SIMCelt

Supporting Implementation of Maritime Spatial Planning in the Celtic Seas

Component 1.2.1

Spatial Demands and Scenarios for Maritime Sectors and Marine Conservation

Deliverable 2

Sectoral briefing notes

Others in the series

Aquaculture

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Wave and Tidal Energy

Maritime Sector Briefing Note

This briefing note summarises the current status of wave and tidal power in the Celtic Seas project area. It looks ahead to upcoming projects and analyses the implications for expansion of the sector in relation to Maritime Spatial Planning.

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About SIMCelt: SIMCelt is a cross-border project involving partners from the UK Ireland and France. It aims to support cooperation between Member States on the implementation of the Maritime Spatial Planning Directive in the Celtic Seas. The SIMCelt project is aimed specifically at the OSPAR Region III Celtic Seas area in accordance with a proposed extension of this region.

http://www.simcelt.eu/about/celtic-seas-area/

Disclaimer: The contents and conclusions of this report, including the maps and figures, were developed by the participating partners with the best available knowledge at the time. They do not necessarily reflect the national governments' positions and are therefore not binding. This report reflects only the SIMCelt project partners' view and the European Commission or Executive Agency for Small and Medium-sized Enterprises is not responsible for any use that may be made of the information it contains.

KEY POINTS

- The development of wave and tidal energy in the Celtic Seas is largely driven by the prevalence of strong marine currents originating in the Atlantic, plus high tidal ranges in channels and bays. This form of renewable energy is attractive as it is more reliable than other renewables such as wind energy.

- The wave and tidal energy sector is in the pre-development stage. That is, progress has been made on prototypes and testing, but further research and development is required. A significant challenge for the industry is scaling up from prototypes to commercially viable schemes.

- Within the countries of the Celtic Seas, a number of wave and tidal energy devices have been tested and deployed, however many of these fall outside the area considered by the SIMCelt project, for example devices at the European Marine Energy Centre (EMEC) in Orkney and Yell Sound in Shetland to the north of Scotland. Within the Celtic Seas, examples include the FabTest wave energy site in Falmouth, south west England, Minesto's tidal stream test and demonstration site in Strangford Lough (Northern Ireland), Open Hydro and La Rance tidal barrage in France which operates on a commercial scale. Several more proposals are in the pipeline, with applications submitted for consent and some at an earlier concept stage.

- International, European and national targets related to renewable energy and climate change are also key drivers of the marine energy sector. However, given the challenges to deploying marine energy at commercial scale the expected contribution of marine energy to renewables generation in the medium term is relatively low compared to offshore wind energy.

- Marine energy has a number of positive and negative interactions with other maritime sectors and the environment. For example, seabed disturbance during construction, introduction of underwater noise and impacts upon navigation and tidal regimes are considered potential negative effects, whilst opportunities for co-location of marine energy with uses such as coastal flood prevention, aquaculture, and leisure and tourism activities provide greater benefits.

- With respect to transboundary issues, the potential alteration of tidal regimes at a distance from the site of proposed tidal range (lagoon) developments and impacts on navigational safety caused by floating/submerged devices, wave reflection and turbine wakes.

DISTRIBUTION OF ACTIVITY

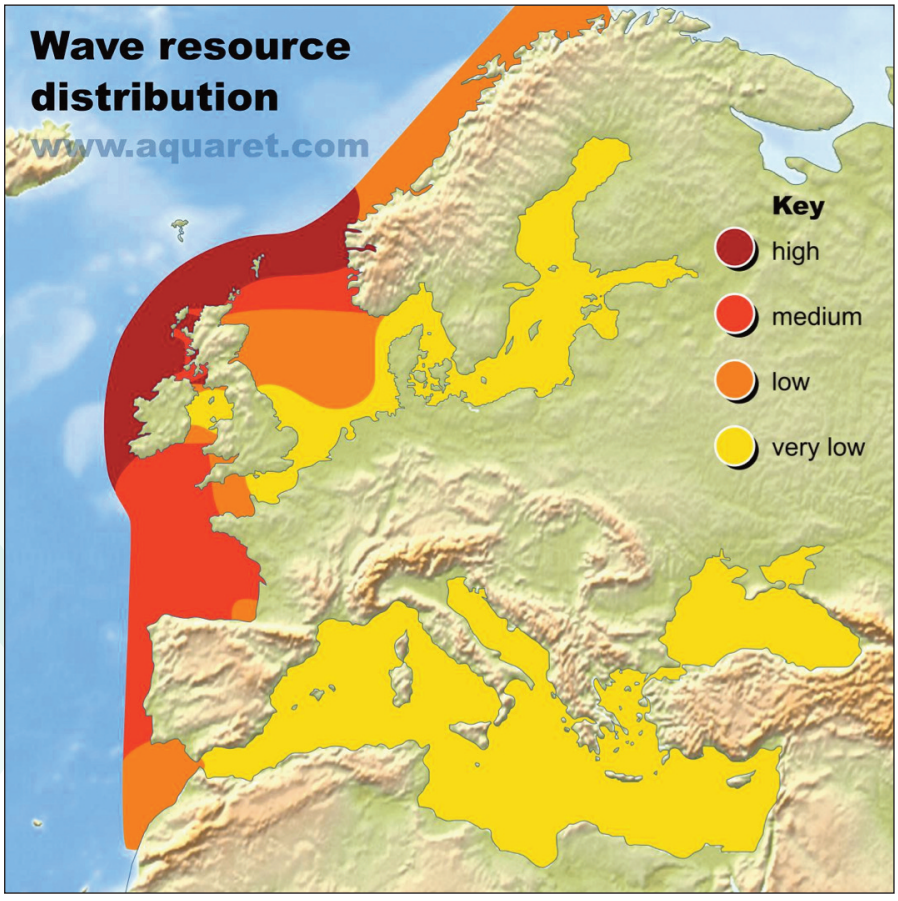
Wave Energy

Wave energy devices can be fixed or floating and capture energy from the oscillation of waves at the surface or movement of the water column. Figure 1 below shows the areas with greatest wave power potential in the Celtic Seas and beyond, with potential at its greatest to the north and west of Scotland and the west of Ireland. Table 1 lists current activities related to wave energy generation within the SIMCelt project area.

Tidal Stream (Current)

Tidal current devices (turbines) are installed where there are strong ocean currents that can be used to generate energy from the fast moving waters. Tidal turbine rotors can be much smaller than wind turbine rotors, thus they can be deployed much closer together (Marine Current Turbines, 2017), however at low tidal depths close to shore generation capacity may be limited. Figure 2 shows the areas with greatest tidal stream potential in the Celtic Seas and beyond, with potential at its greatest to the west of Brittany, Gulf of St Malo, Cornwall, the Severn Estuary, Pembrokeshire coast, Anglesey, between Northern Ireland and south west Scotland and the Inner Hebrides. Table 2 lists current activities related to tidal stream energy generation within the SIMCelt project area.

Figure 1: Wave Resource Distribution in Europe



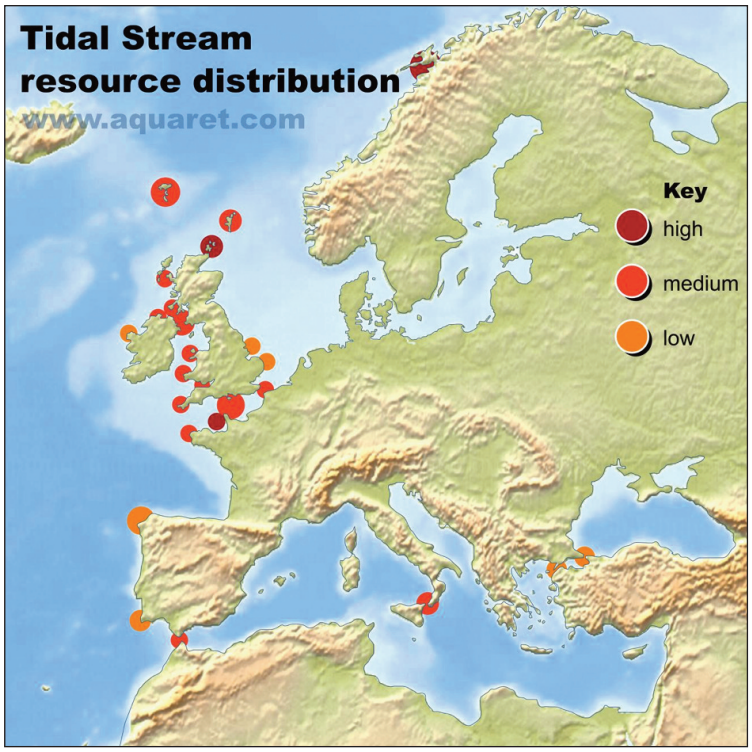
Source: Aquaret.com

Table 1: Status of wave energy projects in the SIMCelt area

Country	Project	Developer	Status
England	**FabTest**	Falmouth Harbour Commissioners	Consented and operational
	Wave Hub test site in Hale	Wave Hub Limited	Consented and operational
Scotland	**Harris Demonstration Zone**	West Harris Trust	Lease agreed – in development
	Portnahaven	WaveGen	Ceased operation
Wales	Wave Hub's **South Pembrokeshire Demonstration Zone**	Wave Hub Limited	In development
Republic of Ireland	**Atlantic Marine Energy Test Site (AMETS)** – Belmullet	Sustainable Energy Authority Ireland (SEAI)	In development – Foreshore Lease awarded in 2016 and shore station planning approved in 2017
	Galway Bay Marine and Renewable Energy Test Site	Sustainable Energy Authority Ireland (SEAI) and the Marine Institute	Operational since 2006, currently seeking new consent application to extend and update lease
	Carnegie Clare Project	**Carnegie Clean Energy**	In planning; investigating site
	WestWave	ESB (Electricity Supply Board)	In planning

Note: There are currently no wave energy projects in Northern Ireland or the area of France covered by the SIMCelt project.

Figure 2: Tidal Stream Resource Distribution in Europe



Source: Aquaret.com

Table 2: Status of tidal stream projects in the SIMCelt area

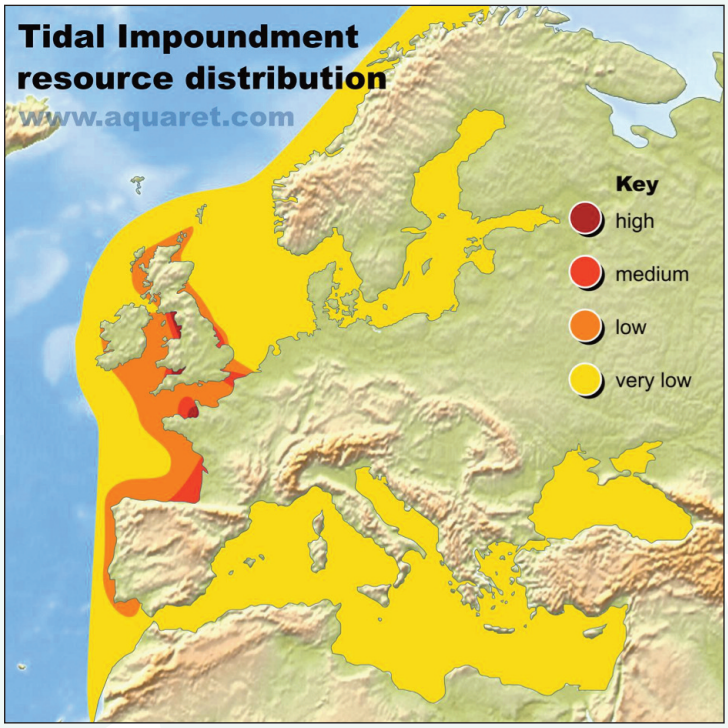
Country	Project	Developer	Status
Northern Ireland	**Strangford Lough (Minesto 1)**	Minesto UK Ltd	Operational
	Strangford Lough (SeaGen)	SeaGeneration Ltd/ Atlantis Resources	Leased, to be fully decommissioned by 2018
	Strangford Lough Array	**Atlantis Resources Ltd**	In development
	Torr Head	Tidal Ventures Ltd	Consented, in planning
	Fair Head Tidal Energy Park Phase 1 and 2	Fair Head Tidal Energy Park Ltd/DP Energy	In planning
England	North Devon Demonstration Zone	**Wave Hub Ltd**	In development
	Portland Bill	Atlantis Resources Ltd	In development
Wales	**Ramsey Sound**	Tidal Energy Limited	Consented, operational
	West Anglesey Tidal Demonstration Zone	Morlais Marine Energy	In development
	Holyhead Deep	Minesto UK Ltd	Consent, Agreement for lease, in development
	Ynys Enlli / Bardsey	**Nova Innovation Ltd**	In development
	Mull of Galloway	Atlantis Resources	Agreement for lease, in development
Scotland	Mull of Kintyre Phase 1 Mull of Kintyre Phase 2	**Nautricity**	Phase 1 prototype consented, Phase 2 demonstration in development
	Sound of Islay	Atlantis Resources	Agreement for lease, awaiting construction
	Islay Demonstration	Site operated by **EMEC**	In development
	West Islay Tidal Energy Park	DP Marine Energy	Consent, Agreement for lease, in development
Ireland	**GKinetic Tidal Energy Device**	GKinetic	First tow test complete
France	**OpenHydro Paimpol-Bréhat**	**EDF** and OpenHydro	Operational
	Sabella D10 - Fromveur	Sabella	Complete (Decommissioned)

Source: RenewableUK Marine Energy Database (UKMED)

Tidal Range

Tidal range uses the vertical difference between high and low tides to generate energy. As tides come in water moves through turbines and is retained by barriers or artificial lagoons. As the tide goes out the water is released and again passes through turbines to generate energy. Figure 3 shows the areas with highest tidal range resource in the Celtic Seas and beyond, with potential for development at its greatest in the Gulf of St Malo, Severn Estuary and along the north west coast of England where there are several tidal estuaries.

Figure 3: Tidal Impoundment Resource Distribution in Europe



Source: Aquaret.com

Table 3: Status of tidal range projects in the SIMCelt area

Country	Project	Developer	Status
Scotland	**Solway Firth**	North West Energy Squared (NWE²) Solway Energy Gateway	In development
Wales	**Cardiff Tidal Lagoon**	Tidal Lagoon Power	Submitted scoping report
	Swansea Bay Tidal Lagoon	Tidal Lagoon Power	Development Consent Order granted by Secretary of State, awaiting lease from The Crown Estate licence from Natural Resources Wales
	North Wales	North Wales Tidal Energy	In development
	Colwyn Bay	Tidal Lagoon Power	In development
England	**West Cumbria**	Tidal Lagoon Power	In development
	Duddon Estuary Tidal Lagoon	Northern Tidal Power Gateways	In development
	Morecambe Bay Tidal Lagoon	Northern Tidal Power Gateways	In development
	Wyre Barrage	Natural Energy Wyre	In development
	Mersey Barrage	No developer	Concept stage; previous scheme by Peel Energy scrapped 2011
	Bridgwater Barrage	No developer	Concept stage
	West Somerset Tidal Lagoon	Longbay Seapower and Halcyon Tidal Power	In development
France	**La Rance**	Électricité de France (EDF)	Operational

Note: there are no tidal range projects proposed for Northern Ireland, Ireland or the Isle of Man at present.

INTERNATIONAL/EUROPEAN LAW AND POLICY

UN Framework Convention on Climate Change (Kyoto Protocol and Paris Agreement)

The Kyoto Protocol (1997) includes binding targets for greenhouse gas reduction. The EU-29 (including Iceland) are committed to 20% carbon reduction below 1990 levels from 2013-2020, building upon the 11.7% reduction achieved from 2008-2012. This is in line with the Union's own climate 2020 package.

The Paris Agreement (2016) commits Parties to limit global temperature rise this century to 2°C. Parties are encouraged to limit it further to 1.5°C and report on 'Nationally Determined Contributions' every 5 years.

Renewable Energy Directive 2009/28/EC

National binding targets % renewables in energy consumption by 2020

23% France, 16% Ireland, 15% United-Kingdom

No obligation to include wave or tidal energy

Europe 2020 and 2030 Energy Strategy

Energy 2020 combined climate change and energy targets into the 20:20:20 package:

- 20% cut in greenhouse gas emissions (relative to 1990 levels)
- 20% of EU energy from renewables
- 20% improvement in energy efficiency

2030 Energy Strategy sets new targets for achieving decarbonisation by 2050:

- 40% cut in greenhouse gas emissions relative to 1990 levels
- ≥ 27% share of renewable energy consumption
- ≥ 27% energy savings compared with business as usual

EU – Energy Roadmap 2050

Sets out key challenges for Europe to deliver 80-95% reduction emissions by 2050.

Explores different routes to decarbonisation - all scenarios involve proportion of renewable energy rising to at least 55% compared 10% in 2011.

Ocean energy can provide an important contribution to electricity supply (p11), but acknowledges the need to improve existing technologies.

Blue Growth and Action to Deliver Ocean Energy

Wave and tidal energy (as types of blue energy) are a Focus Area of the Commission's Communication on Blue Growth.

In 2013 the Commission published a Communication on steps needed to overcome challenges in the ocean energy sector by 2020 and beyond. This established the Ocean Energy Forum for stakeholders to develop a shared understanding of problems and workable solutions. In 2016 the Forum produced an Ocean Energy Strategic Roadmap, proposing 6 actions to facilitate the emergence of a market for ocean energy in Europe. These actions include:

- Identifying suitable sites for early deployment and supporting pre-commercial farms there
- New financial packages and insurance to underwrite risks
- Creating integrated consenting programmes

Atlantic Strategy and Atlantic Action Plan

The Maritime strategy for Atlantic EU Member States (UK, Ireland, France, Spain and Portugal) supports expansion of wave and tidal energy to help reach Europe's renewable energy targets and extend benefits to ports.

The Atlantic Action Plan sets out research and investment priorities to drive the Atlantic Strategy, including assessment and mapping of the Atlantic Ocean's energy resource to help mitigate the environmental and navigational impacts of their construction and operation.

National Policy and Legislation

KEY POLICIES: NATIONAL

UK

For a full consideration of UK renewable energy policy see Marine Sector Briefing Note: Offshore Wind

The Crown Estate has a key role in the development of wave and tidal energy, operating as an independent commercial business managing the land and holdings of the Sovereign in right of the Crown. This includes around half of the foreshore and virtually all of the sea bed out to the 12 nautical mile limit in England, Wales and Northern Ireland. Following the Scotland Act 2016, The Crown Estate Scotland began operations in April 2017. The Crown Estate Scotland has been tasked with managing Scotland's Foreshore and most of the sea bed on behalf of Scottish Ministers. The Crown Estate's activities include the leasing areas of the seabed for development of wave and tidal projects and managing the associated seabed rights. The Crown Estate also sponsors the Offshore Renewables Joint Industry Programme (ORJIP) for Ocean Energy (http://www.orjip.org.uk/) which is a UK-ide collaborative programme of environmental research with the aim of reducing consenting risks for wave, tidal stream and tidal range projects.

In 2012 The Crown Estate released a study of the UK's potential for wave and tidal energy resources (size and distribution). This included a set of maps illustrating areas of wave and tidal key resources and helps to identify seabed areas which may be suitable for wave and tidal energy projects[1]. The findings of this report show that potential for wave energy is relatively evenly distributed along the Atlantic coast of the UK, whilst there are particular sites that are more suitable for tidal energy (stream, lagoon or barrage).

Areas of potential tidal stream resources are located at Orkney, Islay, Kintyre and Galloway in Scotland, Rathlin in Northern Ireland, north of Anglesey, the Lleyn Peninsula, and Pembrokeshire Coast in Wales, the Severn Estuary, and north Devon and Penwith Bay in England (plus other areas outside the Celtic Seas).

For tidal range (barrages) the Solway Firth, Morecambe Bay, Mersey estuary and Severn Estuaries were identified as areas of key resource whilst Wigtown Bay (Scotland), Workington coast, Liverpool Bay, Cardiff Bay and North Devon were identified as areas of key resource for tidal lagoons.

The third Offshore Energy Strategic Environmental Assessment (OESEA3) by the Department of Energy and Climate Change (2016) considers the implications of strategic plans for offshore energy and informs leasing and licensing decisions. It notes that to up to the time of writing there was relatively little information on the environmental impacts of commercial wave and tidal deployments. In addition, the variety of activities that occur across estuaries and bays and the variety of technologies available mean that site specific assessments of impacts may be needed before leasing and consenting decisions can be made.

[1] See https://www.thecrownestate.co.uk/media/502058/ei-uk-wave-and-tidal-key-resource-areas-project-distribution-map.pdf

Hendry Review of Tidal Lagoons, 2017

In February 2016, the Government commissioned an independent review into the feasibility and practicality of tidal lagoon energy in the UK. The review was led by former Member of Parliament Charles Hendry. The purpose of the review was to assess:

- whether, and in what circumstances, tidal lagoons could play a cost effective role as part of the UK energy mix;
- the potential scale of opportunity in the UK and internationally, including supply chain opportunities;
- a range of possible structures for financing tidal lagoons;
- different sizes of projects; and
- whether a competitive framework could be put in place for the delivery of tidal lagoon projects.

The findings of the Review were published in February 2017 and supported the case for developing tidal lagoons on several grounds; ensuring security of energy supply, contribution to renewable energy targets; lower costs compared to nuclear and other low carbon energy sources and the potential for economic development associated with tidal technologies (engineering, supply chain and wider community benefits). Alongside the benefits outlined, the Review made a series of recommendations, including:

- The development of the Swansea Bay tidal lagoon as a "Pathfinder" to demonstrate approaches to funding, construction, mitigation and monitoring before any larger scale projects are developed;
- A new National Policy Statement should be prepared that identifies suitable sites for tidal lagoons. This Statement should take into consideration the hydrodynamic interactions between multiple lagoons and impacts on other sea users;
- Establishment of a Tidal Power Authority to oversee the delivery of a tidal lagoon programme for the UK, with responsibility for offering sites by tender at the appropriate time and driving down technology costs through innovation centres and skills development;
- Contracts for Difference should be used to incentivise energy generation on a per MW basis, as is the case for other forms of renewable energy in the UK;
- There should be a body in place to oversee the decommissioning of lagoons once they reach the end of their operating lives. Lagoon operators should contribute to a fund that supports maintenance, repair and decommissioning works.

ENGLAND

English policy for wave and tidal energy largely follows the ambitions set out in the Climate Change Act 2008 and the Renewable Energy Roadmap of 2011.

At the current time, the National Policy Statements (NPS) for Energy (EN-1) and Renewable Energy Infrastructure (EN-3) do not cover decision making for large scale wave and tidal energy developments. However, acknowledging that they may become economically and technically feasible in the future, Government is considering the need to either revise the NPS for Renewable Energy Infrastructure or produce a separate NPS to provide the primary basis for decision-making under the Planning Act on such schemes[2].

[2] Department for Energy and Climate Change (2011) NPS Renewable Energy Infrastructure, para 1.8.2

Within English waters, The Crown Estate has leased a number of sites to support the development of wave and tidal technology. These include the FabTest wave energy test site in Falmouth Bay, the Wave Hub site in north Cornwall, the North Devon Tidal Demonstration Zone near Lynmouth and others outside the SIMCelt project area (such as Perpetuus Tidal Energy Centre around the Isle of Wight and the Portland Bill project site in Dorset).

SCOTLAND

Scotland is considered a leader in the field of tidal and wave energy, having established the European Marine Energy Centre (EMEC) in the Orkney Islands in 2003 to provide test facilities for wave and tidal energy devices that have been used by developers from around the world.

Scotland's ambitions for developing wave and tidal energy were first set out in the Forum for Renewable Energy Development in Scotland (FREDS) Marine Energy Group's report, "Harnessing Scotland's Marine Energy Potential" in 2004. The report contained an action plan and recommendations to accelerate the commercialisation of wave and tidal energy in Scotland.

Following this in 2007 the Scottish Government commissioned a Strategic Environmental Assessment for wave and tidal stream energy, which found that it would be possible to meet the target of 1300MW generated from marine energy by 2020 with only minor environmental impacts. The SEA also identified key issues that should be considered in the design and siting of future projects.

In 2012 the FREDS Marine Energy Group published a *Marine Energy Roadmap*, which focuses on wave and tidal stream technologies. The Roadmap noted that progress had been slower than expected due to technical difficulties and financial constraints, however there had been progress in terms of public investment in marine energy projects, developing technologies and test deployments. The Roadmap set out a number of recommendations, including:

In 2012 Marine Scotland Science published its Scoping Studies for tidal stream and wave energy development in Scottish waters. These guidance documents detail how Marine Scotland, working with The Crown Estate, have developed wave and tidal stream energy plan options using the MaRS spatial modelling system and grouped themes of factors (different marine activities/uses) to identify technical opportunities and constraints. The Scoping Studies informed Regional Locational Guidance documents for tidal and wave energy, which in turn has been used to identify suitable options for inclusion in their respective sectoral marine plans.

Scotland's National Marine Plan (2015) sets out the marine planning and licensing policies that support the development of wave and tidal power. This recommends that siting for commercial scale wave and tidal developments should be located within the Plan Option areas identified through the Sectoral Marine Plan Process and must take into account Regional Locational Guidance. Licensing for new marine renewable energy projects should be made in accordance with the Marine Licensing Manual and Marine Scotland's Licensing Policy Guidance.

WALES

The consenting of marine renewable energy projects in Wales is currently divided between the UK Government and the Welsh Government on the basis of the energy capacity of projects and devolved powers. Natural Resources Wales (NRW) on behalf of Welsh Ministers is the responsible body for issuing a Marine Licence under the Marine and Coastal Access Act 2009 for projects up to 100 MW. For projects of 1 MW to 100 MW the Marine Management Organisation must also provide the Section 36 consent under the Electricity Act 1989. Projects over 100 MW are considered as nationally significant infrastructure projects, which require consent from the UK Secretary of State under the Planning Act 2008. However, as a result of the Wales Act 2017, there are plans in place for consenting of energy projects of up to 350 MW in Wales to be transferred to the Welsh Government in due course.

The Welsh Government has set out its aims for Wales to be a world leader in the marine energy market, given its strategic assets, including 1200 km of coastline, deep sea ports, accessible grid infrastructure, manufacturing base and up to 6.2 GW of generating capacity (not including potential resources on the Severn Estuary).

Between 2007 and 2011 RPS Consultants, commissioned by the Welsh Government, undertook a study to map Wales' marine energy resource in its Territorial Waters. The final report, the *Marine Renewable Energy Strategic Framework: Approach to Sustainable Development* was published in March 2011. Considering scenarios for low, medium and high energy yield from wave and tidal devices, the Framework found that 1.5 GW, 3.7-5.1 GW and 6.4 GW could be delivered from each scenario respectively by 2025.

Energy Wales: A Low Carbon Transition (2012)

This outlines what the Welsh government will do in order to unlock the energy in its seas, including continuing support for the creation of a Severn Barrage. Support for initiatives to boost the tidal and wave energy sector, including demonstrator projects, working with The Crown Estate to bring forward leasing for marine energy sites in Welsh waters and measures to stimulate and sustain collaboration between business, academia and the public sector are all identified as actions to develop a competitive marine energy sector.

Following on from the Marine Renewable Energy Strategic Framework, the Welsh Government commissioned a Marine Energy Infrastructure Study to consider the opportunities and limits to growing the wave and tidal energy industry in Wales. This study was undertaken by Halcrow Group Ltd and first considered the needs of the marine energy industry and then the main areas in Welsh waters of interest to the marine industry, assessing costs, limits and risks to development. Whilst the Study is not location-specific in terms of addressing infrastructure needs or environmental impacts, it makes general recommendations as to the type of government intervention that may be needed. Stakeholder consultation revealed a preference for support to deliver onshore physical infrastructure, e.g. through:

- Grid connection studies to investigate upgrades to primary resource areas;
- Obtaining strategic site data and analysis for potentially viable resource areas;
- Consult with stakeholders on the need for SEA;
- Work with The Crown Estate to attract developers of commercial-scale projects to sites in Welsh waters;
- Select landfall sites;
- Develop, construct and operate onshore infrastructure projects to support marine renewable energy installations.

Within the Draft Welsh National Marine Plan (2017), policies to support the development of wave and tidal power are set out. The Draft Plan states that to contribute to the decarbonsation of Wales' economy and blue growth the development and demonstration of tidal stream and wave energy projects over the next 5-10 years should be supported, with the number of commercial generation devices increased over the next 10-20 years. Where appropriate, tidal lagoon technologies should also be supported. Coexistence with other activities, for example co-locating tidal lagoons with aquaculture encouraged and should be explored, with the Draft Plan noting that "There is an expectation upon each party to demonstrate that they have had a dialogue and have each attempted to work together to best mutual advantage".

NORTHERN IRELAND

A Strategic Environmental Assessment of Offshore Wind and Marine Renewable Energy in Northern Ireland was undertaken between 2008 and 2010 to inform work on Northern Ireland's Offshore Renewable Energy Strategic Action Plan (ORESAP) (2012). The SEA concluded that approximately 300 MW of tidal energy could be generated from zones on the North Coast by 2020 if appropriate mitigation measures were put in place. Although wave resource was identified, this technology was not considered in the ORESAP.

It was acknowledged in the ORESAP that some tidal projects were already in place or progressing, such as the SeaGen demonstrator in Strangford Lough. In addition, The Crown Estate has already undertaken a round of offshore renewable energy leasing in Northern Ireland; two sites within the Fair Head and Torr Head Strategic Area were leased to developers for the delivery of projects up to 100 MW.

ISLE OF MAN

On the Isle of Man, the inter-departmental Council of Minister's Environment and Infrastructure Committee is responsible for energy policy, including the development of marine renewables.

The Isle of Man Government's *Report by the Council of Ministers on the Strategy for Offshore Energy Production (2014:6)* notes that the Isle of Man could produce several hundred MW of tidal power and is planning to progress plans to develop up to 200 MW from marine renewables. Due to the prohibitive costs of marine renewable installations, in the short term this energy would be exported to the UK. However, the possibility for this depends on installations receiving planning consent from the Isle of Man and that such schemes are eligible for renewable energy incentives from the UK.

In 2015 the Isle of Man Government announced that Manx Tidal Energy had been granted a licence to undertake survey work exploring the possibility of setting up a tidal energy array at a site near Point of Ayre (Isle of Man Government, 2015). Licences for exploring additional sites to the south of the island may be granted in the future.

Ireland

Harnessing Our Ocean Wealth (2012) sets out the Government's Vision, High-Level Goals, and Key 'Enabling' Actions to put in place the appropriate policy, governance and business climate to enable Ireland's marine potential to be realised. It is an integrated Marine Plan for Ireland and has five strategic thematic areas one of which is *Energy from the Ocean.* Early initiatives to establish Ireland as a test-bed for early stage prototype development and pilot array of marine energy deployments will create a cluster of industry and service capabilities.

The Offshore Renewable Energy Development Plan (OREDP) (2014) covers the sustainable exploitation of Ireland's offshore wind and ocean energy resources up to 2030. Within this report it is noted that wave and tidal energy will be introduced into Ireland's energy mix over the medium to longer term as commercialisation of the sector and deployment is achieved. The OREDP has established scenarios for the development of offshore renewable resources in Irish waters up to 2030, and provides a description of developing policy, which will affect the context within which they may develop.

As part of the OREDP a Strategic Environmental Assessment was undertaken of wave, tidal and offshore wind development in Ireland. This included consideration of tidal energy in three areas (east coast (S), Shannon Estuary and west coast (N)), and wave energy in three areas (west coast, west coast (N) and west coast (S)). This found that under a "high" development scenario 1500 MW of wave and tidal energy could be produced without likely significant adverse effect on the environment.

A review of activities supporting the aims of *Harnessing Our Ocean Wealth*, found good progress was made on all actions outlined in the OREDP. In particular, the SEAI has secured a foreshore lease to develop the Atlantic Marine Energy Test Site (AMETS) in Co. Mayo, which will include full scale test facilities off the coast at Belmullet. In addition to this, funding was secured from Apple and the SEAI Ocean Energy Prototype Development Fund to support the testing of new devices at the Galway Bay Ocean Energy test site (Marine Coordination Group, 2016). A mid-term review of the OREDP is currently underway and is due to be complete at end of 2017. The review will consider successes and challenges in implementing the plan. It will also highlight any gaps that have arisen since the plan was first implemented. A public consultation on the review of the plan will take place in autumn.

Ireland's most recent energy policy, *Ireland's Transition to a Low Carbon Energy Future* 2015-2030, published in 2015, states that wave and tidal technologies are at the pre-commercial stage and that, given the current state of readiness of these technologies, recognises that they do not large contribution in the short term. However, it is expected that they will play a part in Ireland's energy transition in the medium to long term. The Ocean Energy Prototype Development Fund was set up to stimulate the development and deployment of ocean energy devices and systems. Funds for the scheme are allocated by the Department of Communications, Climate Action and the Environment and the scheme is administered by the Sustainable Energy Authority of Ireland. To date €14M has been approved for 100 projects.

Innovation 2020 – produced by the Interdepartmental Committee on Science, Technology and Innovation - is Ireland's national strategy for research and development, science and technology. It specifically identifies the opportunity for marine energy research, development and innovation facilities.

France

At present in France wave and tidal energy is limited to small scale pilot projects, with the exception of La Rance tidal range power station at St Malo which has been operational since 1966 and has a peak output of 240 MW.

France's Law on Energy Transition for Green Growth has set out ambitious targets for the proportion of renewable energy in final energy consumption at 23% by 2020 and 32% by 2030. To achieve this requires an increase in installed generation capacity, and the Multiannual Energy Program (PPE, *Programmations Pluriannuelles de l'Énergie)* provides the overarching framework for delivery of this target. For wave and tidal energy, the PPE sets an intermediate target of 100 MW of energy generation by 2023, with the possibility for other projects to come on stream during this period[3] dependent on the success of pilot schemes and market conditions.

The National Strategy for the Coast and Sea (*Stratégie nationale pour la mer et littoral*), published February 2017, outlines support for the development of marine renewable energy (wave, tidal and wind) through research and innovation, calls for projects within the framework of the Investments for the Future Program, changes to the regulatory framework (tendering and site studies) and further calls for projects. In addition, the Stratégie notes that the state is committed to the objective of facilitating the development of marine renewable energy by examining the rules governing coexistence with other activities (maritime traffic, fishing, water recreation) and by mobilising all the sectors concerned, in conjunction with international conventions.

In March 2017, the French government launched a call for tenders for the development of tidal stream projects and also a public consultation on the location of potential developments in the Prefects of Brittany and Normandy.

The deployment of offshore renewable energy technologies (e.g. wind turbines) is subject to two legal authorisations – a *concession* to occupy the public maritime domain and an authorisation related to water resources protection. These authorisations are delivered by the Préfets of Départments after assent of the Préfet of the concerned maritime region. Within the EEZ, authorisation for the installation of renewable energy devices is given by the Préfet Maritime (see Le Lièvre and O'Hagan, 2015).

[3] PPE English version http://www.developpement-durable.gouv.fr/sites/default/files/Synth%C3%A8se_EN_PPE.pdf, p12

INTERACTIONS WITH OTHER SECTORS AND THE ENVIRONMENT

The development of wave and tidal energy has a number of potential impacts, both positive and negative, some of which are considered below. Some impacts relate to the interactions between wave or tidal energy and other sectors, which can also represent opportunities for further development of the maritime economy or enhancement of the environment. Additional drivers for change in the sector are considered in the next section.

The general positive impacts of wave and tidal energy include:

- Development of wave and tidal energy sources supports decarbonisation of energy supply, helping to combat the effects of climate change such as ocean acidification;
- Tidal and wave energy can contribute to the security of national energy supplies;
- Tidal and wave industries will have a positive socio-economic impact through supply chain employment in manufacture of technology and, equally, positive socio-economic impacts through the construction and operational phases of project – given the distribution of wave and tidal resources these operational impacts of employment and project spend will be delivered predominantly in peripheral regions and communities where such impacts are more acutely required;
- Tidal energy generation is more predictable than other sources of renewable energy generation (e.g. wind).

Marine renewable energy installations (both fixed and floating) can have impacts on marine species and habitats such as:

- Artificial reef effects – marine organisms may colonise devices, concrete foundations or sea walls that can provide shelter and food. This in turn may increase populations and fisheries production. If fishing vessels are excluded from these areas due to operational and navigational risks, this may also lead to increased fish populations;
- MRE devices can introduce underwater noise in construction and operational phases. This can have behavioural effects, such as avoidance of/attraction to particular areas, effects on communication between animals of the same species or impact upon echolocation and navigation;
- Devices may cause a collision risk to marine mammals;
- Tidal range developments may also act as barriers to movement for migratory fish species;
- Localised scour effects on the sea bed from devices;
- Potential interference with navigation due to presence of sea walls, wave reflection from walls, effect of turbine wakes and potential for silting (Hendry, 2016).

Tidal range installations in particular may result in the following impacts:

- Negative aesthetic impacts caused by new, hard structures;
- Tidal range developments (lagoons) can cause loss or change to intertidal habitats;
- Changes to hydrological conditions at local level and more broad scales depending on size of development/cumulative impact of several lagoons.

Impacts of wave energy devices may include:

- Disturbance to migratory birds; may avoid or change behaviour;
- Potential competition for space with aquaculture – fish farm cages require mooring to sea bed;
- Wave energy devices may occupy space where fishing takes place, acting as a no – take zone but supporting replenishment of fish stocks (Langhamer et al, 2010).

More information on the impacts of marine renewable energy (MRE) devices on the marine environment, habitats and species can be found in Tethys' Annex IV 2016 State of the Science Report: Effects of MRE Development Around the World (Copping *et al*, 2016).

In addition to these impacts, the development of wave and tidal energy may also have the following interactions with other sectors, including:

- The provision of additional sites for coastal tourism and recreation (e.g. windsurfing in tidal lagoons);
- Developing potential for aquaculture to take place within lagoons;
- Construction of lagoons will boost demand for aggregates;
- Tidal lagoons may help to reduce coastal flood risk, depending on location and design;
- There may be some negative interactions with shipping – retention of water in lagoons may close off certain routes and ports that rely on high tides for shipping movements;
- Competition with other renewables such as offshore wind.

DRIVERS FOR CHANGE

The following issues have been identified as important drivers for change in relation to wave and tidal energy development:

Socio-Political

- European/national policies continuing to drive increased energy production from renewables (2030 and 2050 targets);
- Few large scale wave and tidal energy projects have been through the consenting process, therefore it is difficult to judge the length of time it will take from application to decision. As commercial scale developments are rolled out, the experience and lessons learned from consented projects could be used to inform development processes and speed up decision making (House of Commons Energy and Climate Change Committee, 2012);
- Public perception of tidal and wave energy, including tidal impoundments and their potential environmental impacts may be a barrier to development.

Economic

- Increasing fossil fuel prices may increase the attractiveness of marine renewables as an alternative form of energy;
- Continued investment in R&D and capital financing for upscaling from pilot to commercial deployment is essential. The attractiveness of subsidies for wave/tidal energy production, e.g. Feed-in Tariffs and Contracts for Difference will increase the financial viability of generation from these sources;
- The Levelised Cost of Energy (derived from the cost per unit of electricity compared to the costs of developing projects) relative to other forms of renewable energy is not yet fully understood for wave and tidal projects. Evidence gathered from the commercial deployment of early projects will help to determine true costs and the level of financial support required to enable further development of the sector (Renewable UK, 2013).

Technological

- Further modelling and testing of components, sub-systems and devices and demonstration in real conditions is needed at all stages of development to show validity of concepts;
- Improving monitoring systems in real conditions will help to improve the design, reliability and durability of installed devices;
- Utilisation of existing infrastructure such as harbours, vessels and grid connections may be feasible in the short term, but new solutions may be needed to support the deployment and efficient operation of rapidly evolving and higher capacity ocean energy devices;
- Developing grid capacity to support commercial scale marine energy generation, which may take place in remote coastal areas that are not well services by electricity grids;
- Development of onshore infrastructure (e.g. port facilities) to support maintenance and construction of devices;
- Increased funding into methods of storing energy (battery technology, hydrogen, compressed gas, pumped hydro, etc.) may be used to ensure that the energy produced can offset production of energy from fossil fuels.

KEY MSP AND TRANSBOUNDARY CONSIDERATIONS

Wave and tidal energy is still at a pre-commercial scale, and thus there is still some uncertainty as to whether the full range of projects and proposals for the Celtic Seas will make it to deployment stage. However, it is possible to identify some key issues that must be taken into consideration in future maritime spatial plans:

- The main impacts of wave and tidal devices are likely to relate to competition with other maritime users for space. In particular, issues of navigational safety around proposed wave and tidal energy installations need to be taken into account;
- Depending upon location, electricity infrastructure for bringing power ashore from wave and tidal devices may cross marine borders, therefore requiring consent from different national jurisdictions;
- Planning for connection to appropriate onshore infrastructure (e.g. transformer stations and grid connections) will require effective integration between MSP and terrestrial planning systems;
- Tidal range developments are likely to have impacts on tidal processes across a large area, potentially regional sea scale. Impact assessments for proposed developments must therefore consider effects at an appropriate scale that includes transboundary areas and cumulative effects.

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