Use of the Rochdale Envelope Principle for Tidal Energy Projects

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INTERREG IVB

EXECUTIVE SUMMARY

This report provides a review of the use of the 'Rochdale Envelope' approach to defining a flexible design envelope when consenting tidal energy projects.

The 'Rochdale Envelope' arises from two legal cases in the UK: *R. v Rochdale MBC ex parte Milne (No. 1) and R. v Rochdale MBC ex parte Tew* [1999] and *R. v Rochdale MBC ex parte Milne* (No. 2) [2000].

The Rochdale Envelope approach has been adopted in the consenting of a number of offshore wind farm projects in the UK, with the Environmental Impact Assessment (EIA) based on assessing the realistic worst-case scenario where flexibility or a range of options are sought as part of the consent application. The Infrastructure Planning Commission (IPC) (2011) provides guidance on the use of the Rochdale Envelope for Nationally Significant Infrastructure Projects, particularly offshore wind.

The same principle has been used successfully in the tidal industry to support project requirements for flexibility of design and technology of varying degrees and extent. The approach taken to consenting and the amount of flexibility required in the design envelope will depend on the objectives and circumstances of the development with each project often facing unique challenges. This report provides a review of the approaches taken by the tidal industry to date, including an outline of the wide range of possible tidal technology designs which can be deployed to harness tidal energy.

This report also provides case studies of key consented tidal projects and outlines the advantages and disadvantages of the approaches to design envelope taken, in terms of project details and flexibility.

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1. INTRODUCTION

This report provides a review of the use of the Rochdale Envelope approach in consenting tidal energy projects.

The 'Rochdale Envelope' arises from two legal cases in the UK: R. v Rochdale MBC ex parte Milne (No. 1) and R. v Rochdale MBC ex parte Tew [1999] and R. v Rochdale MBC ex parte Milne (No. 2) [2000] (see Section 2.1). These cases dealt with outline planning applications for a proposed business park in Rochdale, England and provide the basis upon which a project can be described by a series of maximum extents known as the 'worst case' scenario. The detailed design of the scheme can then vary within this 'envelope' of design without invalidating the corresponding EIA and consent. (TCE, 2012)

The Rochdale Envelope approach has been adopted in the consenting of a number of offshore wind farm projects in the UK, with the Environmental Impact Assessment (EIA) based on assessing the realistic worst-case scenario where flexibility or a range of options is sought as part of the consent application. For offshore wind, key areas of required flexibility include:

- The size/capacity of the wind turbine generators (rotors);
- The foundation types;
- The layout within the redline boundary; and
- Installation methodology.

These areas of flexibility are also common to the consenting of tidal energy developments. However, because the tidal energy industry is currently at an early stage of development compared with offshore wind, and because there is a wide range of possible technology designs available to harness tidal energy (see Section 1.1), wider flexibility may be required in terms of the technology deployed. This report provides a review of the Rochdale Envelope principles and how use of this approach has developed in the consenting for the tidal energy industry.

While the Rochdale Envelope principle is specific to UK law, the use of design envelopes and the potential need for flexibility in consented design is a potential requirement internationally. Therefore a brief review is also provided of the project details used in consenting of key international tidal projects.

1.1. TIDAL TECHNOLOGIES

TABLE 1 provides an overview of some of the tidal device technologies in development worldwide. The wide range of forms of commercial scale tidal stream technologies currently being developed and demonstrated, shown in TABLE 1 demonstrates the potential need for flexibility in the device technology consent envelope.

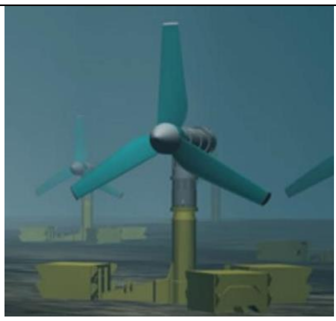
TABLE 1: EXAMPLE TIDAL STREAM TECHNOLOGIES	
Example Devices	Image
Bottom mounted single open (unshrouded) rotor axial flow	
Developer: Alstom (in the process of being acquired by General Electric) Device technology: Deep Gen Seabed mounted single open rotor. Fully submerged. Base typically formed from tripod, quadrapod or monopile foundation with drilled pin piles, gravity base or drilled monopile.	 Image source: www.alstom.com
Developer: Voith Hydro Device technology: HyTide Fast seabed mounted single rotor. A seabed mounted single rotor with fast rotation (60 RPM)	 Image source: www.offshorewind.biz
Developer: Atlantis Resource Ltd Device technology: AR series Seabed mounted single open rotor. Fully submerged. Base typically a gravity base tripod, with potential to be drilled piles (pin piles or monopile).	 Image source: www.offshorewind.biz
Developer: Andritz Hydro Hammerfest Device technology: HS1000 Seabed mounted single open rotor. Fully submerged. Base typically a gravity base tripod, with potential to be drilled piles (pin piles or monopile).	 Image source: www.hammerfeststrom.com

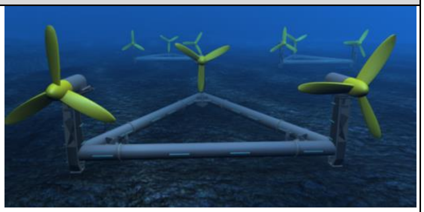
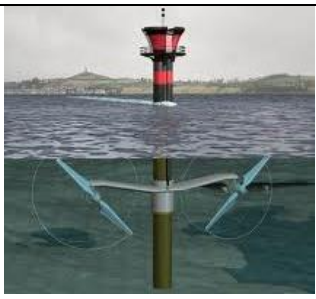
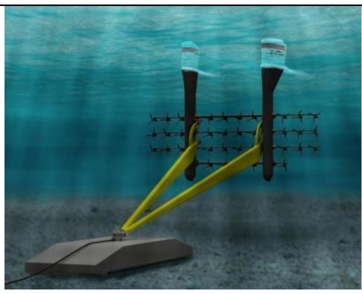
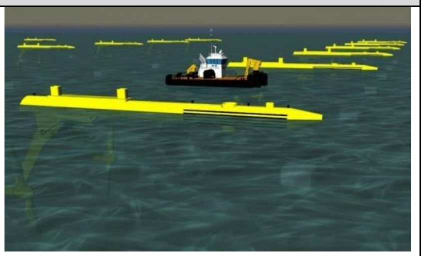
TABLE 1: EXAMPLE TIDAL STREAM TECHNOLOGIES	
Example Devices	Image
Multiple rotor seabed mounted devices or platforms	
Developer: Tidal Energy Limited (TEL) Device technology: Deltastream 3 rotor seabed mounted platform. Bottom mounted platform with 3 open axial flow rotors, fully submerged. Base typically gravity base.	 Image source: www.tidalenergyltd.com
Developer: Marine Current Turbines (MCT), now owned by Atlantis Resources Ltd (ARL) Device technology: SeaGen Twin rotor tower. Bottom mounted, pin piles or monopile with a surface piercing tower.	 Image source: Marine Current Turbines
Developer: Tidal Stream Limited Device technology: Triton Multiple rotor buoyant platform. Surface piercing with buoyant superstructure attached to seabed, with monopile, pin piles or gravity structure utilising mooring lines or a rigid structure. Multiple rotors (e.g. Schottel) typically installed on a single platform.	 Image source: www.tidalstream.co.uk
Floating/buoyant open rotor axial flow	
Developer: Scotrenewables Device technology: Scotrenewables Tidal Turbine Twin rotor floating. Surface piercing floating superstructure with catenary moorings/anchors to hold the device in place.	 Image source: www.scotrenewables.com

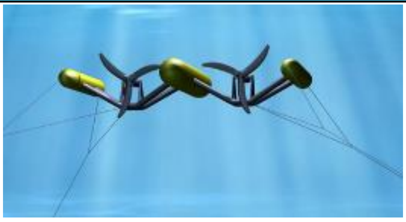
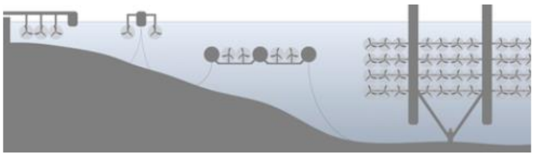
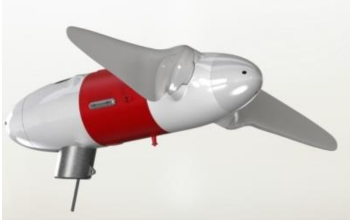
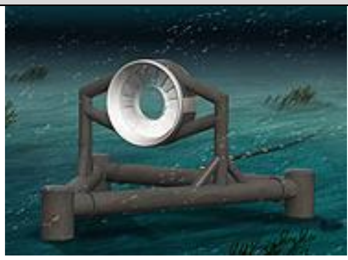
TABLE 1: EXAMPLE TIDAL STREAM TECHNOLOGIES	
Example Devices	Image
Developer: SME Device technology: PLAT-O Twin rotor buoyant mid water. Mid-water column (floating submerged), 2 rotors on single buoyant platform located below the sea surface. Platform maintained in position with tension cables secured with pin piles or gravity anchors.	 Image source: www.sustainablemarine.com
Small diameter rotors used on tidal stream platforms or barrages and lagoons	
Developer: Schottel Device Technology: Schottel Instream Turbine (SIT) Small three blade open rotors which can be deployed on a variety of tidal stream support structures such as floating, mid water buoyant, or submerged platforms as well as from infrastructure such as jetties and bridges, or in lagoons and barrages.  Image source: www.schottel.de	 Image source: www.offshorewind.biz
Developer: Tocardo Tidal Turbines Device Technology: T series or R series Small two blade open rotors which can be deployed on tidal stream support structures as well as from infrastructure such as jetties and bridges, or in lagoons and barrages.	 Image source: http://subseaworldnews.com
Bottom mounted ducted/shrouded rotor	
Developer: OpenHydro Device Technology: Open-Centre Turbine (OCT) Ducted axial flow rotors. Fully submerged, bottom mounted. Typically gravity base.	 Image source: www.openhydro.com

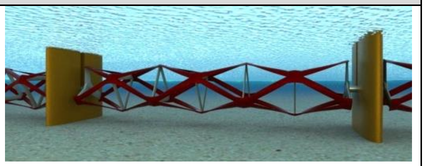
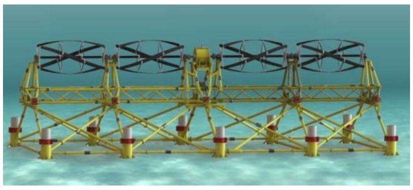
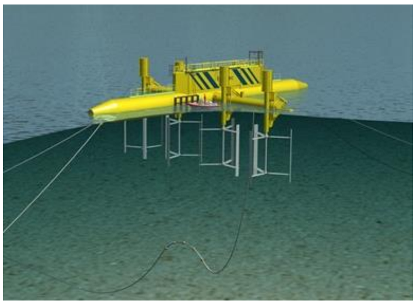
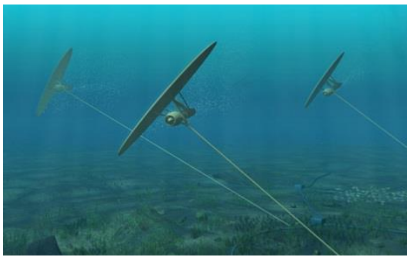
TABLE 1: EXAMPLE TIDAL STREAM TECHNOLOGIES	
Example Devices	Image
Transverse axis	
Developer: Kepler Energy Device technology: Turbine generator unit Bottom mounted transverse axis. Surface piercing support columns on monopile foundations.	 Image source: www.keplerenergy.co.uk
Developer: Ocean Renewable Power Company Device technology: TidGen Modular transverse axis rotating foils powering a gearless, central permanent magnet generator. Foundations include seabed mounted support frames, or floating with buoyant tension mooring systems. Designed to be deployed in tidal streams, rivers or deep water currents.	 Image source: www.cleantechnica.com
Developer: Bluewater Device technology: BlueTEC Vertical transverse axis TECs mounted on a floating device, similar to axial flow floating device type.	 Image source: www.bluewater.com
Belt rotors	
Developer: Atlantis Resources Ltd Device Technology: AN Series The turbine uses Aquafoils to capture momentum from the flow of water to drive a chain perpendicular to the flow. This turbine system is suited to shallow water locations in rivers, man-made structures or open ocean tidal streams.	 Image source: http://atlantisresourcesltd.com

TABLE 1: EXAMPLE TIDAL STREAM TECHNOLOGIES	
Example Devices	Image
Developer: Tidal Sails Device Technology: Tidal Sails Approximately 400 "sails" are attached at each end to a wire-pulling system, forming a belt that drives the generators. There can be a generator at either end of the belt, or the belts can be in a triangle formation with three generators.	 Image source: http://tidalsails.com
Seabed moored kite	
Developer: Minesto Device Technology: Deep Green Kite structure moored to the seabed uses the water current to create hydrodynamic lift force on the wing which pushes the kite forward. As the kite moves, water flows through the turbine mounted below the wing.	 Image source: http://minesto.com

2. ROCHDALE ENVELOPE PRINCIPLE

2.1. BACKGROUND

As mentioned in Section 1, the cases of *R v Rochdale MBC ex parte Tew* [1999] and *R v Rochdale MBC ex parte Milne* [2001] led to the "Rochdale Envelope" concept for design envelope definition. This approach was applied during EIA and consent determination in the context of an application for outline planning permission under the Town and Country Planning Act 1990 in order to comply with the EIA Directive (85/337/EEC).

Both cases dealt with legal challenge following the decision of the Local Planning Authority to grant outline planning permission for a business park. In both cases an Environmental Statement (ES) was provided but in the case of ex parte Tew, the Court upheld a challenge to the decision and rejected the planning permission. In ex parte Milne, the Court rejected the challenge and upheld the authority's decision to grant planning permission (SNH, 2013).

In ex parte Tew, the authority approved a scheme based on an illustrative masterplan showing how the development might be developed, but with all details left to reserved matters. The ES assessed the likely environmental effects of the scheme by reference to the illustrative masterplan. However, there was no requirement for the scheme to be developed in accordance with the masterplan and in fact a very different scheme could have been built, the environmental effects of which would not have been properly assessed. The Court held that description of the scheme was not sufficient to enable the main effects of the scheme to be properly assessed, in breach of Schedule 4 of the Regulations. (SNH, 2013)

In ex parte Milne, the ES was more detailed; a Schedule of Development set out the details of the buildings and likely environmental effects, and the masterplan was no longer merely illustrative. Conditions were attached to the permission to "tie the outline permission for the business park to the documents which comprise the application". The outline permission was restricted so that the development that could take place would have to be within the parameters of the matters assessed in the ES. Reserved matters would be restricted to matters that had previously been assessed in the ES. Any application for approval of reserved matters that went beyond the parameters of the ES would be unlawful, as the possible environmental effects would not have been assessed prior to approval. (SNH, 2013)

The Judge emphasised that planning permission can only be granted in the full knowledge of the project parameters and likely impacts on the environment. This was not to mean that developers would have no flexibility in developing a scheme but such flexibility would have to be properly assessed and taken into account prior to granting outline planning permission.

The implications of the Rochdale cases are summarised in the Office of the Deputy Prime Minister (ODPM) (2002) guidance entitled "Note on Environmental Impact Assessment Directive for Local Planning Authorities (1999 EIA Regulations)".

While the "Rochdale Envelope" approach was developed during onshore planning applications, this principle of providing flexibility whilst ensuring the impacts of the final development do not exceed those outlined, has also become important in the consenting of offshore renewables (see Section 2.3).

2.2. KEY PRINCIPLES OF THE ROCHDALE ENVELOPE

It is important that an ES clearly outlines if the EIA has been undertaken using the Rochdale Envelope principle, including signposting where areas of flexibility are required.

It is good practice to discuss the planned approach with the relevant planning authority prior to proceeding with any impact assessment to avoid risks to programme if aspects of the assessment are not agreed. This is usually done initially through the request for scoping opinion, with ongoing consultation during the EIA.

Sufficient detail must be provided to allow the impacts to be assessed and the parameters used should be transparent. Where there are a range of potential options or parameters the assessment of each impact should outline the relevant realistic worst case scenario. Appropriate mitigation measures can then be developed, to address the potential impacts of the worst case scenario with the aim of ensuring that the impacts of the development are acceptable. Commitment is generally made to defining the mitigation in agreement with stakeholders post-consent, once the final design is known.

Through comments made regarding the use of the Rochdale Envelope in offshore renewables to date, it is clear that stakeholders and regulators are concerned not only with ensuring that the actual impacts of the development will be equal to or less than those assessed in the EIA, but also that the EIA does not excessively exaggerate the impact by combining multiple worst case scenarios into a development scenario which is highly unrealistic. Such an exaggerated approach can make it difficult for stakeholders to provide meaningful advice and judgement during the consent determination process.

If consent is granted on the basis of the Rochdale Envelope approach, it will be conditional on providing the final details for agreement prior to construction.

2.3. ROCHDALE ENVELOPE IN UK RENEWABLE ENERGY POLICY AND GUIDANCE

The Infrastructure Planning Commission (IPC) Advice Note 9: Rochdale Envelope (IPC, 2011) considers the use of the 'Rochdale Envelope' approach under the Planning Act 2008, following requests from a number of developers, particularly those for proposed offshore wind farms, seeking guidance on the degree of flexibility that can be included in applications for a Development Consent Order (DCO) which is applicable to projects of over 100MW generating capacity in England and Wales. The advice note states:

"Revised draft NPS EN-3 states (paragraph 2.6.43) that the IPC should 'accept that wind farm operators are unlikely to know precisely which turbines will be procured for the site until sometime after the consent has been granted'. This is not to say that the use of the 'Rochdale Envelope' should be used as an excuse not to provide sufficient details. Developers should make every effort to finalise as much of the project as possible prior to submission of their DCO application"

"One practical way forward would be for the DCO application to set out specified maximum and minimum. For example, for offshore wind farms, these could be in terms of:

- *maximum number of turbines;*
- *minimum number of turbines;*
- *maximum nacelle (hub) height;*
- *minimum nacelle (hub) height;*
- *maximum blade tip height;*
- *minimum blade tip height;*
- *minimum clearance above mean sea level;*
- *minimum separation distances between turbines.*

Developers should be in a position to be able to identify the most likely variations of options and so provide a more focused description."

While the advice note refers primarily to offshore wind of over 100MW, the majority of key messages are equally applicable to tidal developments of all sizes throughout the UK.

For projects under 100MW in England and Wales, applications are submitted to the Marine Management Organisation and Natural Resource Wales, respectively. There is no available guidance on use of the Rochdale Envelope from these organisations at the time of writing.

In Scotland offshore renewable applications are submitted to Marine Scotland, which is currently developing licensing policy guidance in relation to the Rochdale Envelope approach and consulting widely within the offshore renewables industry as it does so. The guidance will aim to address some of the issues associated with projects where there are uncertainties over the final details of a proposed development, while ensuring compliance with environmental legislation. These uncertainties could include scale, type of device, elements and dimensions of the device and/or other factors, if there remain limitations in the amount of detail that is available on the project at the time at which consent is being sought (Marine Scotland website[1], accessed September 2015).

In Northern Ireland applications are submitted to the Department of Environment Northern Ireland (DoENI). No guidance is currently available from DoENI in relation to use of the Rochdale Envelope.

The Crown Estate (TCE) report of the Rochdale Envelope Workshop for wave and tidal energy developments in the Pentland Firth and Orkney Waters (TCE, 2012) looks at de-risking the use of an envelope in project consenting and concluded that clear guidance was required for developers. The workshop confirmed that it is highly unlikely that developers would ever be in a position to determine all design parameters prior to submitting an application for consent. It is therefore important that consent can be granted on the basis of consent conditions, providing the flexibility for detailed design and construction methodologies to be finalised post-consent.

TCE held another Rochdale Envelope Workshop in 2015. The Pre-Workshop Discussion Note (TCE, 2015) states that the objectives for the workshop were:

- *"To consider existing approaches or best practice in defining project (Rochdale) envelopes;*
- *To agree principles or guidance for defining project (Rochdale) envelopes for the demonstration zones and test sites (assuming zone/site-wide consents will be the preferred option for managers);*
- *To develop the understanding of the advantages and limitations of wide and narrow project envelopes; and*
- *To identify any further areas of work which are required, including opportunities for joint working across zones and test sites (and sites which are consented or under development) or shared approaches."*

The final report from the workshop is not yet available.

[1] http://www.gov.scot/Topics/marine/marineenergy/background/licensing

3. TIDAL INDUSTRY REVIEW

3.1. OVERVIEW

This section provides a review of the tidal industry, focussing mainly on the UK in relation to the use of the Rochdale Envelope principle, but also briefly considers wider international projects.

3.1.1. TIDAL STREAM

As shown in TABLE 1, the tidal stream industry is subject to considerable variation in the device types being developed and their associated design parameters.

A number of tidal stream sites in the UK have been leased and in many cases consented, allowing demonstration of one specific technology, as summarised below:

- Marine Current Turbines (MCT), now owned by Atlantis Resources, who deployed the SeaGen tidal turbine in Strangford Lough, Northern Ireland (discussed further in Section 3.2.1) in 2008;
- Scottish Power Renewables gained initial consent for deployment of an array of Andritz Hammerfest devices in the Sound of Islay in 2010, with re-consent in 2015 (see Section 3.2.2);
- MCT gained consent for an array of SeaGen devices in the Skerries site in north Wales (Section 3.2.3) in 2013;
- Minesto currently has a lease to develop a 10MW array of their Deep Green technology in north Wales, with a consent application in planning; and
- Scotrenewables (SR) is currently undertaking and Environmental Impact Assessment for deployment of their SR technology in Lashy Sound, Orkney.

In addition, Atlantis has received consent for the MeyGen site in Orkney for the deployment of their technology as well as the similar, Hammerfest Strøm device (Section 3.2.4).

The development strategies for these sites all require an element of flexibility in the project design envelope, as the technology is still in development and may be undergoing testing elsewhere and/or manufacturers for certain components may not yet be known or finalised. Site investigation works post consent may also allow refined resource modelling which leads to alterations to the device or the development layout in order to maximise efficiency. In addition, flexibility in relation to supply chain for post-consent procurement may allow cost reduction and avoid developers becoming vulnerable to price volatility of a limited supply source.

In contrast, some site developers have limited or no affiliation to one technology developer and are therefore keen to maintain flexibility in the devices to be installed at the site until further site investigation and technology procurement works are undertaken. Due to the financial constraints on the majority of tidal developments, these works are usually undertaken post-consent once additional confidence is available in the project and financing can be secured.

Perpetuus Tidal Energy Centre (PTEC) Ltd has submitted an application for consent for a site to demonstrate a range of tidal technologies (discussed further in Section 3.2.5). The EIA for PTEC (Royal HaskoningDHV, 2014) reviews a range of tidal device types that might be installed at the site and undertakes an impact assessment based on realistic worst case scenarios for each receptor impact. This is an attractive development strategy for developers of a tidal stream site that do not have an affiliation to a particular technology, and a similar approach has since been adopted by the third sector company Menter Môn, for the development of their Morlais Marine Energy site in north Wales. A scoping opinion for Morlais was provided in early September 2015 and is currently being considered by the developer.

Other projects, such as the Tidal Ventures Torr Head proposal in Northern Ireland, are seeking to use a device neutral Rochdale Envelope, but have limited the device types to seabed mounted single rotor devices with either shrouded or unshrouded rotors. Foundation systems may be gravity base, pin-pile or monopile with the varying associated construction methodologies. The application for the Torr Head project has been submitted in 2015 (Tidal Ventures, 2015) and a decision has not yet been announced. Westray South Tidal Array and Brims Tidal Array in the Pentland Firth and Orkney Waters have completed the scoping phase for their projects on a similar basis to Torr Head, but are yet to submit their applications.

Where the project description is highly defined in the ES, this can lead to requirements for an addendum to the consented project post-consent. This is likely to require Supplementary Environmental Information (SEI) with associated public consultation and may result in delays to the project programme.

Although the Rochdale Envelope principle is clearly defined in UK law, the need for design envelope flexibility is not limited to the UK. Other EU countries may take alternative approaches to design envelope definition and consenting under the EU EIA Directive. For example, the EDF tidal stream development in Paimpol-Bréhat, France, involved one device technology, the OpenHydro OCT device and therefore had minimal requirements for flexibility in the device parameters, installation method and O&M strategy, as this device had been previously tested at EMEC and its requirements were well understood.

North America also represents an important area for tidal developments. A key example is the Fundy Ocean Research Center for Energy (FORCE) in Canada which provides a consented site with the electrical infrastructure required for the deployment of three specific devices. FORCE was assessed under a joint federal and provincial Environmental

Assessment (EA) review process. The consent application was submitted in 2009 with details of the following devices (including their parameters) which were to be installed at three sites (berths) within the FORCE boundary (FORCE, 2009):

- SeaGen S;
- Clean Current; and
- OpenHydro.

An Addendum was required in 2010 for the following key changes (FORCE, 2010):

- The relocation of the onshore facility; and
- Inclusion of a fourth berth and cable within the approved lease area.

3.1.2. TIDAL RANGE

Tidal lagoons and barrage infrastructure have been used on a commercial scale since the 1960s with well-known developments such as La Rance Barrage in Brittany, France, still in operation. To date, tidal lagoons and barrages have generally used hydro turbine technologies, in particular the bulb turbine type, for example the Alstom bulb turbine and Voith bulb turbine.

These turbines are mounted in a wall structure to hold back the water in either an artificial lagoon or as a barrage. The parameters of this type of tidal energy development are generally more defined compared with tidal stream but as with most offshore developments, the contractors, installation vessels, equipment, materials and rotors may not be fully defined, particularly for the infrastructure and supporting structures, until post-consent to allow for refinement as site investigation progresses, as well as any potential developments in rotor efficiency and lower cost materials.

The Rochdale Envelope principle is also used in tidal lagoon/barrage applications, and a recent example is the consented tidal lagoon in Swansea Bay, Wales which is discussed further in Section 3.2.6.

3.2. UK CASE STUDIES

The following sections provide an outline of consented sites and key lessons learned in relation to the consent approach in terms of the details of the project description. A review of the approach taken in the PTEC EIA is also provided in Section 3.2.5, which at the time of writing is still in the consent determination phase.

3.2.1. MCT, SEAGEN DEVICE IN STRANGFORD LOUGH

MCT developed the 1.2MW twin rotor surface piercing tower device, SeaGen S following the installation of the 300 kW SeaFlow prototype device that had been installed and successfully operated off the north Devon coast in 2003.

A consent application for the installation of a single SeaGen S device in Strangford Lough, Northern Ireland was submitted in 2005. Details of the proposed scheme were brief and highly defined, stating "*The proposed turbine for installation in Strangford Narrows will comprise a twin rotor machine consisting of a central monopile with two 16m diameter rotors mounted on either side*" supported by a diagram of the device parameters and information on the export cables. An appendix to the ES provided a detailed installation method statement, including the equipment and installation vessel to be used.

Due to commercial reasons, MCT were unable to use a number of proposed jack up rig installation vessels and therefore sourced an alternative, crane barge vessel. However, the crane barge did not have the capacity to install the monopile foundation defined in the original design, and the foundation was redesigned to utilise a quadropod, with smaller piles. These changes and revisions were assessed in an addendum to the original application, which was submitted in 2007. The addendum provided supplementary environmental information (SEI) and updated the relevant impact assessments in relation to the altered footprint and installation methodologies. The revised application was consented and SeaGen was installed in 2008.

The quadropod foundation had the following key advantages:

- Shorter installation duration
- Reduced footprint
  - 3.8m diameter (11.3m^2) for the original monopole
  - 4 x 1m diameter pin piles (3.1m^2) for the revised quadropod structure
- Reduced drill arisings and drill depth
  - Drill depth of 25m for the original monopole
  - Drill depth of 7m for each of the four pin piles

It is possible that had the original EIA and consent application taken a Rochdale Envelope approach the post-consent changes in design and methods may have been a refinement of the envelope, reducing the impacts and fully encompassed by the original consent. However, this project was a pioneer project, and at that time, MCT chose to define the project description as much as possible, and it was felt that the device structure and installation method were fully understood, based on the experience gained in the SeaFlow installation. The need for a change in installation vessel was unforeseen, but provided an important lesson for MCT and the rest of the tidal stream industry.

3.2.2. SCOTTISH POWER RENEWABLES (SPR), SOUND OF ISLAY TIDAL ARRAY

The Sound of Islay tidal array was consented in 2010 for the installation of ten Hammerfest Strøm devices in defined locations within a redline boundary, with micro-siting allowed up to 50m.

Following further site investigation post consent, it was determined that movement of devices beyond the micro-siting limit was required. In addition, following test deployments of the Hammerfest Strøm device at the European Marine Energy Centre (EMEC), alterations were made to the device parameters (see TABLE 2) and the installation methodology.

TABLE 2: SUMMARY OF SOUND OF ISLAY TIDAL ARRAY DEVICE CHANGES (SOURCE: SPR, 2014)

Parameter	Original ES	Revised HS 1000
Substructure	Gravity	Gravity
Hub Height	22m	26m
Rotor diameter	23m	26m
Tip height	33.5m	39m
Deployment depth	50m	52.6m (min)
Under keel clearance	16.5m	13.6m (min)
Yaw mechanism	None	180°
Rotational Speed	10.2rpm	8.5rpm
Tip Speed	$12ms^{-1}$	$12ms^{-1}$

Also, due to changes in land ownership, the substation location had to be changed (from the island of Jura, to the island of Islay) and the associated export cable route also changed.

An addendum was submitted in 2014 to reassess the impacts in relation to the new device locations, installation method, and consent was granted in 2015.

Had the redline boundary been the basis of the application and the worst case scenario device locations been assessed, as is usually done for offshore wind farms, alterations to the device locations within this redline would have been unlikely to trigger the need for reassessment.

A Rochdale Envelope approach which allowed some increase in device parameters may have avoided the need for the consent to be altered, following the lessons learned at EMEC and the revised design. However, in common with MCT's experience in Strangford Lough, this project was a pioneer project (as the world's first consented tidal stream array project), and engineering advice at the time of the consent application was that it was appropriate that the consent be as defined as possible.

It is unlikely that the original application could have been broad enough to allow the relocation of the substation from Jura, as originally consented, to the revised location on Islay. IPC (2011) states "*any flexibility should not permit such a wide range of materially* *different options such that each option in itself might constitute a different project*". It is therefore likely that separate outline planning applications would be required for multiple substation location options. However, options for the export cable route could potentially have been considered if it was made clear that they were mutually exclusive.

3.2.3. MCT, SKERRIES TIDAL STREAM ARRAY

The next step for MCT, following the Strangford Lough project discussed in Section 3.2.1, was to deploy a small array of SeaGen S devices. In 2013, consent was granted for an array of five 2MW SeaGen S devices at the Skerries site in north Wales.

The EIA used the Rochdale Envelope principle and the ES Project Description chapter provided significant detail, but with some built in flexibility. The device technology was known, but it was acknowledged that there was uncertainty in the device parameters and wider project requirements, including:

- Rotor diameter;
  - 16 to 20m;
- Array layout within the defined redline boundary;
  - Defined by minimum and maximum spacing parameters for both rotor diameter options;
  - Indicative layouts provided;
- Two possible landfall and cable options (substation consented separately); and
- A range of installation vessel options.

Pre-construction monitoring surveys have been undertaken, but the project has not yet been constructed. To date, no known changes are required to the consented envelope.

3.2.4. ATLANTIS, MEYGEN TIDAL ARRAY IN ORKNEY

The MeyGen EIA takes a phased approach to device installation and follows the Rochdale Envelope principle in relation to the following key parameters (MeyGen, 2012):

- Number of turbines;
- Maximum number of turbines and a range of total capacity is provided for each phase;
- Layout;
- Rotor diameter between 16-20m; and
- Foundation type – gravity or drilled monopile or tripod.

At the start of each ES section the maximum project extents relevant to the specific assessment are defined. Potential variances in the impacts predicated based on the different design options have been summarised qualitatively following the main impact assessment. (MeyGen, 2012)

Phase 1 was consented in 2013 for the installation of 86MW capacity on the condition that a 'Stage One', limited to 6 turbines, is installed and monitored before written agreement can be sought from Marine Scotland to build-out the remaining phases under the existing consent (Marine Scotland, 2013). Construction is underway at the time of writing and no known alterations are required for Stage One.

3.2.5. PERPETUUS TIDAL ENERGY CENTRE (PTEC), ISLE OF WIGHT

Perpetuus Tidal Energy Centre (PTEC) Ltd has submitted an application for consent for a commercial site to demonstrate a range of tidal technologies. The EIA for PTEC reviews a range of tidal device types that may be installed at the site, providing examples of specific technologies of each type but the envelope is not limited to these as long as the parameters of any alternatives are within the maximum parameters outlined by the envelope.

The Project Description aims to consider each component of the tidal device which is of relevance to the impact assessments, breaking each device into three key components with associated parameter flexibility:

- Surface piercing superstructure;
  - Length, width and height above the water surface;
  - Range of movement on the water surface;
- Foundations and moorings;
  - Footprint, including potential drag footprint of moorings for floating devices;
- Rotors;
  - Formation;
  - Diameter;
  - Minimum seabed and sea surface clearance of rotor tips; and
  - Rotation and tip speed.

Each technical chapter identifies the realistic worst case scenario which is of relevance to a specific receptor and/or impact and provides suggested mitigation where necessary with the aim of ensuring all permutations of the proposed development would be acceptable.

The ES also puts limits on the maximum numbers of each type that can be installed at the development, with particular restrictions on the number of devices which represent the worst case scenario in terms of footprint and those which would have the maximum visual impact.

A range of minimum and maximum spacing parameters are provided for each device type in order to identify the worst case scenario space to move in between devices as well as the maximum area that an array could encompass within the redline boundary.

In addition, flexibility is built in to associated offshore infrastructure, including electrical hubs and monitoring equipment, inter-array cables, and navigational aids.

A review of the likely installation and operation and maintenance (O&M) strategies is also provided.

The Crown Estate UK Wave and Tidal Stream Demonstration Zones and Test Sites Workshop: Pre-Workshop Discussion Note (TCE, 2015) states "*Section 5.17 of the (PTEC) ES summarises the Rochdale Envelope and provides a clear overview of all key components of the project description which have been taken forward in the assessments of environmental impacts. The key relevant information is carried forward clearly in the assessment chapters and a worst case assessment made, based on the assumptions.*"

The ES provides commitment that details of the final deployments will be submitted to the MMO prior to installation to seek approval that the parameters are within the Rochdale Envelope. The approach required for any deployment outside the Rochdale Envelope would be agreed with the MMO on a case by case basis depending on the extent to which it varies.

Further to the offshore development, PTEC also used the Rochdale Envelope principle to capture a range of options for outline planning of the onshore works, in keeping with the original use.

3.2.6. SWANSEA BAY

The Swansea Bay Tidal Lagoon was consented in 2015 using the Rochdale Envelope principle and following the guidance of IPC (2011), Advice Note 9 (see Section 2.3). The ES (Tidal Lagoon Swansea Bay Plc, 2014) outlines all of the realistic and likely worst case variations and where an alternative exists, the option with the likely worst case effect has been assessed in the impact assessment chapters. Where there is more than one route choice or construction method (e.g. cable route or temporary cofferdam), and where the potential effects of the options are noticeably different, such that a single worst case cannot be determined, or the characteristics of such effects are different, then all variations have been considered in the assessment.

The following key areas of flexibility are included:

- Two options for the turbines, including bi-directional turbines of fixed speeds or variable speed turbines, both with rotor diameters of up to 7m;
- The total number of turbines (13 – 16);
- The number of sluice gates (6 – 10);
- The maximum volume of materials;
- The maximum width/ total footprint of the seawall; and
- The types of materials to be used in the seawall construction.

4. SUMMARY AND RECOMMENDATIONS

Due to the rapidly evolving nature of the tidal energy sector, fully defined details of proposed developments are often not available at the time of the application. Therefore, the project description and methods upon which applications for consent are based will fall within a range of defined criteria, an envelope of potential development, which describes the potential extent and nature of the development. This approach allows a degree of flexibility and future proofing for determining the final specific project details post-consent, maintaining flexibility in supply chain, while still meeting the requirements of the EIA process.

The approach taken to consenting and the amount of flexibility required in project design will depend on the objectives and circumstances of each developer, e.g. demonstrating a single technology or developing a site which could take a range of technologies. A device neutral approach and therefore wide Rochdale Envelope has the following potential advantages and disadvantages:

Pros

- Flexibility to attract a wide range of technology developers
- Reduce cost and time for technology developers to install devices that are within 'envelope'
- Flexibility to select optimum device technology for the conditions
- Flexibility in supply chain options

Cons

- Complex EIA
- Challenging stakeholder and regulator consultation in order to seek agreement on the approach to EIA and the assessment results

As mentioned previously, a device neutral approach may not be appropriate if a developer has affiliation to a specific device. However, a tightly defined envelope presents risks to the project if later changes are required, primarily in terms of delay to programme and additional costs in revisiting the assessments, as well as having implications for supply chain costs.

As shown in some of the case studies (e.g. SeaGen in Strangford and the Sound of Islay Tidal Array) outlined in Sections 3.2.1 and 3.2.2, the need for flexibility was not apparent to early tidal stream projects. However, learning from those experiences has shown that, while it is not always possible to foresee all potential changes, a degree of future proofing is advisable where possible and therefore the use of the Rochdale Envelope to a certain extent is advisable for all tidal projects. This approach provides the following advantages to future proof the consent and therefore minimise the potential work for the developer and regulators in revising existing consents:

- Allows variation in device layout pending detailed site investigation surveys to;
    - optimise generation efficiency;
    - micro-site around constraints;
- Allows for some device and technique advances; and
- Flexibility in some areas of supply chain options.

In accordance with the IPC (2011) Advice Note for offshore wind (see Section 2.3), the project description must be sufficiently defined with worst case scenarios being realistic so that a thorough and realistic assessment of the impacts can be undertaken that stakeholders and regulators are confident to provide advice and a decision on.

The Rochdale Envelope principle has been used successfully in the consenting of tidal energy developments, for example the MeyGen Tidal Array, MCT Skerries Tidal Array and Swansea Bay Tidal Lagoon with conditions that the final details are within the envelope and fully approved by the consenting authority prior to construction.

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