LoC)	Fee for providing letter of credit for decommissioning cost. Fee linked to credit risk of operator/ parent. Bank is likely to periodically monitor the operator/ parent From an operator perspective funds still need to be reserved/ provided for to cover the actual cost of decommissioning	Ongoing arrangement fee	Counterparty : Prime Bank providing the letter	Beneficiary of the credit letter should be Marine Scotland	Amount agreed at start Need additional provisions for cost escalation/ reforecasting Bank is likely to require accumulation of some cash reserve – as cash reserve increases, the amount in the LoC should decrease	The limit on any asset sale needs to be that the new owner provides an equivalent LoC	Medium	3 (but has to go in hand with accrual)
Bonds	Similar to Letter of Credit Arrangement fee plus premium on top of decommissioning costs	Arrangement fee & premium payments on ongoing basis	Counterparty : Underwriter of the bond (Prime Bank or Insurance Company)	Ring-fenced so Marine Scotland can draw on it	No provision for cost escalation	Dependent on company the bond is linked to within the corporate structure - if ability to transfer to different owners on transfer (e.g. if linked to HoldCo and HoldCo is transferred), then no additional provision needed	Medium	3 (similar to LoC)

* Likely impact on LCoE is ranked from highest, 5 to lowest, 1

Consultation feedback

The developers liked BEIS' current approach regarding securities, it is prescriptive, provides adequate security but allows some flexibility and innovation. Some developers mentioned that Parent Company Guarantees (PCGs) have less of a cost impact than a decommissioning fund account. The developers also stated that building up an accrual around year 15 is an acceptable approach but earlier may be difficult, building up from year 7, for example, would not be acceptable. Additionally, the developers would like assurance that to pay for the decommissioning they are able to draw down from the accrued fund.

With regard to the approach Marine Scotland should take with the securities, the consultees made it clear that it should not make developments in Scotland more unattractive. The developers agreed that Scotland needs to compete with the rest of the UK in terms of financing and regulations and this will be key for CfD auctions. The idea of an industry fund to cover decommissioning was not well supported however it was suggested that the decommissioning security fund may stay with the site, not the site owner, so that the money is still available if the site changes hands.

8.3.1 Risk of decommissioning obligations falling to government

When considering which security arrangements to adopt, Scottish Ministers should consider the impact a developer default would have throughout the life of the project. Table 7 illustrates how the risks of decommissioning obligations passing to the government may change throughout an OWF project's lifecycle.

Table 7: Risk of decommissioning obligations falling to government

Project phase	Risk of decommissioning obligations transferring to government
Construction	Potential risk of transfer. This will depend on what stage during construction the developer defaults and why. If the OWF business case is sound then it is likely that an alternative development partner would step in.
Operation during CfD period	Lowest risk of transfer. Other development partners would be likely to step in and continue operating the OWF in the event of a developer default.
Operation post CfD period	Higher risk of default. It may be more difficult to find alternative developers to step in and support the OWF in the event of a developer default.
Decommissioning	Highest risk of transfer. If the developer defaults during decommissioning then it is unlikely that another party, who didn't previously have decommissioning obligations, will step in.

8.4 Considerations regarding securities

As discussed in section 5.2.2, functions under the Energy Act 2016 in relation to decommissioning OWFs in Scottish waters transferred to Scottish Ministers on 1st April 2017. Along with the powers discussed in section 5.2.2, this also means that the Scottish Government is now the decommissioner of last resort in cases where the OWF developers cannot meet their decommissioning obligations. This means that costs will fall to the Scottish Government, and hence taxpayers, in cases where the developer has insufficient funds to meet the decommissioning costs.

The Scottish Government has a responsibility to protect tax payers from becoming exposed to decommissioning costs if the developer defaults on their decommissioning obligations. Under the powers transferred by the Scotland Act 2016 the Scottish Government has the power to require developers to build up an adequate security. The Scottish Government would like to ensure that the security arrangements agreed with developers are built up in a suitable timeframe, to a suitable value and held in an appropriate form.

Regarding the value of securities, the issues around decommissioning cost estimation are discussed in section 8.1 and 8.2. When considering securities the following aspects need to be taken into account:

- The decommissioning cost estimate that is informing the value of securities should be reviewed regularly and updated to take account of developments in regulation, technologies and methodologies.
- To help provide robust cost estimates that can be easily reviewed and challenged by the regulator it is suggested that the WBS be used to provide a basis of cost estimating.
- When determining the level of security required it should be confirmed whether the decommissioning cost estimate includes some revenue from the waste materials that are brought back to shore, e.g. revenue from the sale of the waste steel equivalent to the scrap value of the steel. It should be determined, and clearly communicated, whether the security can be reduced by the amount of expected revenue or whether the security amount should cover the full decommissioning cost not accounting for any expected revenue.
- The level of security should include some funds for ongoing monitoring if infrastructure is to be left in situ. For example, following the completion of decommissioning activities, a JV operating an OWF may cease to exist and so if funds have not been reserved for ongoing monitoring it is likely this cost would pass to the Scottish Government.
- The security may need to include VAT as the Scottish Government will be required to pay VAT on any decommissioning costs should they need to decommission the asset.

The appropriate timeframe for building up securities was discussed during the consultation and the developers' views have been outlined in the consultation feedback above. The Scottish Government should consider the following issues when deciding the policy regarding security build-up:

- In the draft version of the guidance (22), BEIS has outlined a timeline for mid-life accrual of securities, based around key dates in the subsidy support mechanism. This is summarised below.

Table 8: BEIS timeline of security accrual from draft guidance

Subsidy support mechanism	
Renewable obligation	For projects with a 'renewables obligation certificate', 'mid-life' accruals should start no later than year 10 and be completed by year 20.
Contract for Difference	For projects with a 15 year 'contract for difference', 'mid-life accruals should start no later than year 10 and be completed by year 15.
OFTO Revenue	For OFTOs, projects with a 20 year license 'mid-life' accruals should start no later than year 10 of the license and be completed by year 20.

- It is understood there have been some concerns from developers regarding this timeline and it is not yet known what the final guidance will be.
- For test sites that are not expected to have a lifetime as long as commercial OWF sites a different security accrual timeframe will be required. The draft BEIS guidance states that upfront pre-construction securities will generally be expected for pre-commercial projects. This is more applicable to wave and tidal sites in Scotland and is to be considered in a separate study.

The different types of security and their advantages and disadvantages, including the risk level for government is outlined in Table 6 above. Additional considerations related to the form, maintenance and drawdown of the security that the Scottish Government should consider include:

- The handling of securities and liabilities as the ownership of the OWF changes throughout its life. For O&G installations, any party with decommissioning obligations, as detailed in the section 29 notice (this notice requires the recipient to submit a costed decommissioning programme to the SoS), will retain decommissioning liability even if they sell the assets, unless the section 29 notice is withdrawn by the SoS. The same principle could be applied to OWF decommissioning liabilities, and the draft BEIS guidance states that 'changes in ownership will be treated on a case by case basis and the SoS may decide not to absolve a party of their obligations to decommission'.
- How the security passes from one party to another if the OWF ownership changes. Depending on the form of the security this may not be an issue, for example where the security is held in an escrow account. The governance of transition of securities due to ownership changes should be clear when the form of the security is being approved by the regulator.
- Whether the accrued security can be used to fund the decommissioning or if it is released only upon completion of decommissioning. This would only be applicable in the case of an accrued cash fund.

- Allowing the security to be used for decommissioning may be perceived as risky by the regulator. However, if it can be assured that the money is being used to pay for decommissioning and that the security fund is sufficient to cover the total decommissioning cost then the use of this fund presents little risk to the government and would be beneficial for the developer.

8.5 Cost and securities summary

As outlined above there are many issues to consider when determining the acceptable decommissioning security arrangements for OWF. The Scottish Government needs to strike a balance between the level of risk they are willing to accept and what is acceptable to the industry.

Irrespective of which security arrangements are deemed acceptable, the security needs to be of the right value to cover the decommissioning cost. To ensure robust cost estimates it is suggested that the WBS is used as a framework to provide a structure for cost estimates. It is also recommended that the cost estimate is reviewed regularly to ensure the estimate is based on the latest information and takes account of changing regulation, technologies and methods.

9 Recommendations for adaptation of the OWF decommissioning regulatory regime

Following the transfer of Energy Act 2004 functions in relation to the decommissioning of offshore renewable energy installations, Scottish Ministers are now responsible for ensuring the decommissioning of these installations is conducted in line with international obligations. These functions include:

- the authority to request decommissioning programmes from the developer;
- the authority to request financial securities for the developer's decommissioning liability;
- the authority to review decommissioning programmes and financial securities and request appropriate actions; and
- ensuring decommissioning is carried out by either the responsible party or by other means if the responsible party is unable to fulfil their obligations.

In the exercise of these powers it is understood that the Scottish Government will develop policy and provide guidance for the industry to allow the execution of the Energy Act functions. In order to help the Scottish Government define policies this report examined the current policy and guidance for decommissioning in the UK as well as investigating the methodologies for OWF decommissioning.

This study has found that, given the limited activity to date and thus experience gained across the industry, there are many uncertainties relating to the decommissioning of OWFs. The methodologies for OWF decommissioning have been informed by existing decommissioning programmes submitted to Marine Scotland and BEIS, and the limited number of decommissioning projects completed to date. Whilst the methodologies presented by developers are generally focussed on reverse installation there are some ambiguities in the definition of decommissioning as understood by the regulator and the OWF developers. This ambiguity is partially due to the lack of an evidence based approach in understanding the long term effects of decommissioning, either as a result of leaving infrastructure in place, or removing it.

As well as a lack of clarity in the definition of decommissioning, this study also found that clarity around what is expected of developers in terms of their decommissioning programmes and security provision would be beneficial to both the Scottish Government and the OWF industry. Furthermore, this study has also highlighted that adopting a different policy in Scotland to the rest of the UK may have implications for future investment in OWF projects in Scotland.

As a result of these findings Arup proposes the following recommendations.

Recommendation 1 – Evidence based approach

Current decommissioning guidance is ambiguous and the approaches to decommissioning do not appear to be based on sound, peer reviewed evidence relating to the long term effects of leaving infrastructure below the sea-bed, or the potential effects of removing such infrastructure. Evidence regarding the long

term impact of leaving infrastructure (cables or piles) below the sea-bed, or removing them, would help define what is an acceptable decommissioning option for the marine environment. There is an opportunity for Scotland to take a more progressive evidence based approach, as outlined below, that should ensure that the selected decommissioning option is acceptable in terms of impacts on the marine environment, and acceptable to the Scottish Government and OWF developers.

The environmental and other effects of OWF decommissioning could be assessed by the regulator through a CA process. This is used in O&G decommissioning programmes to select preferred options for decommissioning when seeking a derogation from OSPAR Decision 98/3 or to select a pipeline decommissioning option.

One suggestion is that, in the first instance, the regulator (i.e. Marine Scotland), conducts a strategic CA using available evidence to determine the preferred decommissioning option. This would involve reviewing evidence of the long term effects of leaving infrastructure (cables, piles, scour protection etc.) in place and the long term effects of removing such infrastructure (e.g. how long it would take the sea-bed to recover from the disturbance caused by pulling up a cable). This CA would also examine evidence in relation to safety, technical, societal, economic impacts of the decommissioning options. Gaps where evidence was not available would also be highlighted by this strategic CA.

This strategic CA could be completed in collaboration with other regulators (e.g. BEIS, Crown Estate Scotland), and industry, to define a baseline for decommissioning, i.e. informing the decommissioning definition adopted in Scottish policy. So if the preferred decommissioning option based on the CA was to remove all cables, foundations and scour protection material then this would be the definition of decommissioning that developers should strive to achieve. Developers could then complete a project-specific CA should they wish to gain exemption from the agreed decommissioning baseline, or where they have specific circumstances, such as the proximity of a Marine Protected Area.

If such an evidence based approach is adopted, it should be understood by both the developer and the Scottish Government that the policy based on such evidence may be subject to change in the light of future updated evidence, for example evidence that fills some of the gaps identified in the CA process. Therefore, it is recommended that there should be flexibility within the policy to allow changes based on new evidence, e.g. a revision to the strategic CA that in turn revises the preferred decommissioning option.

Recommendation 2 - Define decommissioning

Following directly from recommendation #1, recommendation #2 relates to being clear on the definition of decommissioning that developers are expected to achieve at the end of the life of the OWF.

As outlined in this report there are several options for the definition of decommissioning:

- Complete removal - removal of all infrastructure above and below the seabed;
- Clear seabed - removal of infrastructure to leave a clear seabed that is over trawlable, but some infrastructure remains subsurface and, through appropriate assessment, is deemed to remain buried;
- Partial removal - some infrastructure left in place on the seabed; and
- A combination of these options.

Developers have largely understood the decommissioning definition to be that of a clear sea-bed, with many decommissioning programmes assuming that piled foundations will be cut off below the sea-bed and that buried cables can remain in place. This is in line with the expectations outlined in the BEIS guidance but in conflict with BEIS's '*general requirement to remove installations*'. As evidenced during consultations completed during this study, other regulators and stakeholders understand decommissioning to be the complete removal of all infrastructure.

International standards and guidelines (UNCLOS and IMO) call for the removal of infrastructure on the sea-bed but are unclear on, or do not explicitly include, infrastructure below the sea-bed. This appears to leave the decision regarding infrastructure below the sea-bed down to state Governments.

As outlined in recommendation 1 it is suggested that the definition of decommissioning be decided using an evidence based approach. In terms of policy, when outlining the definition of decommissioning, whatever definition is adopted, the following issues should be considered:

- BEIS have already approved several decommissioning plans[2] which will leave infrastructure below the sea-bed (cables and foundations), although BEIS's definition of decommissioning in the guidance appears to be complete removal. If exemptions become the default then the definition is of limited use.
- The definition of decommissioning in policy or guidance should consider all infrastructure and longer-term issues (such as scour protection, sea-bed restoration) and define what is expected in a developer's decommissioning programme.
- Clarity on the liabilities for addressing issues post decommissioning and how long a developer would be liable.
- Removing ambiguity in policy and guidance would be beneficial to both the Scottish Government and to OWF developers, allowing developers to fully understand their decommissioning obligations[3] from the outset and allowing decommissioning plans to be reviewed effectively by the regulator.

[2] Note: it is unclear what further approvals will be required prior to execution and what value will be assigned to the construction stage approvals
[3] Whether that is total removal, clear sea-bed, or presenting evidence on a case-by-case basis.

Recommendation 3 – Expectations of decommissioning programmes

As well as providing clarity on the definition of decommissioning, the Scottish Government should set out their expectations regarding submission, approval and review of decommissioning programmes. This should include:

- What is the expected form of the decommissioning programme;
- When the initial decommissioning programme should be submitted;
- Whether the decommissioning programme needs to be approved prior to construction;
- The review timetable which is expected. This could be a prescribed timetable as outlined in BEIS's draft guidance or a more event-driven timeline, with reviews linked to project events such as construction completion, prior to security accrual, following the completion of a similar decommissioning programme;
- The process for final approval of the decommissioning programme prior to implementation; and
- What is expected in terms of supporting studies such as a decommissioning EIA. This should include defining the baseline for the EIA.

Being clear on all these issues will help the Scottish Government in streamlining the review and approvals process for decommissioning programmes and also allow the developers to prepare suitable decommissioning programmes. The following are suggestions to help the implementation of these recommendations.

- A template for decommissioning programmes: BEIS has outlined the recommended contents of a decommissioning programme in their guidance but have not produced a template for an OWF decommissioning programme. The OGA has produced a template for O&G decommissioning which has been helpful for O&G operators.
- Use a WBS for OWF decommissioning: A WBS provides a common language and structure for cost estimating for regulators, developers and the supply chain. As highlighted in the consultation feedback this has proved useful for O&G decommissioning. A WBS would help facilitate collaboration in relation to OWF decommissioning.

Recommendation 4 – Decommissioning securities

As well as setting out expectations in relation to the content of decommissioning programmes the Scottish Government should clearly set out their expectations in terms of securities, including what form the security should take, what value is expected and by when the full security should be in place. When defining these expectations, the following issues need to be considered:

- The acceptable forms of securities need to strike a balance between what is adequate for the Scottish Government, in terms of the risk they are willing to accept, and what the impact is on industry;
- The lowest risk option for the Government is an upfront cash reserve, however this is often unattractive to developers whose preferred option is commonly a PCG;
- If an accrual type form of security is acceptable then expectations regarding the timing of accruals should be set out in guidance;
- The level of the security should be based on a robust cost estimate for decommissioning, guidance for cost estimating should be provided which makes it easier for the Scottish Government to review and approve, or challenge, cost estimates, to ensure their robustness; and
- Any additional costs that need to be added to the security should be clearly defined, e.g. VAT, contingency and the cost of ongoing monitoring post decommissioning (if required).

In relation to setting out cost estimating methodology, the WBS covered in recommendation #3 would also be beneficial here, as would a clear definition of decommissioning outlined in recommendation #2.

In order to adequately review developer cost estimates it is necessary to understand the basis of the estimate including what infrastructure is being removed and whether anything is being left in place. Having a clear definition of decommissioning should remove several ambiguities in the cost estimates. A common WBS would provide a framework for cost estimating, making it easier for the Scottish Government to review costs and compare estimates with industry benchmarks.

Recommendation 5 – Consistency in policy

When the Scottish Government is considering the recommendations described above and defining their decommissioning policy they should consider that having a different approach from the rest of the UK may create challenges and could impact on the development of the Scottish offshore wind market.

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