EnFAIT

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ENFAIT
ENABLING FUTURE ARRAYS IN TIDAL

Decommissioning Lessons Learned Report

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1 The Project

1.1 Introduction

A Funding Grant was awarded from the European Union's Horizon 2020 research and innovation programme in January 2017 to demonstrate a grid-connected tidal energy array at a real-world tidal energy site, propelling tidal energy towards competing on a commercial basis with alternative renewable sources of energy generation – Enabling Future Arrays in Tidal (EnFAIT). This was in response to the call *LCE-15-2016: Scaling up in the ocean energy sector to arrays* to generate significant learning through demonstration of cost-effective tidal arrays.

This document is produced to capture best practice for decommissioning tidal turbines and lessons learned from the industry, to inform the EnFAIT decommissioning plan. It is to be submitted to satisfy deliverable D7.1 of the EnFAIT project and to be also made available for public dissemination.

The report discusses the following items:

- Relevant policy and legislation;
- Lessons learned from the deployment and decommissioning of the Nova 30 Tidal Turbine; and
- Lessons learned from the decommissioning of other tidal energy turbines.

2 Policy and Legislation

This section contains a discussion of relevant policy and legislation, both internationally and at the UK level.

Tidal energy is an emerging industry and the legislative framework for the deployment and decommissioning of tidal energy devices is still being developed. Legislators and developers are learning valuable lessons that can inform the best legislative approach to tidal energy.

Currently, there are two forms of legislation governing the decommissioning process:

- **Direct Legislation**: Legislation that is specific to the decommissioning of tidal or marine energy infrastructure; for example, the UK Energy Act 2004, which governs the process for decommissioning tidal energy installations in the UK.

- **Indirect Legislation:** Legislation that is not specific to the decommissioning of tidal or marine energy infrastructure, but that applies to the operations involved with the decommissioning process, for example, health and safety legislation, recycling legislation, and environmental legislation.

The UK has played a leading role in the development of wave and tidal energy. Because of this, UK legislation and regulations for the decommission of tidal energy devices are relatively well advanced and are highlighted below as an example of best practice for the industry.

2.1 Review of International Policy and Legislation

2.1.1 International Legislation and Standards

International legislation and standards are discussed in Table 2.1 below.

Table 2.1 Existing International Framework

Legislation	Description
United Nations Convention on the Law of the Sea ("UNCLOS"), 1982	The United Nations Convention on the Law of the Sea (UNCLOS), signed in 1982, established the requirement to remove all abandoned or disused installations or structures. This is to ensure safety of navigation. This requirement forms the basis of all UK legislation dealing with the decommissioning of tidal energy infrastructure.
OSPAR Convention for the protection of the Marine Environment of the North East Atlantic	The OSPAR Commission is the mechanism by which 15 Governments and the EU cooperate to protect the marine environment of the North-East Atlantic Ocean and its resources. The fifteen Governments are Belgium, Denmark, Finland, France, Germany, Iceland, Ireland, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. The OSPAR Decision 98/34 sets out binding requirements for the disposal of disused offshore oil and gas installations. While there is no equivalent decision for offshore renewable energy installations, OSPAR has produced guidance documents on offshore wind farms, incorporating ideas on their decommissioning. The OSPAR convention is often cited by national governments when developing decommissioning standards.
International Maritime Organization (IMO) Standards	The IMO is a UN agency that develops and maintains a comprehensive regulatory framework for shipping, including safety and environmental concerns. In 1989, the IMO developed the 1989 Guidelines and Standards for the Removal of Offshore Installations and Structures on the Continental Shelf and in the Exclusive Economic Zone (IMO Resolution A.672 (16)). The IMO 1989 guidelines are directly applicable to the decommissioning of tidal energy devices and are often the basis for the standards developed by national governments.

2.1.2 EU Legislation

While there is no EU Legislation dealing directly with the decommissioning of tidal energy turbines, there is a lot of legislation that deals indirectly with decommissioning and provides a framework for the decommissioning operations. This is discussed in Table 2.2 below.

Table 2.2 EU Framework

Legislation	Description
EU Environmental Legislation	Relevant EU Environmental legislation includes: **The Habitats and Birds Directive**[1]: provides EU member states with the power and responsibility to classify Special Protection Areas (SPAs) to protect birds and establish areas protecting natural habitats and other species of wild plants and animals, as well as Natura sites. **The EIA Directive**[2]**:** established the Environmental Impact Assessment Process. Depending on the decommissioning process, an EIA might be required. **Waste Framework Directive**[3]**:** established a requirement on EU Member States to ensure that waste is recovered without endangering human health or the environment.
EU Health and Safety Legislation	Relevant EU Health and Safety Legislation includes: **EU Framework Directive on Safety and Health at Work**[4]: adopted in 1989 and sets out to guarantee minimum health and safety standards throughout Europe. **EU Directive on Minimum Health and Safety Requirements for the workplace** & **EU Directive concerning the use of work equipment**[5]**:** Both these directives provide further requirements on the health and safety standards at the workplace. Operations undertaken during decommissioning must meet all relevant EU and national health and safety legislation

2.2 UK decommissioning legislation

Table 2.3 provides an overview of the existing legislative framework for the decommissioning of tidal energy turbines and the associated infrastructure in the UK.

[1] Directive 2009/147/EC of the European Parliament and of the Council of 30 November 2009 on the conservation of wild birds, available at: http://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32009L0147 Accessed on 28/05/2018
Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora. Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A31992L0043 Accessed on 28/05/2018

[2] Directive 2014/52/EU of the European Parliament and of the Council of 16 April 2014 amending Directive 2011/92/EU on the assessment of the effects of certain public and private projects on the environment Text with EEA relevance http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32014L0052 Accessed on 28/05/2018

[3] Directive 2006/12/EC of the European Parliament and of the Council of 5 April 2006 on waste (Text with EEA relevance). Available at: http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32006L0012 Accessed on 28/05/2018

[4] Council Directive 89/391/EEC of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of workers at work. Available at: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A31989L0391 Accessed on 29/05/2018

[5] Council Directive 89/654/EEC of 30 November 1989 concerning the minimum safety and health requirements for the workplace (first individual directive within the meaning of Article 16 (1) of Directive 89/391/EEC) Available at http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:31989L0654 Accessed on 29/05/2018
Directive 2009/104/EC of the European Parliament and of the Council of 16 September 2009 concerning the minimum safety and health requirements for the use of work equipment by workers at work (second individual Directive within the meaning of Article 16(1) of Directive 89/391/EEC) (Text with EEA relevance). Available at https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32009L0104 Accessed on 29/05/2018

Table 2.3 Relevant Legislation

Legislation	Description
Direct legislation	
Energy Act 2004[6]	Chapter 3 of the UK Energy Act 2004 (and subsequent updated versions) established the UK framework for the decommissioning of offshore installations.
Marine (Scotland) Act 2010	The Marine (Scotland) Act 2010 governs applies to all operations in Scottish waters. It contains the requirement for developers to obtain Marine Licence to remove any objects from the seabed. This means a Marine Licence is required for the decommissioning of a tidal energy array.
Scotland Act 2016	The Scotland Act transferred responsibility for considering decommissioning cases in Scottish Waters to the Scottish Ministers (see Section 2.2.4).
Indirect legislation	
Environmental legislation	Operations undertaken during and after the decommissioning process must meet the relevant environmental legislation. This includes, but is not limited to: – The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2000 (as amended) – The Pollution Prevention and Control (Scotland) Regulations 2012;
Waste Management legislation	All materials must be decommissioned in a way that meets the relevant waste management legislation. This includes, but is not limited to: – The Special Waste Regulations 1996 (as amended)
Health and Safety legislation	Operations undertaken during decommissioning must meet all health and safety legislation. This includes, but is not limited to: – Health and Safety at Work etc. Act 1974; and – Construction (Design and Management) ("CDM") Regulations 2015.

2.2.1 UK Decommissioning Programme

In the UK, the decommissioning process is governed by the Energy Act 2004, which established the requirement for a developer to submit a Decommissioning Programme to the Department for Business, Energy & Industrial Strategy (BEIS), which manages the decommissioning process. Recent changes have seen responsibility for decommissioning installations located in Scotland to the Scottish Government – see Section 2.2.4; the guidance below applies to Offshore Renewable Energy Installations in England and Wales.

[6] https://www.legislation.gov.uk/ukpga/2004/20/part/2/chapter/3#statusWarningSubSections

The submission of a Decommissioning Programme goes through the following stages[7]:

- Stage 1: Preliminary Discussions with BEIS (recommended)[8]
- Stage 2: Issue of notice by the Secretary of State requiring a decommissioning programme
- Stage 3: Detailed discussions; submission and consideration of a draft programme (including proposed financial security measures)
- Stage 4: Consultation with interested parties; BEIS conducts decommissioning Appropriate Assessment (where necessary)
- Stage 5: Formal submission of a programme and approval under the Energy Act
- Stage 6: Reviews and modifications of decommissioning programme (and any financial security); review or conduct of decommissioning Appropriate Assessment (where necessary)
- Stage 7: Undertake approved decommissioning programme
- Stage 8: Monitoring of Site.

2.2.2 UK Decommissioning Standards

As part of its role in managing the decommissioning process, BEIS has developed standards for the decommissioning process[9]. These standards are based on:

- The International Maritime Organisation ("IMO") Standards
- The OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic and OSPAR guidance on documents for offshore wind farms
- The concept of Best Practicable Environmental Option (BPEO), that is the option which provides the most benefit or least damage to the environment as a whole, at an acceptable cost, in both the long and short term.

Developers are also advised to meet the following standards:

- **General requirement to remove installations**: A general presumption in favour of the complete removal of disused installations from the seabed (see Section 2.2.3 for exceptions to this rule).
- **Sea-bed clearance**: Once decommissioning is complete, evidence of the seabed clearance needs to be provided.
- **Method of removal**: While the method of removal is not prescribed, it should use the BPEO mentioned above, and take into account health and safety.
- **Management of waste**: All installations are to be reused, recycled, incinerated with energy recovery or disposed of on land.
- **Notification and marking of any remains**: Notification of a change in status of the decommissioned installation should be provided to the appropriate authorities, including the UK Hydrographic Office, so that mariners may be advised, and appropriate amendments made to charts; where required, aids to navigation should be installed and maintained.
- **Post-decommissioning monitoring, maintenance and management of the site**: Where an installation is not removed entirely, post-decommissioning monitoring, maintenance, and management is expected.

[7] DECC, Decommissioning of offshore renewable energy installations under the Energy Act 2004 Guidance Notes for Industry, January 2011 (revised)
[8] NB the guidance refers to DECC, the predecessor department to BEIS
[9] DECC, Decommissioning of offshore renewable energy installations under the Energy Act 2004 Guidance Notes for Industry, January 2011 (revised)

2.2.3 Exceptions to complete removal of the installation

While BEIS expects all installations to be removed completely, it considers the following potential exceptions:

- 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;
- The entire removal would involve extreme cost;
- The entire removal would involve an unacceptable risk to personnel;
- The entire removal would involve an unacceptable risk to the marine environment;
- The installation or 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.

2.2.4 Decommissioning projects in Scottish waters

The Scotland Act 2016 transferred responsibility for considering decommissioning cases in Scottish Waters to the Scottish Ministers. Marine Scotland, on behalf of Scottish Ministers will be issuing its own guidance to developers/owners seeking to deploy renewable energy devices in Scottish waters.

The Scotland Act 2016 also transferred responsibility for The Crown Estate's offshore assets in Scotland to a new body, Crown Estate Scotland, which has taken on the functions of The Crown Estate in relation to offshore renewable energy installations in Scottish waters.

A concordat has been agreed between the Scottish Government and BEIS that sets out practical arrangements for the transfer of the UK Secretary of State's Energy Act functions in relation to the decommissioning of offshore renewable energy installations to Scottish Ministers under the Scotland Act[10].

2.2.5 Updated UK decommissioning guidance

BEIS recently consulted on proposed updates to the guidance on decommissioning for developers of offshore renewable energy installations. This consultation ran from February to March 2018 and focused on issues relating to the provision of decommissioning cost estimates and associated financial security. BEIS are currently considering their response to the consultation[11].

2.3 Other examples of decommissioning guidance

2.3.1 European Marine Energy Centre

EMEC, the European Marine Energy Centre, has developed detailed guidelines for the development of projects in the marine energy industry. Decommissioning is discussed as one of the 6 stages of marine energy projects. The guidelines' focus is on decommissioning in a safe and environmentally sustainable manner. It emphasises the importance of mitigating the potential environmental impact of the decommissioning process, and the use of site surveys to provide evidence of the removal to an acceptable

[10] https://beta.gov.scot/publications/offshore-renewable-decommissioning-concordat/
[11] https://www.gov.uk/government/consultations/offshore-renewables-decommissioning-guidance-for-industry-proposed-updates

standard. It further stresses the importance of adhering to health and safety guidelines and following the proper consultation process as set out in the decommissioning plan and the required Marine Licence.

2.3.2 Nova Scotia

The province of Nova Scotia, Canada has been at the forefront of tidal energy research and legislation. With the Bay of Fundy, Nova Scotia has one of the largest tidal resources in the world. The Fundy Ocean Research Centre for Energy (FORCE) as well as the Ocean Energy Research Association (OERA) have done significant work to advance tidal energy.

In 2012, the Nova Scotia Department of Energy and Marine Renewables developed Standards and Practices for In-Stream Tidal Energy.[12] The document outlines the standards and best practices for the development of tidal energy projects in Nova Scotia and includes best practices for the decommissioning of tidal energy devices.

3 The Nova 30

3.1 The Nova 30: introduction

In 2014, Nova Innovation installed its first turbine, the 30 kW Nova 30 device (see Figure 3.1). The Nova 30 consisted of the following:

- A turbine consisting of three composite blades, each approximately 2 m in length.
- A steel nacelle incorporating the drive train, attached via a mating mechanism to the substructure.
- A steel, gravity-moored tripod base with concrete ballast located in a steel box on each foot.
- A main power cable connecting the device to shore, laid directly on the seabed, with clamshell cable protection at the turbine and shore ends.
- An auxiliary cable secured to the main power cable along its length using cable ties.

Figure 3.1 The Nova 30

The Nova 30 was fully decommissioned in 2016, and the site was returned to its original state. Lessons learned from the installation, operation and decommissioning of the Nova 30 were applied to the design of devices and operational procedures for the Shetland Tidal Array.

One of the key lessons from the Nova 30 project was that the small-scale design of the turbine and its gravity base reduced the time, cost, complexity and risk of all operations associated with the device. The use of a gravity mooring for the device, and cables laid directly on the seabed, ensured that decommissioning was quick and easy, and could be completed in a cost-effective manner with minimal risk and disturbance to personnel or the environment. A subsea survey confirmed that the seabed was completely cleared following decommissioning operations, in line with best practice guidance.

[12] Available at: http://0-nsleg-edeposit.gov.ns.ca.legcat.gov.ns.ca/deposit/b10689163_Report.pdf Accessed on May 24 2018

3.2 The Nova 30: Lessons learned

The following lessons learned from the deployment and the decommissioning of the Nova 30 were applied to the development and deployment of the Nova M100 device, the Shetland Tidal Array and the EnFAIT project, to ensure that the turbines, infrastructure and operations meet the best practice standards for decommissioning.

Table 3.1 Lessons learned from the Nova 30

Lesson	Description
Turbine Design	
Small Scale	Nova's small-scale device means that the turbines can be installed and decommissioned with widely available work boats. This makes decommissioning quick and cost-effective.
Gravity mooring	The use of gravity-moored base structure means no piling or drilling is required when installing the turbines. This makes the structure easy to install and decommission. To decommission the substructure, it simply needs to be lifted from the seabed. Using gravity base structures further minimises the environmental impact of the substructure on the environment – for example, by avoiding loud, impulsive noises during installation and decommissioning.
Number of blades	The reduction of the number of turbine blades from three for the Nova 30 to two for the Nova M100 made the installation, maintenance and decommissioning of the M100 safer, simpler and quicker. This change allows the nacelle to be placed directly on the quayside or a vessel deck, reducing lifting requirements and minimising the need to work at height.
Biofouling	Biofouling accumulates on the device over time and can lead to difficulties e.g. accessing lifting points, releasing the nacelle from the substructure or accessing and releasing bolts. Methods to reduce and manage biofouling are currently being investigated by Nova.
Operations	
Cabling design	The cable connecting the Nova 30 device to the grid was laid directly on the seabed without additional protection (e.g. concrete mattresses or rock bags). Cable protection was provided by layers of integral armour within the cable; this had the added benefit of increasing the cable density, making the cable stable on the seabed under its own weight. This design choice made cable decommissioning a quick, simple and easy operation – the cable was lifted directly from the seabed using a small workboat, and the operation was completed in just a few hours without the need for divers or specialist equipment. The optimal cabling design will vary from site to site depending on local conditions, but this experience suggests that cables laid directly on the seabed are an effective solution at appropriate sites.
Improved planning	Experience gained in the decommissioning of the Nova 30 allowed Nova to make improvements in its planning, through "learning by doing". The methodologies and risk assessments for decommissioning operations at the site have now been successfully field-proven, increasing Nova's confidence in planning and estimating the time and cost

	of future operations. The methodologies performed well, with refinements made in accordance to the lessons learned highlighted in this report.
Divers	Divers are still widely used offshore; for example, the installation of an offshore wind farm typically involves hundreds or thousands of dive operations. Commercial diving is increasingly safe and well-controlled, and accidents are rare. However, there is an unavoidable element of risk when humans operate in the hazardous subsea environment. Technology is improving, but there is some way to go before divers can be replaced for all operations: divers can operate a wide variety of tools, are adaptable, and can assess the situation and use their initiative to solve problems to an extent that modern technology is as yet unable to match. However, the need for divers can be minimised by suitable design choices: for example, using "oversized" lifting points that can more easily be threaded using a remote operated vehicle.
Post Decommissioning	
Drop-cam	The use of a drop-cam (a weighted camera lowered from a vessel) for the post decommissioning survey of the site proved very successful. The survey ensured that all equipment had been removed from the site, providing evidence to the regulator that decommissioning had been completed. Drop-cams are cheaper, safer to use and more easily controlled in a tidal stream than remote operated vehicles (ROVs). ROVs offer greater functionality but are typically designed for use in environments with little or no flow, and their operation can be severely impaired once the tide starts to flow.
Recycling	In the drive towards a circular economy, it is important to maximise local recycling and re-use of decommissioned materials. This can best be achieved by talking to communities to assess local needs, particularly as a project approaches decommissioning. Coastal communities are traditionally resourceful and self-reliant and are used to taking advantage of opportunities as they become available. As an excellent example of this resourcefulness: the concrete ballast blocks for the Nova 30 were re-used locally as a compound security wall.

4 Other tidal projects

So far, a limited number of tidal energy generators have been decommissioned. Prominent ongoing decommissioning projects are listed below; learnings from these projects that are shared with the public will be integrated into the EnFAIT project as they become available.

4.1 Decommissioning of SeaGen turbine at Strangford Lough

The 1.2 MW SeaGen turbine was installed and commissioned in Northern Ireland's Strangford Lough in 2008 and operated until 2015. An Environmental Statement[13] for the decommissioning of the turbine was produced in 2016; overall, decommissioning of the SeaGen device "is not predicted to result in any

[13] MarineSpace Ltd, 2016. Decommissioning of the SeaGen Tidal Turbine in Strangford Lough, Northern Ireland: Environmental Statement. Report for Sea Generation Ltd.

medium to long-term environmental impacts". A licence was awarded for decommissioning in March 2018.

4.2 EMEC Foresea Decommissioning Study

The European Marine Energy Centre (EMEC) has contracted Orkney-based operations provider Leask Marine to decommission a tripod foundation from EMEC's Fall of Warness test site as part of the FORESEA-funded FoDTEC project (Forensic Decommissioning of Tidal Energy Convertors). This study will use forensic analysis to obtain an understanding of the end of life conditions of the tripod.[14]

5 Conclusion

Tidal energy is an emerging industry. To date, a limited number of tidal energy devices have been decommissioned, with activity focused in the UK. This experience has placed the UK in a leading role in the development of legislation and regulations for the decommissioning of tidal energy devices.

In 2016, Nova Innovation successfully decommissioned its Nova 30 tidal turbine. The turbine and associated infrastructure were removed from the seabed and the site was returned to its original state. This decommissioning process has provided Nova Innovation with a unique learning opportunity. Lessons learned from decommissioning the Nova 30 have been incorporated into the design of the Nova M100 and into the design of the equipment and operations developed for the EnFAIT project.

[14] See http://www.emec.org.uk/press-release-emec-foresea-tidal-energy-tripod-decommissioning-study/, accessed on 21/05/2018

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