The Channel's MRE Sector: Status Report

Dr Emma McKinley and Mark Feast

University of Chichester

December 2014

EXECUTIVE SUMMARY

Marine renewable energy (MRE) is a fast evolving sector, with increasing recognition of its role in establishing energy security, reducing dependence on traditional fossil fuels, mitigation of the impacts associated with climate change, and supporting an increased reliance on clean, renewable energy. The Channel region, spanning from Norfolk to Devon in England and Nord Pas de Calais to Brittany in France, has the potential to further develop its MRE activity, and really highlight its capacity as a leader in MRE technologies and advancement. Within the Channel region, there are currently a number of MRE proposed MRE installations, including the Rampion wind farm, Navitus Bay, and the AREVA 8 installation and, currently, the UK is a global leader in MRE investment and development, particularly in the wave and tidal sector. However, it should be noted that the English and French MRE markets are at different stages of development; however, as MRE in France continues to develop, the potential for an effective and sustainable Channel wide supply chain, supporting local content across the Channel region will continue to increase. The Channel MOR project has been funded by INTERREG IV A to evaluate and identify the current and future business opportunities for SMEs within the Channel/ Le Manche region. Further to this, the Channel MOR project highlights the value of the sector on both a national and European level and the importance of ensuring MRE has a supportive policy landscape. In addition, the Channel MOR project aims to create an MRE community across the Channel region, with particular emphasis on supporting SMEs engaging with the sector.

This component of the project research aimed to meet the following objectives:

- Analysis of current and future MRE markets, understanding barriers for entry
- To identify the current activities and opportunities for international collaborations
- To map the current MRE market and identify opportunities for SMEs
- To identify the current and future requirements in relation to innovation, new processes, diversification, and skills

This research takes a multi-phase approach to evaluation of the current MRE activity within the Channel region, including planned and projected projects. Two comprehensive databases were compiled: 1) a detailed database of all global MRE installations, including offshore wind (OSW), wave and tidal energy technologies and 2) a database providing an overview of current and future potential business activity and capacity for engagement with the MRE sector. Analysis of these databases highlighted the opportunities for Channel businesses on a more global scale, and also identified where and how SMEs could engage with the MRE supply chain across the entire 5 tier lifecycle. In total over 4500 businesses were identified as being currently or having the potential to become operational within the MRE supply chain, across a range of activities. In fact, the analysis indicated that the Channel region is very well placed to serve the supply chain across the entirety of the MRE lifecycle, with only a small number of business activities within the supply chain found to be real capacity gaps. These gaps included the construction of wind turbines for OSW energy development, and on a smaller scale, tuned damper (part of the noise and vibration reduction technologies) development was not found to have any current or potential supplier, highlighting it as a potential opportunity for businesses to enter into the supply chain. One of the key observations is that due to the size of the region, it is likely that at all phases of the MRE lifecycle, there will be at least one company that has, or could have, the potential to deliver/ supply; however, the key challengeis whether these SMEs have the capacity in terms of resources and logistics to deliver within a short time frame. Understanding these capacity gaps and, additionally, the challenges associated with intellectual property and commercial relationship issues within the MRE sector will be key to supporting SME involvement as marine renewable technology continues to develop.

In addition to the desk based analysis of the sector, a number of stakeholder and expert workshops were organised to identify key challenges facing the sector and highlight new opportunities, with specific focus on opportunities for SMEs. Analysis of the current and future market opportunities both across the Channel region and on a more global scale found that, on the whole, SMEs have the knowledge and expertise to engage with most activities across the MRE lifecycle. In addition, working alongside a number of industry experts, five new spaces/ opportunities were identified:

- Wave energy
- Tidal energy
- Electrical connectors
- Surveys
- Condition monitoring

While it is recognised that MRE is continually growing energy technology with an increasing role in future energy security, would benefit from greater involvement from local and regional SME activity within the supply chain, there are a number of challenges that need to be addressed. Currently the sector is underpinned by a complex, lengthy and costly consent process, and is often challenged by the perception that it is a high risk investment for financiers, limiting attractiveness for SMEs. Further to this, there is a need to reduce associated costs both for suppliers and customers, and a lack of certainty around social acceptability of MRE and its impact on the overall growth of the sector; both of which require significant effort in order to make the sector a more attractive and viable business option for SMEs.

Through this research, a number of requirements/ recommendations for the future success of the Channel's MRE sector have been identified.

- Further recognition of the MRE sector as a strategic priority for Europe, supporting economic regeneration and energy security across the region
- Improved connections to the national grids and development of required infrastructure in England and France
- In order to address the perception of high risk associated with the MRE sector, evidence is required to ensure the sector will have long-term and sustainable financial stability over time, including: funding support, grant opportunities and market pull initiatives that support both developers, but also the SMEs within the wider supply chain
- Standardisation of device and array design, training and skills qualifications and other sector requirements
- Identification of SME capacity gaps and encouragement of collaboration between SMEs to enhance overall capacity for delivery (perhaps through the formation of regional clusters or networks)
- Provision of clear and transparent information be provided to SMEs; particularly as the emphasis on local content within the MRE supply chain continues to grow
- Overall, it is recognised that the real opportunities for Channel based businesses are likely to focus on activity on a more global scale, with potential for SMEs to engage with a more

international supply chain, developing and exporting skills and expertise from the Channel region

1. INTRODUCTION

In a time of economic recovery, the global energy sector is of increasing importance, acting as a significant driver for growth, a key opportunity for reducing carbon emissions and as a mitigation for climate change (DECC, 2013). The UK and France, alongside other EU member states and international neighbours, have committed to facilitating a move to low carbon energy, lower carbon emissions, a reduced dependence on fossil fuels and an increased role of renewable energy technologies (IPCC, 2007; Bergmann et al., 2006; Gill, 2005). Marine energy sources (offshore wind, wave and tidal energy) are under-utilised (Inger, et al., 2009), and have a significant role to play in ensuring these obligations are met. Indeed, the importance of marine renewable energy (MRE) as a developing maritime industry was acknowledged in the European Blue Growth strategy (Henley, 2013). The Channel region is in an ideal position to promote itself as an area of excellence in the MRE sector. For example, the UK and France are currently ranked first and second globally in terms of their potential for tidal energy generation (Bailey et al., 2012). Within the Channel region, there are currently a number of proposed MRE installations, including the Rampion wind farm, Navitus Bay, AREVA 8MW projects off St Brieuc and Le Tréport as well as two EDF/Alstom offshore wind farms based off Courseulles and Fécamp in Normandy". English and French MRE markets are at different stages of development; however, as MRE in France continues to develop, the potential for an effective and sustainable Channel wide supply chain, supporting local content across the Channel region will continue to increase.

This research has been conducted as part of an INTERREG IVA Capitalisation project: Channel MOR under Work Package 3.2 of the research programme.[1] The project brings together eleven partners[2] (including universities, local authorities and innovation centres) from across the Channel region, capitalising on the work conducted through existing INTERREG projects[3]. As part of its research, Channel MOR aims to evaluate the current status of the MRE market, identifying future market opportunities for businesses within the Channel region and highlighting growth options for the Channel's MRE sector. The objectives of the Channel MOR project were to:

- Pool and strategically analyse the data, knowledge, and tools developed by the constituent projects and identify any significant gaps

[1] More information on the Channel MOR project can be found at www.channelmorenergy.eu
[2] University of Chichester, University of Portsmouth, CCI Dieppe, Bretagne Development Innovation, MEFP, Cornwall Marine Network, Region Haute Normandie, Southampton City Council, Universite Le Havre, Technopole Cherbourg Normandie, Technopole Brest Iroise, Pole Mer Bretagne-Atlantique
[3] Mer Innovate, CAMIS, 2OM, BEEMS, DEEDS, Channel Marine Academy.

- Agree the common tool/database set that combines the knowledge and expertise of the project's constituent MRE projects
- Enhance the common tool/database set to optimise access and usability by MRE stakeholders, particularly SMEs
- Develop a set of decision tools that allow potential MRE stakeholders to access and engage with the future MRE sector
- Lead and facilitate a range of communication, networking and collaboration opportunities to create MRE industry growth, on cross Chanel area

These objectives were achieved through extensive research activity across a number of work packages led by different members of the Channel MOR partnership.

2. RESEARCH AIM AND OBJECTIVES

This part of the programme aimed to develop a comprehensive understanding of current and future market opportunities for SMEs entering the MRE sector within the Channel region. The work package had four objectives:

- To analyse current and future markets, both for wind power and for other MRE technologies, assessing any potential barriers to entry
- To identify the current activities (industrial, technology development, ports, maintenance) for MRE, including wind and other technologies (e.g. tidal turbines) and opportunities for potential international collaborations
- Mapping the markets and identifying the technical data and the potential stakeholders operating in the Channel region
- To identify the current and future requirements in relation to innovation, new processes, diversification, skills (among other factors) in order to form a comprehensive understanding of the markets and associated processes in the MRE sector

2.1. Phase One: Literature Review

An extensive literature review was undertaken as an underpinning activity for this phase of the research. This literature review allowed key barriers and opportunities associated with the wider MRE sector to be identified, with the later phases of research used to place these factors in the context of the Channel region. A discussion outlining the key findings of this process is presented in

Section 3. In addition, the themes identified through the literature were used to support the identification of new spaces for SMEs involvement in the MRE sector in the future.

2.2. Phase Two: Installations Database and Evaluation

The second phase of research supported the development of a comprehensive database detailing all MRE installations currently planned, proposed, under development or operational as demonstration sites on an international basis. It was determined that a global view would give the most comprehensive analysis of the local, regional and export based opportunities available to SMEs operating within the Channel region. A database template was prepared and sent to all Channel MOR partners for population, collating the results gained through the partner INTERREG projects. In addition, to supplement existing knowledge, an extensive desk based investigation into MRE (offshore wind, wave and tidal)[4] installation status was conducted by the University of Chichester with support from Channel MOR partners, using existing databases and information sources such as the Crown Estate and 4COffshore[5].

The information listed in the database included:

- Installation status (Installed, Approved, Planned, Projected, Cancelled, Dormant, Demonstration Site)
- Location (region and country)
- Size of installation (number of devices and KW capacity)
- Mooring Type
- Operation and Management
- Developer
- Development phase dates (start and finish)
- Depth of installation
- Distance from shore/ grid connection
- Budget for development

[4] It should be noted that there are additional sources of marine energy but as the Channel MOR project focused on offshore wind, wave and tidal, these were the primary areas of interest.
[5] Information available at http://www.4coffshore.com/index.html Last Accessed 29th September 2014

2.3. Phase Three: Business Supply Chain Database and Evaluation

A second database[6] was generated to map current business activity to the MRE supply chain. In order to generate this activity, a list of activity codes, linked to activities across various phases of the MRE lifecycle was produced (amended from work done by 4COffshore). This allowed the current and potential capacity for business engagement with the MRE sector to be identified. In order to develop the database, Channel MOR partners acted as representatives for their regions, and completed a database template, produced by the University of Chichester, utilising existing networks and sources of information (including databases produced through the CAMIS, MERiFIC and BEEMS projects) and supported by additional desk based activity and internet searches. This was supplemented by an extensive desk based search conducted by the University of Chichester to validate this information. The database includes information on:

- Company name, address and contact details
- Company turnover
- Number of employees
- Type of MRE activity that the company could be involved in
- Activity codes

2.4. Phase Four: Expert and Stakeholder Workshops

As part of the activity in WP 3.2 a number of stakeholder and expert workshops were held to collect necessary information supporting a greater understanding of the wider MRE sector and its on-going development.

Workshop one: Thetis Workshop held in April 2014 in Cherbourg, France. The workshop aimed to identify the challenges SMEs experience in terms of their visibility, as well as solutions to these challenges.

Workshop two: MRE: SMEs Innovation Required Workshop held in Bognor Regis, in June 2014. This workshop's aim was to identify new opportunities and spaces for businesses in the future progress of the MRE sector.

---

[6] Both the installation and business supply chain database have been used, alongside the skills and training database produced in WP 3.1., to generate a relational database structure that will underpin the functionality of the web-based Channel MOR portal being developed in WP 4 accessible at www.channelmorenergy.eu.

2.5. *Phase Five: Case Studies*

In order to ensure the project produced valuable and useful results for the MRE sector, case studies were undertaken on a number of themes (presented in Section 6). These themes included: New Spaces, Tier 1 Analysis and a Gap Analysis relating to the current supply chain.

3. REVIEW OF THE CHANNEL'S MRE SECTOR

Despite their geographical proximity, the current state of affairs for the MRE sector in England and France is very different.

3.1. Current Energy status in England

The UK is a global leader in MRE development, with the European Marine Energy Centre (EMEC) in Orkney, Scotland, the first open sea testing facility, and the 2012 designation of both the South West Marine Energy Park and the Pentland Firth and Orkney Waters Marine Energy Park highlights its investment in advancing MRE technologies (Henley, 2013). The Renewables Objective (RO) (2002) outlines that the UK goal is to ensure that 5% of energy demands is met by renewable sources by 2020, with an aim to increase this to 30-45% of all energy consumption (UK Renewable Energy Roadmap, 2011). Therefore, current energy policies are focused on supporting significant investment into low carbon energies, including offshore wind and other marine energy sources, which, in particular, are expected to increase in importance (DECC, 2013; RenewableUK, 2013).

National targets for MRE production are 33-58TWh of offshore wind (OSW), and a further 1TWh of wave and tidal energy generation by 2020 (Vantoch-Wood et al., 2012). Current OSW energy potential in the UK is estimated to be approximately 406TWh per year, while the wave energy is predicted to be in the region of 40TWh, with tidal energy resources having the potential of between 20-200TWh per year (Bailey et al., 2012)[7]. It is clear that there are sufficient resources to support energy generation of the expected levels. However, although the Renewables Obligation in 2002 proposed reform and additional support for the wider renewable energy sector, it has limitations which mean it has failed to adequately support the 'technology push' of less developed, non-market ready technologies, such as wave, tidal and floating wind developments (Bailey et al, 2012). It should be noted that between 2014 and 2017, the policy landscape influencing the MRE sector will change, with a move from the Renewables Obligation into the new Contract for Difference regime, a

[7] It should be noted that there are other estimates of energy potential, the Crown Estate (2012) estimated that the UK's resources for tidal energy are 95 TWh/year (32 GW) for tidal stream, tidal range (barrage schemes) 96 TWh/year (45 GW) for tidal range (barrage schemes) and 25 TWh/year (14 GW) for tidal range (lagoon schemes).

move which underpins the Electricity Market Reform (EMR) of 2012 (DECC, 2012), and it is hoped that the CfD will have the potential to address these issues. Under current consenting processes, the UK grants consent through the Marine Management Organisation (MMO) on a two-tier basis covering marine renewable energy installations of above and below 100MW (Bailey et al., 2012). Wave and tidal energy technologies are advancing, although OSW remains the more mature of the MRE technologies, and industry expertise is being supported by long-term policy support and government commitment to the sector, resulting in progression from single device to array installations. In 2013, Renewable UK (2013) identified 12 full-scale prototypes deployed across the UK, and there is continued industry commitment from major firms, including both engineering firms (Siemens) and utilities (Vattenfall, EDF, ScottishPower Renewables) to continue developing the sector. In the UK, guidelines state that the industry must deliver a first round of demonstration projects by 2017, and exhibit progression towards multi-device arrays.

In the UK the energy industry is dominated by the 'Big Six', who are British Gas, E.ON, NPower, SSE, Scottish Power and EDF, supplying 95% of electricity and gas to UK Households (BBC, 2014). E.ON and British Gas have made significant investments in renewable energy, although it is predominately in the wind and biomass industries. Further to this, E.ON recently announced their intention to cease their work on gas and coal, shifting their focus to renewable energy[8]. Additionally, it should be noted that there are alternative energy utility companies in the UK, such as Good Energy and Ecotricity, who are aiming to source their electricity from green resources.

3.2. Current Energy Status in France

Due to its continental shelf positioning, France has considerable MRE potential on the north-west coastline, directly within the Channel region. The current energy potential of offshore wind energy in France has been documented as 70TWh per year, which is considered to be relatively small compared to French wave and tidal energy resources (Bailey et al., 2012). Despite the extensive potential for the MRE sector, an analysis of stakeholder responses suggested it is dominated by pre-commercial developments (Henley, 2013). However, like other member states, France has a firm commitment to advancing MRE technologies, and in 2012 the France Energies Marines was established as a research institute dedicated to MRE research and development. In addition, a number of studies were launched in 2013 to establish a medium to long-term strategy for MRE, evaluating grid connections to installations off the Contentin Peninsula and the Brittany coast (Henley, 2013).

[8] http://www.theguardian.com/environment/2014/dec/01/eon-splits-energy-renewables

In France the main supplier of electricity is Electricité de France (EDF), who supplies 92.1% of the country's electricity. The other significant supplier is GDF Suez, who supplies 5.26% of France's electricity. France, like the UK, is a signatory to a number of international policies which aim to decrease dependence on traditional energy sources. Bailey et al. (2012) reviewed the current consent process in France, illustrating the various levels of consent required for any MRE development. MRE developers must get permission from the Minister of Energy to operate an installation generating over 4.5MW (based on the French Energy Code). In addition, use of marine resources must be authorised by the Prefect and the Maritime Prefect, as instructed by the Maritime Public Domain Decree (2004). Investment in the French MRE sector is supported by a number of French government led incentives: 1) a system of guaranteed repurchasing prices supplemented by revenue from electricity customers, and 2) competitive tendering processes for green electricity targets. A full review of this process is outlined in a report produced by Cornwall Marine Network (2014) as part of the Channel MOR project.

3.3. MRE in the Channel

Offshore wind energy is a more developed MRE sector within the Channel region, in comparison to wave and tidal energy generation, and has moved past the demonstration phase into installation of large scale arrays across Europe. The UK has the largest volume of installed offshore wind capacity, with 23 projects supporting 1,183 turbines currently in operation. Wave and tidal energy are less developed than offshore wind energy developments. However, as an emerging sector, the benefits of wave and tidal technologies to marine energy sources and the wider renewable energy sector are becoming increasingly well accepted. In particular:

- It is expected that wave and tidal technologies would have less of an impact on the seascape
- Wave and tidal resources are easier to predict than other renewable energy sources, meaning the overall generation may be higher
- It has also been suggested that the load factors for wave and tidal (as well as other marine energy sources) would be higher than those exhibited by offshore wind resources

Although progress is underway to advance this sector, there are a number of challenges still impacting progress of the sector, including: resource assessment and predictability, engineering design and manufacturability, installation, operation and maintenance, survivability, reliability and cost reduction (Mueller and Wallace, 2008). Further to this, the main barrier to wave and tidal energy development is that they are not cost-competitive in comparison to other energy technologies, due to technology developments still being in the early stages. Additionally, this type of technology has limited connection to the grid meaning infrastructure and grid connections will be vital for ongoing development of the sector. Additional challenges are posed by complex marine licensing and planning regulations, which can be a costly and time consuming process for businesses. Overall development and maintenance costs are higher than in other renewable technologies, including offshore wind, and there is a need for enhanced innovation within the wave and tidal technology sector to drive costs down, making both access and implementation easier for businesses. As a result of these challenges, engaging in full-scale development of either wave or tidal technology can be outside the capacity of many SMEs. However, there are opportunities for SMEs to improve their involvement in the wider supply chain and manufacturing life cycle as technologies develop.

Although there are challenges, efforts are being made across the Channel region to support the growing needs of the developing MRE sector. Table 1 presents a list of all existing associations, clusters and technopoles currently operational within the project region, with an interest in any phase of the MRE lifecycle (OSW, wave and/ or tidal energy). In addition, there is a clear emphasis on ensuring the sector is supported by a skilled and trained workforce with a number of education institutions offering courses relating to the MRE sector in some way (presented in Table 2). Furthermore, there is a growing focus on research within the MRE sector, supported by activity within the university sector and a number of research institutions listed in Table 3. In terms of infrastructure, there is evidence to suggest that capacity to support the MRE Sector within the Channel region is growing, with a number of ports in the area offering facilities suitable for MRE device installation and maintenance. Table 4 presents a summary of the information available on the ports currently operating within the project region, highlighting overall vessel length capacity (LOA) and measurements of draught[9].

[9] Draught = is the measurement of the vessel from the surface of the water to the bottom; Beam = is the measurements of the vessels width at the widest point.

Name	Region	Link
Technopôle Brest-Iroise	Bretagne	http://www.tech-brest-iroise.fr/
Pole Mer Bretagne-Atlantique	Bretagne	http://www.pole-mer-bretagne-atlantique.com/
France Energies Marines	Bretagne	http://en.france-energies-marines.org/
DCNS (Marine Renewable Energy)	Bretagne	http://en.dcnsgroup.com/energy/marine-renewable-energy/
Cornwall Marine Network	Cornwall	http://www.cornwallmarine.net/
Devon Association for Renewable Energy	Devon	http://dare.btck.co.uk/
Sustainable Dorset	Dorset	http://www.sustainabledorset.org.uk/
East of England Energy Group	East Anglia	http://www.eeegr.com/
ECOWindS (European Clusters for Offshore Wind Servicing)	East of England (including South Denmark, North-West Germany and the offshore cluster Møre in Norway)	http://ecowinds.eu/
National Oceanographic Centre	Hampshire	http://noc.ac.uk/science-technology/marine-resources/energy/marine-renewable-energy
BEEMS (Building European Environmental and Maritime Skills)	Hampshire	http://www.marinerenewableskills-beems.eu/uk/
Solent Offshore Renewable Energy Consortium (SOREC)	Hampshire/IOW	https://www.competefor.com/sorec/
Future Solent	Hampshire/IOW	http://www.futuresolent.org.uk/
Kent Wind Energy	Kent	http://www.kentwindenergy.co.uk/index.php
The Kent CORE[10]	Kent	http://www.locateinkent.com/uploads/Kent%20CORE%20Brochure%20February%202013%20V4.pdf
North Norfolk Renewables	Norfolk	http://www.northnorfolkrenewables.org/
Great Yarmouth & Lowestoft CORE	Norfolk/Suffolk	https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/286197/CORE_Brochure.pdf
West Normandie Marine Energy	Normandy	http://www.west-normandy-marine-energy.fr/en/
Energies Haute Normandie	Upper Normandy	www.energies-haute-normandie.com
CCI Business EMR	Normandy	www.ccirezo-normandie.fr/page/69375-presentation
Orbis Energy	Suffolk	http://www.orbisenergy.net/
Marine Offshore Renewables	South West of England	http://www.morenewables.co.uk/

[10] *CORE (Centre for Offshore Renewable Energy) is partnerships between central governments, local governments and local economic partnerships. The UK's Government has identified six COREs across England, which include: Great Yarmouth & Lowestoft, Tyneside, Teesside, the Humber, Kent (Sheerness) and Liverpool. The aim of the COREs is to focus their efforts to attract renewable energy manufacturing companies.

South West Marine Energy Park	West England

Table 1: List of associations/technopoles/clusters/COREs* specialised in marine renewable energy in the Arc Manche region

Name	Region	Specialisms/ Additional info	Link
UNIVERSITÉ DE BRETAGNE OCCIDENTALE	Bretagne	Marine and coastal sciences	http://www.univ-brest.fr/
University of South Brittany (Université de Bretagne-Sud)	Bretagne	Engineering Sciences, Technology and Construction;	http://www.univ-ubs.fr/
Ensta Bretagne	Bretagne	Advanced Master in Renewable Marine Energies(RME)	http://www.ensta-bretagne.eu/index.php/advanced-master-in-renewable-marine-energies/
University of Exeter	Devon	BEng Energy Engineering, MEng Energy Engineering, BSc Renewable Energy	http://www.exeter.ac.uk/undergraduate/degrees/clean-energy/
Plymouth University	Devon	FdSc Renewable Energy Technologies	http://www5.plymouth.ac.uk/
Bournemouth University	Dorset	Engineering and Environmental Science courses	https://www1.bournemouth.ac.uk/
University of Sussex	East Sussex	Mechanical and Electrical Engineering	http://www.sussex.ac.uk/study/ug/2015/3892
University of Essex	Essex		http://www.essex.ac.uk/
University of Portsmouth	Hampshire	BEng (Hons) in Engineering Geology and Geotechnics; Architecture, Civil Engineering and surveying courses such as: MSc in Civil Engineering with Environmental Engineering	
University of Southampton	Hampshire	Engineering and the Environment including courses such as: MSc Sustainable Energy Technologies and MSc Marine Technology / Marine Engineering (2 yrs)	http://www.southampton.ac.uk/engineering/index.page?
University of Lille (Université de Lille)	Nord pas de Calais	Science and Technologies	http://www.univ-lille1.fr/
Lille Catholic University (Univeriste Catholique de Lille)	Nord pas de Calais	Science and Technologies	http://www.univ-catholille.fr/
University of East Anglia	Norfolk	Engineering and Environmental Sciences	https://www.uea.ac.uk/#
University of Rouen **INSA** **Esigelec**	Normandy Upper Normandy Upper Normandy	Science and Technology Engineering and Environment Engineering and Environment	http://www.univ-rouen.fr/

University of Le Havre	Upper Normandy	Logistics Studies

Table 2: List of universities in the Channel region offering courses related to the MRE sector.

Name	Region	Additional information	Link
Marine Institute (Plymouth Univeristy)	Devon	Coastal, Ocean and Sediment Transport LAB	http://www1.plymouth.ac.uk/marine/Pages/default.aspx
Ifremer	Bretagne	French Research Institute for the Exploitation of the Sea	http://wwz.ifremer.fr/institut
WaveHub	Cornwall	Wave Hub provides shared offshore infrastructure for the demonstration and proving of offshore renewable energy technologies.	http://www.wavehub.co.uk/
Centre for Operational Research and Logistics (University of Portsmouth)	Hampshire	The key aim of the centre is to achieve research excellence in Operational Research and Logistics fields, and enhance the knowledge transfer activities to deepen the strategic partnership between CORL and the business and public organisations to address greater challenges.	http://www.port.ac.uk/centre-for-operational-research-and-logistics/
PRIMaRE (Partnership for Research in Marine Renewable Energy)	west, south, and south west of England	The Partnership for Research in Marine Renewable Energy (PRIMaRE) is a network of world-class research institutions based in the west, south, and south west of England who undertake research and development to address challenges facing the marine renewable energy industry at the regional, national and international level.	http://www.primare.org/
Dynamic Marine Component Test Facility (DMaC)	Devon – University of Exeter	The Dynamic Marine Component Test facility (DMaC) is a purpose built test rig that aims to replicate the forces and motions that components are subjected to in offshore applications.	http://emps.exeter.ac.uk/renewable-energy/research/research-interests/offshore/reliability/facilities/dynamicmarinecomponenttestfacility dmac/
CEVEO Cluster (Centre d'Expertise et de Valorisation de l'Eolien)	Northern France	R&D Centre focused on offshore wind energy and currently leading the WIN innovation project (test facilities on- and offshore)	http://www.energies-haute-normandie.com/main-win-offshore/ceveo/
Le Grand Reseau de Recherche Energie	(INSA/ Upper Normandy)		http://grrhn.insa-rouen.fr/?page_id=5

Electronique - Materiaux

Table 3: Specific research centres or organisations focusing on MRE activity within the Channel region.

County/ Region	Name	Ownership	Port Depth (Metres)	Entrance Width (Metres)	Maximum Vessel Size (Metres)	Quay length (Metres)	Quay loading capacity
Norfolk	Great Yarmouth	Great Yarmouth Port Company Ltd	9	210	LOA*: 220 Draught*: 10m Beam*: 75m	1400	3 tonnes/m^2
Suffolk	Lowestoft	Associated British Ports	Unknown	Unknown	LOA: 125 Draught: 5.5 to 6 Beam: 22 to 35	1400 to 2100	Unknown
	Felixstowe	Port of Felixstowe Ltd	Unknown	Unknown	Unknown	Unknown	Unknown
	Ipswich	Associated British Ports	5.5 to 8.4		LOA: 90 to 150 Draught: 5.5 to 8.4 Beam: 13.8 (Wet Dock)	320 to 1215	Unknown
Essex	Harwich Haven	Harwich Haven Authority	Unknown	Unknown	Unknown	Unknown	Unknown
	Harwich International	Hutchison Port Holdings	Unknown	Unknown	Unknown	Unknown	Unknown
	Port of Mistley	Mistley Quay and Forwarding Co. (part of TW Logistics Ltd)	Unknown	Unknown	Draught: 5 LOA: 130	500	Unknown
	Brightlingsea	Brightlingsea Harbour Commissioners	Unknown	Unknown	Unknown	Unknown	Unknown
	Tilbury (London)	Forth Ports plc	Unknown	Unknown	Unknown	Unknown	Unknown
	Purfleet	The Cobelfret Group	Unknown	Unknown	Unknown	Unknown	Unknown
Kent	Chatham Docks (Sheernes)	Peel Ports	Unknown	Unknown	Unknown	Unknown	Unknown
	Ridham Dock	Ridham Sea Terminals Ltd	Unknown	Unknown	LOA: 102 Beam: 17 Draught: 6.2	520	Unknown
	Sheerness	Peel Ports					
	Thamesport	London Thamesport (Part of Hutchison Port Holdings)	15	Unknown	Unknown	655	Unknown
	Whitstable Harbour	Canterbury City Council	Unknown	Unknown	Unknown	Unknown	Unknown
	Dover	Dover Harbour Board	Unknown	Unknown	Unknown	Unknown	Unknown

	Ramsgate	Thanet District Council	6.2	160	LOA: 180 Beam: 6.5 Draught: 160	80	30 tonnes/m^2
Sussex	Littlehampton	Littlehampton Harbour Board	Unknown	Unknown	Unknown	Unknown	Unknown
	Newhaven	Newhaven Port and Properties Ltd	5 to 6	55	LOA: 35 Draught: 3 Beam: 12	330	90 tonnes/m^2
	Shoreham	Shoreham Port Authority	Unknown	Unknown	Unknown	Unknown	Unknown
Hampshire	Langstone	Langstone Harbour Board	Unknown	Unknown	Unknown	Unknown	Unknown
	Lymington	Lymington Harbour Commissioners	Unknown	Unknown	Unknown	Unknown	Unknown
	Portsmouth	Portsmouth City Council	Unknown	Unknown	Unknown	Unknown	Unknown
	Southampton	Associated British Ports	Unknown	Unknown	LOA: any Draught: 12 Beam: any	Unknown	Unknown
	Yarmouth	Yarmouth Harbour Commissioners	Unknown	Unknown	Unknown	Unknown	Unknown
Dorset	Poole	Poole Harbour Commissioners	Unknown	Unknown	Unknown	Unknown	Unknown
	Portland	Portland Port Ltd	Unknown	Unknown	Unknown	Unknown	Unknown
	Weymouth	Weymouth & Portland Borough Council	Unknown	Unknown	Unknown	Unknown	Unknown
Channel Islands	Braye	States of Alderney	Unknown	Unknown	Unknown	Unknown	Unknown
	St Helier	States of Jersey	Unknown	Unknown	Unknown	Unknown	Unknown
	St Peter Port/St Sampson	Guernsey Harbour Authority	Unknown	Unknown	Unknown	Unknown	Unknown
Devon	Teignmouth	Teignmouth Harbour Commissioners	Unknown	Unknown	LOA: 100 Draught: 5	Unknown	Unknown
	Cattewater (Plymouth)	Cattewater Harbour Commission	Unknown	Unknown	Unknown	Unknown	Unknown
	Dartmouth	Dart Harbour and Navigation Authority	Unknown	Unknown	Unknown	Unknown	Unknown

	Millbay Docks (Plymouth)	Associated British Ports	Unknown	Unknown	LOA: 120 to 295 Draught: 5 to 8.5	150 to 170	Unknown
	Bideford	Bideford Harbour Board	Unknown	Unknown	LOA: 100 Draught: 5	Unknown	8 cranes, loading up to 60T
Cornwall	Falmouth	Falmouth Harbour Commissioners	10.5	435	LOA: 250m+ Draught: 8.3	1400	Permanent craneage available
	Fowey	Fowey Harbour Commission	8.5	100	LOA:16.8m Draught:8.5	850	No permanent craneage
	Padstow	Padstow Harbour Commissioners	Dry at low tide	91	LOA: 80m Draught: 5m	400	No permanent craneage
	Truro	Truro Harbour Authority	4.3m / Dry at low tide (Truro	50	LOA: 85m Draught: Beam: 85m	350	Unknown
	Hayle	Hayle Harbour Management Ltd	3.5	30	LOA: 20m Draught:3m	250	No permanent craneage
	Penzance	Cornwall Council	Wet Docks / Dry at low tide	100m (drying bassin) 12.8m (wet docks)	Unknown	Unknown	Unknown
	Newquay	Cornwall Council	Dry at low tides	Wide	Unknown	Unknown	No permanent craneage
	Newlyn	Newlyn Pier and Harbour Commission	3	45.7	LOA: 30m Draught: 2.4m	730	No permanent craneage
	Looe	Looe Harbour Commissioners	Unknown	Unknown	Unknown	Unknown	Unknown
Nord-Pas-de-Calais	Port de Dunkerque	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port de Calais	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port de Boulogne-sur-Mer	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port de le Havre	Port Authority of Le Havre	Unknown	Unknown	Unknown	Unknown	Unknown
Upper Normandy	Port de le Havre	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port de Rouen	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port of Caen	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port de Fecamp	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

	Port de Dieppe	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port du Treport	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Lower Normandy	Port de Caen	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
	Port de Cherbourg	Unknown	14	Unknown	LOA: any Draught: 14 Beam: any	Unknown	15 tonnes/m^2
Brittany	Port de Brest	Unknown	Unknown	Unknown	LOA: any Draught: any Beam: any	Unknown	Unknown
	Port de Lorient	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown

Table 4: Review of information available on MRE ready ports in the Channel region.

3.3.1. Introduction to Wave Energy

Wave energy is an emerging technology within the wider MRE sector, in an early development phase, progressing towards the installation to multiple device arrays (Melo et al., 2013).

The Channel region is well positioned to take advantage of wave resources. The majority of UK wave energy resources arrive from the Atlantic and are available in the west, namely north west Scotland and south west England (Carbon Trust, 2012), with the majority of wave energy potential found in the deeper parts of the offshore Exclusive Economic Zone (EEZ). An evaluation of the Crown Estate leases conducted by Renewable UK (2013) indicates that 92% of wave energy projects are currently leased in the Scottish Islands; however, it is evident that there is considerable potential for wave technology development across the Channel region. The UK is estimated to have 35% of Europe's wave energy resource (MERiFIC, 2013). This would relate to a theoretical wave resource of 69 TWh per year (27 GW) (The Crown Estate, 2012). France's wave energy resource is estimated at 30 TWh per year (MERiFIC, 2013).

Wave energy potential is dependent on the length of the resource frontage, the wave power levels, efficiency of the extraction technology, and the available exploitation space for installations.

There are a number of types of wave technology available including:

1) Shoreline devices: these are fixed or embedded in the shoreline, and therefore do not require deep water moorings. They tend to be less powerful than other technologies.
2) Near shore devices: these are often deployed at moderate depths (20-25m) up to 500m from the shore. They are higher power devices than the shoreline devices.
3) Offshore devices: deployed in deeper water with current research focusing on the development of small devices which are deployed in arrays.

3.3.2. Introduction to Tidal Energy

As with wave energy technologies, tidal energies remain in the developmental and testing phases. Tidal power has significant potential to contribute towards on-going energy security supplies on a global scale. Tidal power is a predictable and reliable energy source, which means energy generation can be planned in advance (RenewableUK, 2013) and as a result is a more developed energy technology than wave or floating wind energy generation (Melo et al., 2013; Bailey et al., 2012).

It is evident that the Channel region has significant tidal resources, with France and the UK estimated to represent approximately 80% of the whole European tidal potential. The UK is estimated to have around 50% of Europe's tidal energy resource (Department of Energy & Climate Change (DECC), 2013), although it should be noted that much of this is based in Scotland and the Irish Sea. However, tidal energy has the potential to provide the UK between 12 to 15% of its electricity demand (DECC, 2013 and World Energy Council, 2014). Positively, wave and tidal energy has been highlighted as a priority for deployment in the UK (National Renewable Energy Action Plan for the United Kingdom, 2009). Further to this, it has been estimated that France has the potential to generate between 5 and 14 TWh/year from tidal stream turbines (West Normandie Marine Energy, 2014). Achieving this would also support France's aim of producing 23% of its overall energy from renewable sources by 2020 (National Action Plan for the Promotion of Renewable Energies 2009-2020). Indeed, it should be noted that there is an existing tidal barrage at La Rance, Brittany; cited as the world's first tidal power station. In comparison, the UK has aimed to generate 15% of their overall electricity from renewable energy's by 2020. Increasing the production of tidal energy for electricity generation would also support the European Union's climate change and sustainability targets of producing 20% of energy through renewable sources.

3.4. The Channel Region's MRE Policy Landscape

In terms of policy, it should be noted that, across Europe, efforts are being made to more effectively manage marine and coastal resources which are currently under significant pressure and over-used, meaning it could be difficult to get public backing for marine energy projects. MRE is still a developing sector, but progress needs to be supported by an effective policy framework (EU-OEA, 2009), as the sector has the potential to have a significant impact on the on-going marine planning process across Europe. The UK Government's energy policy aims to establish a diverse, sustainable, secure and competitively priced energy supply. Central to this aim is an 80% reduction in carbon dioxide emissions by 2050, with increasing inclusion of renewable energy resources, set at a target of 20% by 2020. These national targets will help the UK to meet its international energy obligations and will ensure there is more promotion of renewable energy production. Onshore wind energy and solar energy are well developed, heavily researched forms of renewable energy technologies. As a growing sector, MRE faces a complex policy landscape with national, European and international policies impacting progression. Table 1 presents information on the range of policies impacting MRE development across the sector. A report by CMN presents a comprehensive overview of the current regulatory framework impacting the MRE sector.

Policy and Funding Framework Influencing the Channel region			
Mechanism Type	**England**	**France**	**Europe**
Financial Mechanisms	➢ Marine Energy Array Demonstrator Fund (MEAD) ➢ The Crown Estate ➢ The Technology Strategy Board's Marine Energy Supporting Array Technologies (MESAT) ➢ The Energy Technologies Institute ➢ European Commission in the form of the European New Entrants Reserve (NER) and the Marine Renewables Infrastructure Network (MARINET) ➢ Green Investment Bank (GIB) ➢ Strategic Initiative for Ocean Energy (SI Ocean) [European level]	➢ European Commission in the form of the European New Entrants Reserve (NER) and the Marine Renewables Infrastructure Network (MARINET) ➢ Green Investment Bank (GIB)	
Environment, Regulation and Legislation	➢ Renewables Directive ➢ The Renewables Objective (2002) ➢ Climate Change Act (2008) ➢ Energy Security Strategy ➢ Statutory Security of Supply Report ➢ Annual Energy Statements ➢ The Carbon Price Floor ➢ The Emissions Performance Standard ➢ Low Carbon Industrial Strategy (2009) ➢ Marine Energy Action Plan (2010)	➢ Renewables Directive ➢ Bill n° 68-1181 du 30 décembre 1968 ➢ Bill n°76-655 du 16 juillet 1976 ➢ Decree n°2013-611 du 10 juillet 2013 ➢ art. L.311-5 et s. et L.311-10 et s. ➢ Bill n°2013-312 du 15 avril 2013 ➢ Bill project du 18 juin 2014 ➢ Bill n°86-2 du 3 janvier 1986 ➢ Decree n°2004-308 codifié du 29 mars 2004 ➢ art. L.122-1 et s., L.123-1 et s. and L.214-2 et s. ➢ Bill n°2006-1772 du 30 décembre 2006 ➢ Bill n°2009-967 du 3 août 2009 ➢ Bill n°2010-788 du 12 juillet 2010	➢ Strategic Environmental Assessment (SEA) (2001/42/EC) Directive ➢ Environmental Impact Assessment (EIA) Directive (85/337/EC) ➢ Habitats Directive (92/43/EEC) ➢ Wild Birds Directive ➢ The Water Framework Directive ➢ Marine Strategy Framework Directive (2008/56/EC) ➢ *Offshore wind must also consider airspace legal requirements as outlined by Europe and global legislation.

		and Decree 2012-219 du 16 Février	
Collaborative Initiatives	➢ The Energy Technology Institute (2007) ➢ The Marine Energy Programme Board (2011) ➢ Sustainable Power Generation and Supply Initiative ➢ UK Renewable Energy roadmap (2011) ➢ Future of Marine Renewables in the UK (2012)		

Table 1: An evaluation of the policy framework influencing MRE technology development in the Channel region (guided by RenewableUK, 2013; DECC, 2012; Bailey et al., 2012)

4. BARRIERS TO IMPLEMENTATION

While MRE technologies are developing at a relatively fast rate and support for this type of energy source is growing, there are a number of barriers to successful implementation of MRE installations (RenewableUK, 2013; Carbon Trust, 2012; Smit et al, 2007). However, if the MRE sector is to continue to grow and develop, it will be necessary to reduce the barriers to business entry (Newbery, 2012). All MRE developers face a number of challenges across the lifecycle from design to deployment: these challenges most commonly relate to risks associated with gaining access and connecting to the national grids, managing consent processes, securing finance and technology advancement (RenewableUK, 2013 a; b). More specifically, the challenges identified by earlier research have been shown to include:

- Levels of uncertainty around the reliability and predictability of these technologies in comparison to other renewable or low carbon technologies, such as nuclear energy (Newbery, 2012). A range of challenges associated with market position have been identified, including: predictability[11], manufacturability, installability, survivability, affordability and reliability (Karim, 2012). In the UK, it has been suggested that the uncertain nature of this type of energy technology renders the Contracts for Difference (CfDs) impractical and potentially limiting for the progression of MRE technologies, as the CfDs are more suited for more predictable energy types, allowing for fluctuation in price/ costs.

- Lack of accessible grid infrastructure - Limited grid connection has been identified as one of the key barriers to large scale deployment of MRE installations (Henley, 2013), limiting the opportunities for meaningful investment in the sector. The MERiFIC project highlighted this as a significant challenge for MRE in the South West of England. It should also be noted, when discussing grid infrastructure, that no MRE technology is 100% predictable or reliable, meaning there is a variable level of supply. As a result, flexible grid connections will be essential (Karim, 2012) making the process more complex than that associated with other energy sources. Further to this, it should be noted that these connections will need to be supported by mechanisms for energy storage and compensatory energy generation, activities which may themselves be future opportunities for SMEs within the MRE sector.

---

[11]It should be noted that predictability can encompass a number of areas and could include: predictability of energy generation and supply, predictability of technology performance and lifespan, predictability of financing, charging and subsidy plans, and predictability of long term policy landscape.

- There are a number of challenges that have been identified around financing MRE related Research and Development (R&D), testing/ demonstration sites (associated with reliability and commercial potential), and installation of devices. Currently, the MRE sector, particularly the wave and tidal energy sectors, represent high risk investments to many businesses, as the majority of the technology remains in the demonstration phase, rather than full deployment (EU-OEA, 2010). However, as technology advances, and energy generation can be predicted, MRE technology systems should be able to secure financial investment. Current incentives are not sufficient to adequately support the sector; however, with progress, energy levels will become more reliable, increasing the sector's economic viability. While it has been suggested that the Green Investment Bank views MRE technologies as a viable investment, the challenge for early stage developers is acquiring match funding (an EU funding requirement) (Vantoch-Wood et al, 2012).

- Lack of reliable information regarding investment returns and timescales due to the industry immaturity and complex and lengthy planning cycles associated with the sector have added to the perception that investment in the MRE sector is high risk (Jeffrey and Sedgwick, 2012). This level of risk is something many SMEs cannot afford, and may therefore influence their decision (and, indeed, their capacity) to enter the SME market, regardless of the potential financial benefits.

- High costs associated with the sector for both SMEs and developers. As a whole, the MRE sector has some of the highest costs associated with energy generation. This, along with the costs associated with training, skills provision, and development, for sub-contractors and SMEs has further resulted in the industry being perceived as a high risk investment, as mentioned above. Companies/ SMEs have concerns around supporting additional training for their staff as the sector remains unpredictable. A further concern associated with training costs is linked to the often migratory nature of the MRE workforce – is it worth SMEs investing in their work force (in terms of training etc) when the MRE workforce is expected to travel, meaning staff are unlikely to come from the local area? It should be noted that this may possibly change as the sector transitions from the installation to operational phase of arrays and devices, where O&M activities may call for a locally resident body of staff. Work has been done through the BEEMS project to identify and standardise training requirements for the MRE sector.

- Public perception and social acceptance of MRE is of growing importance within the sector. Many studies have highlighted public perception as a key (KARIM, 2012; MERiFIC). Recent changes to marine policy across Europe have resulted in an improved level of public engagement and consultation regarding any development that may impact the marine environment, which encompasses all MRE installations. Following the ratification of the EU Marine Strategy Framework Directive (MSFD) (2007), both England and France are in the process of formulating an effective marine policy and marine planning strategy to ensure sustainable use of marine resources, and the MRE market must take the recommendations of these Directives into consideration. As part of the MSFD, both countries must recognise the role of public perception of MRE when considering development of the marine environment. Public recognition of MRE as a valuable and legitimate use of marine resources and energy generation has an integral role to play in ensuring a supportive policy landscape for MRE development as a long-term energy solution in both England and France.

- It should also be noted that the changing political landscapes in both the UK and France may have a bearing on the political support, and, therefore, the further development of the MRE sector. While it is true that energy security is a continual concern for national governments, the political backing for renewable energy, and MRE specifically, can vary; again, increasing the perception of MRE as a high risk investment.

- Challenges for SMEs engaging with Tier 1 providers and developers within the MRE sector. For example, within the OSW sector, wind turbine manufacturers and developers have established effective supply chains over recent years, making it difficult for new suppliers to enter into these supply chains. This can be particularly challenging for SMEs , unless MRE policy promotes higher levels of local content within MRE installations. In addition, there are challenges associated with the procurement process, and SMEs having an awareness of the specific requirements and regulations outlined by developers.

Although some of these challenges have a direct impact on the tier 1 providers, they all have a consequent impact on successful SME involvement. As such, the MRE industry is often viewed as a high risk investment, particularly for smaller companies limited by resources and financial capital.

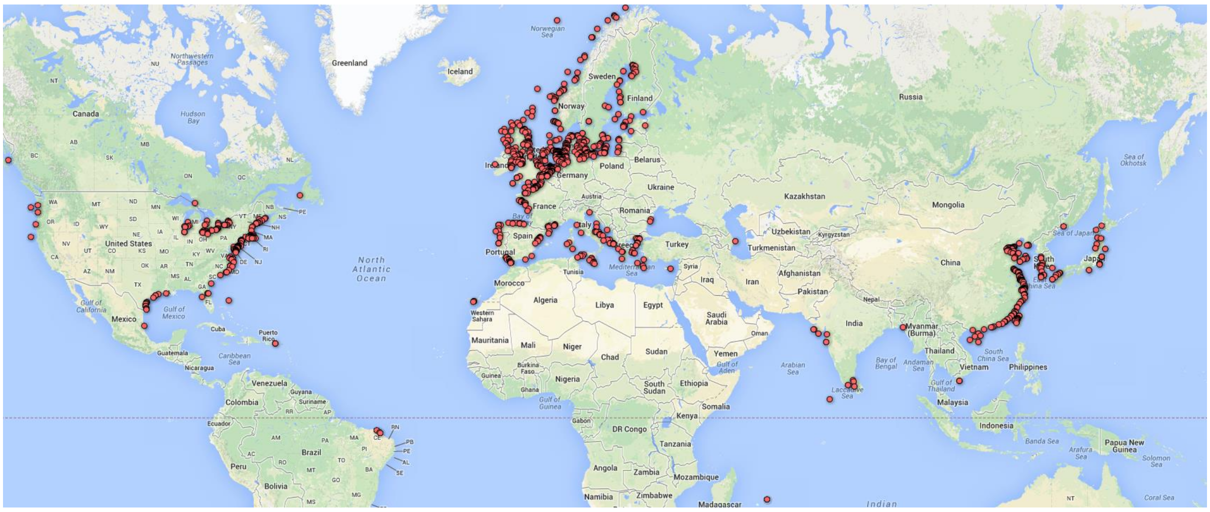
5. ANALYSIS, RESULTS AND DISCUSSION

This section presents an evaluation of the current status of MRE installations on a global scale. Each energy type will be discussed in terms of number of installations, size of turbines, possible barriers to installation and the implications for the wider MRE market and supply chain development.

5.1. Geographical spread of MRE

As part of the analysis, maps have been produced using Google Earth and Google Fusion Tables to illustrate the current (installed, approved, cancelled[12], and dormant status), and future (planned and projected) market within the MRE sector on an international scale (presented in Figures 1-3). It is evident from the maps that MRE activity is well developed across Europe.

Figure 1: Geographical spread of global offshore wind energy installations



[12] It should be noted that Cancelled status has been determined to include any type of cancellation, and has been defined as including planned installation that have been cancelled due to failed proposals.

Figure 2: Geographical Spread of Global Tidal energy installations

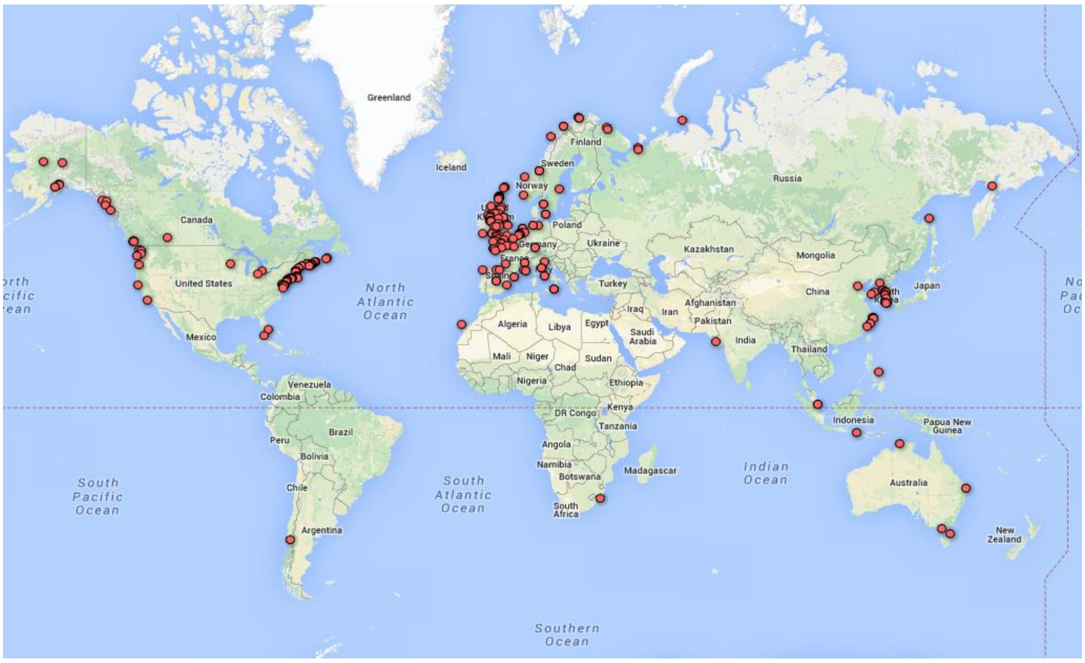


Figure 3: Geographical spread of global wave energy installations

Table 5 presents an overall summary of MRE installations, giving an indication of the current and future opportunities for supply chain development and business support within the MRE sector.

Tables 6-8 present an indication of the geographical spread of MRE installations of various installation statuses (supported by the maps presented in Figures 1-3)[13].

	Offshore Wind	Wave	Tidal
Total number of Installed sites	109	7	13
Total number of approved sites	140	4	3
Total planned sites	153	20	32
Total number of projected sites	816	9	59
Total number of Demonstration sites	0	209	148
Total number of Cancelled sites	300		
Total number of Dormant sites	154		
TOTAL number of installations (based on database entries)	**1284**	**268**	**263**

Table 5: Global MRE installation status for OSW, wave and tidal energy.

Installation Status							
Location	**Projected**	**Planned**	**Approved**	**Installed**	**Cancelled**	**Dormant**	**Decommissioned**
Australia	1						
Azerbaijan						1	
Bangladesh						1	
Belgium		2	5	5			
Brazil	3						
Canada		1	1		24		
China	72	12	49	20		3	
Croatia	1				2		
Cyprus					1		
Denmark	28	4	1	15	14		
Estonia		9			1		
Finland	11	2	1	3	3	1	
France	**13**	**1**	**4**		**37**	**1**	
Germany		63	32	7	9		

[13] It should be noted that data was collected for all phases of wave, tidal and OSW installations, meaning that the final number may represent further developments and expansions of arrays, test facilities and planned sites.

Greece	22				11		
India	9	1					
Ireland	3	5		1			
Isle of Man	1						
Italy	14				15		1
Japan	10	2				1	3
Latvia	1				1	1	
Lithuania	1					1	
Maldives					1		
Malta	3				1		
Mauritius	1						
Mexico	1						
Netherlands	5	1	15	4	9	58	
Norway	13	1	5	3	21	6	
Poland	12				1	1	
Portugal		2		1	1		
Romania						2	
Russia	1					2	
South Korea	11	2	2	2	1	3	
Spain	9	4	1		5	36	
Sri Lanka	1						
Sweden	13			8	4		2
Taiwan	24						
Tunisia					1		
UK	50	16	18	23	37	1	
US Virgins Islands	2						
USA	76	11	1		87	29	

Table 6: Global Offshore wind installation status (UK and France illustrated by the coloured bar)

Location	**Status of installation**						
	Projected	**Planned**	**Approved**	**Installed**	**Demonstration Site**	**Cancelled**	**Dormant**
Australia	1	2			5		1
Belgium	1						
Brazil					1		
Canada	1				3		

China					4		
Cyprus					3		
Denmark					26	1	
Finland					1		
France	**1**			**2**	**19**		
Germany					4		
Ireland		1			8		
Israel					1		
Italy	1	1			6		
Japan					1		
Malta					2		
Maldives			1				
Namibia		1					
Netherlands					3		
New Zealand					4		
Norway				1	10	1	
Portugal				1	5	2	
South Africa						1	
South Korea					1		
Spain		3		2	21		
Sweden				1	5		
Taiwan					1		
Turkey					1		
UK*	**2**	**10**	**2**		**38**	**2**	
USA	2	2	1		30		

Table 7: Global Tidal energy installation status (UK and France illustrated by the coloured bar)

Location	Status of installation						
	Projected	**Planned**	**Approved**	**Installed**	**Demonstration Site**	**Cancelled**	**Dormant**
Australia	1	1			2		
British Channel Islands		1					
Canada	6	3	1	2	8		
Chile	1						

China	3	1		1	5		
Denmark					3		
France	1	1		1	20		
Germany					5		
India		1					
Indonesia					1		
Ireland					1		
Italy		1			8		
Netherlands	1			1	8		
New Zealand							1
Norway		1			11		
Russia	3	1		1			
Singapore					1		
South Africa		1					
South Korea	2	2		3	2		
Spain					11		
Sweden					4		
UK	7	14		3	40	2	
USA	11	2	1	1	16	21	3

Table 8: Global wave energy installation status (UK and France illustrated by the coloured bar)*The Philippines were also found to have evidence of tidal energy activity but no information on current status was found.

From Tables 4-8, it is clear that there is a variance in the maturity of the three MRE markets being evaluated through this research. It is well documented that offshore wind is a far more mature market than wave and tidal energy; however, the volume of demonstration sites in both the tidal and wave energy sectors suggests technology is advancing and that efforts are being made to develop the sector so that it can operate at a level of full commercialisation. As expected, the level of activity in OSW energy far exceeds that in either wave or tidal. However, it should be noted that 35% of the installations detailed within the database were identified as being either Cancelled or Dormant, suggesting there are still significant complexities associated with moving from planning and proposal of MRE to the actual installation and operation of devices and farms.

The database component of the research has resulted in one of the most comprehensive databases relating to global MRE activity currently available. This database has the potential to be a valuable asset to the sector's on-going development as it can act as an information point for SMEs interested in entering the MRE market, and the information has been used to underpin the development of the Channel MOR Energy portal (accessible at www.Channelmorenergy.eu).

5.1.2. MRE status in the Channel region

Evidence suggests that the MRE sector is continuing to grow on a global scale, a trend that is being mirrored across the Channel region, with an increasing number of initiatives in place to support development of the sector in both England and France. Figures 4 - 6 provide an illustration of the current MRE installations across the Channel region.

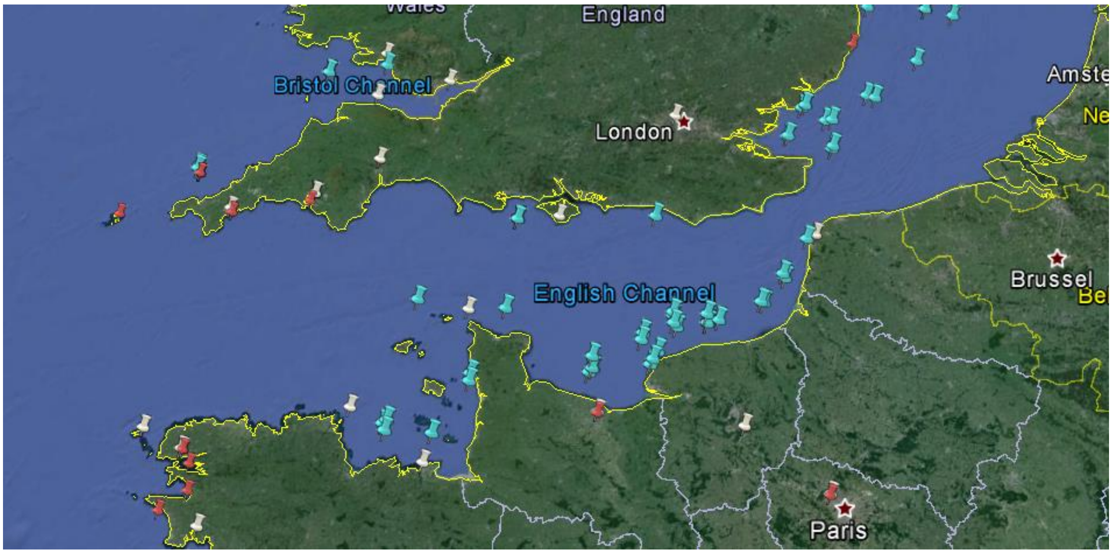


Figure 4: An illustration of MRE installations in the Channel region (Wave – red pins, Tidal - white pins, Offshore Wind - blue pins)

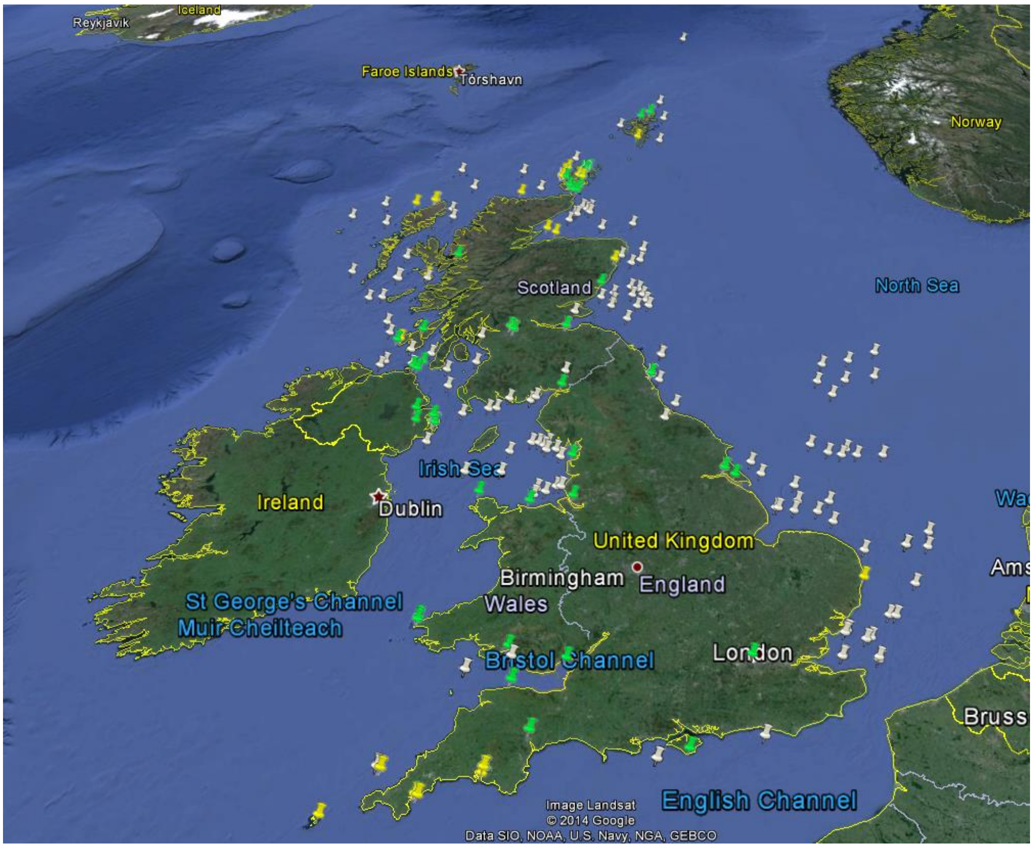


Figure 5: An illustration of MRE installations in England and the wider UK (Wave – yellow pins, Tidal – green pins, OSW – white pins)

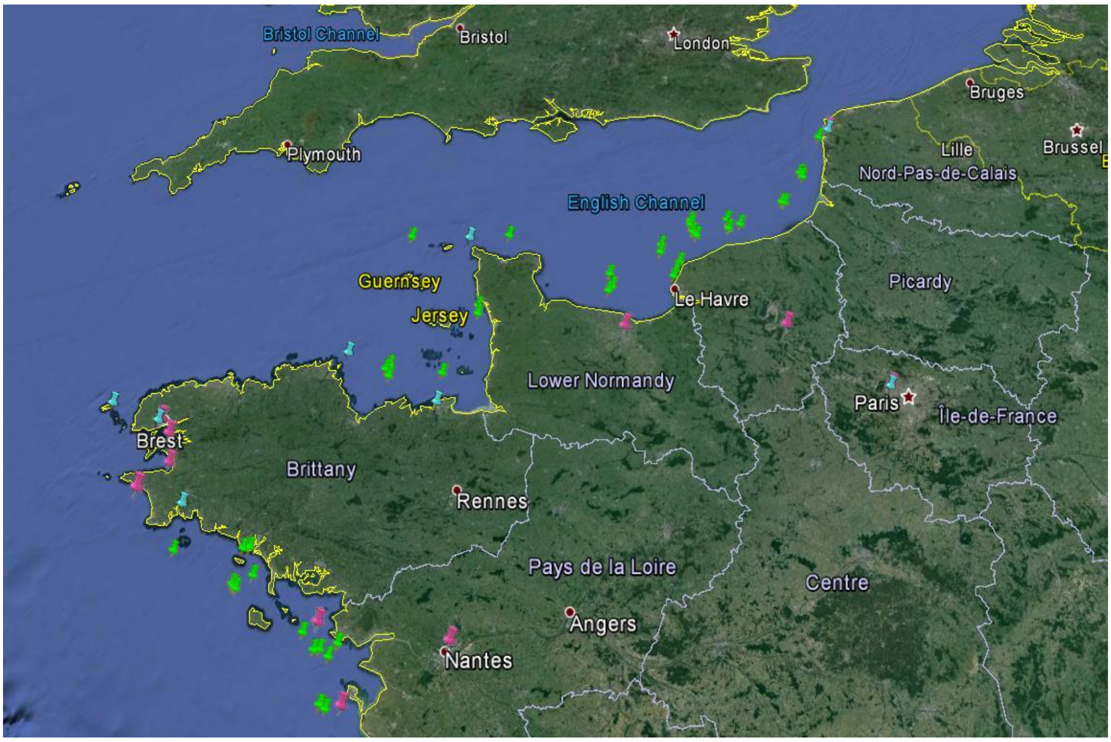


Figure 6: An illustration of MRE installations in France (OSW – lime green pins, Wave – pink pins, Tidal – turquoise blue pins)

	Offshore Wind	Wave	Tidal
Channel region	60	23	29
England	147	69	57
France	58	22	20

Table 9: Number of MRE installations currently within the Channel region, France and England.

It is clear from the maps presented above, and analysis of the data collected through the Channel MOR project, that there is a significant level of development occurring within the Channel region's MRE sector. Table 9 presents a summary of the number of planned and projected sites, as well as providing information on the number of sites currently under construction, or sites acting as demonstration sites that act to support the wider MRE sector (in the Channel region, Wave Hub and FabTest are of particular importance to strengthening the regions' capacity for engaging with the sector). Figures 7-9 present an illustration of the MRE activity in different phases of development around the Channel region.

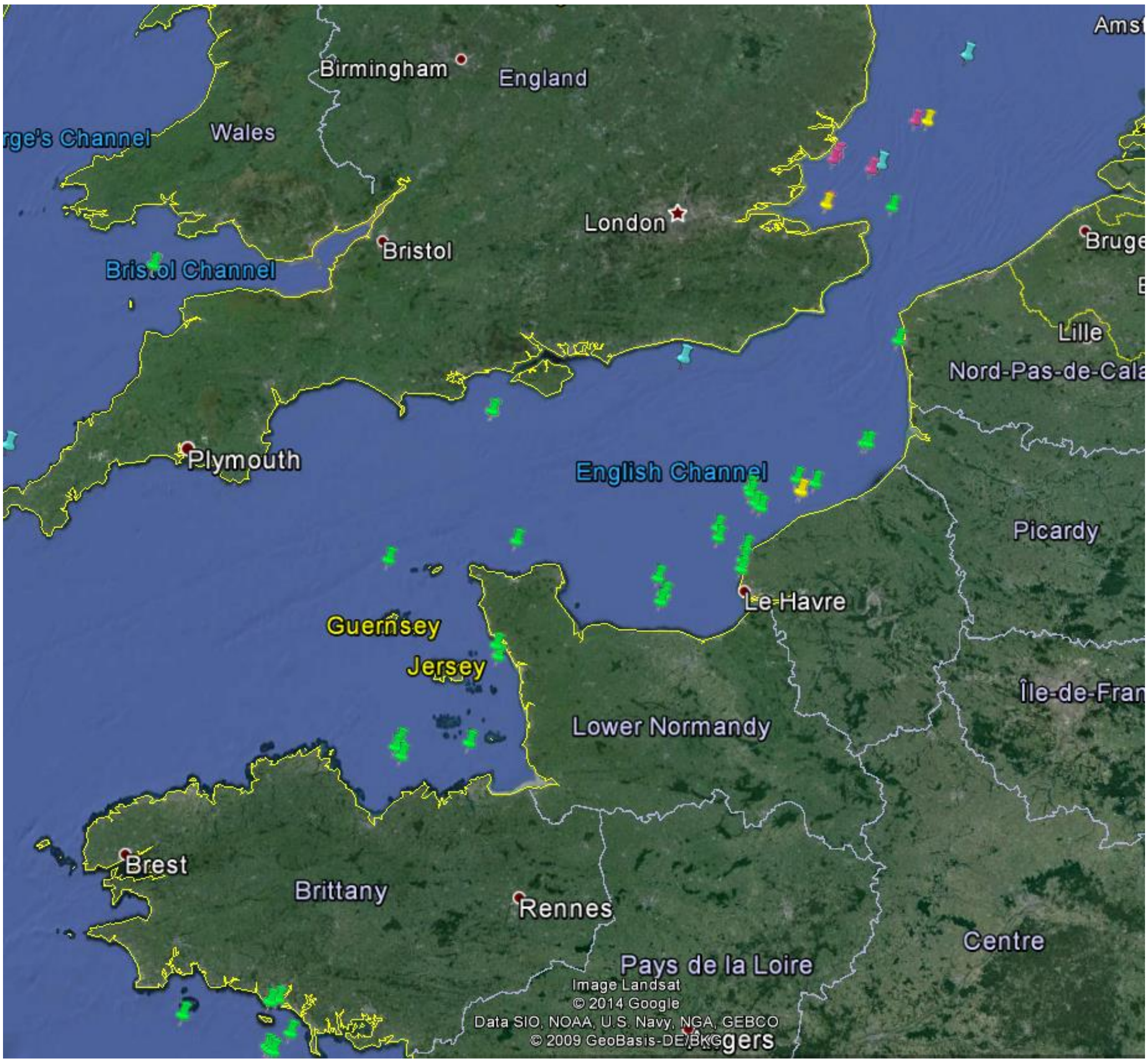


Figure 7: Map of current OSW energy activity in the Channel region (projected sites - green pins, approved sites - yellow pins, planned sites: turquoise pins, installed sites - pink pins)

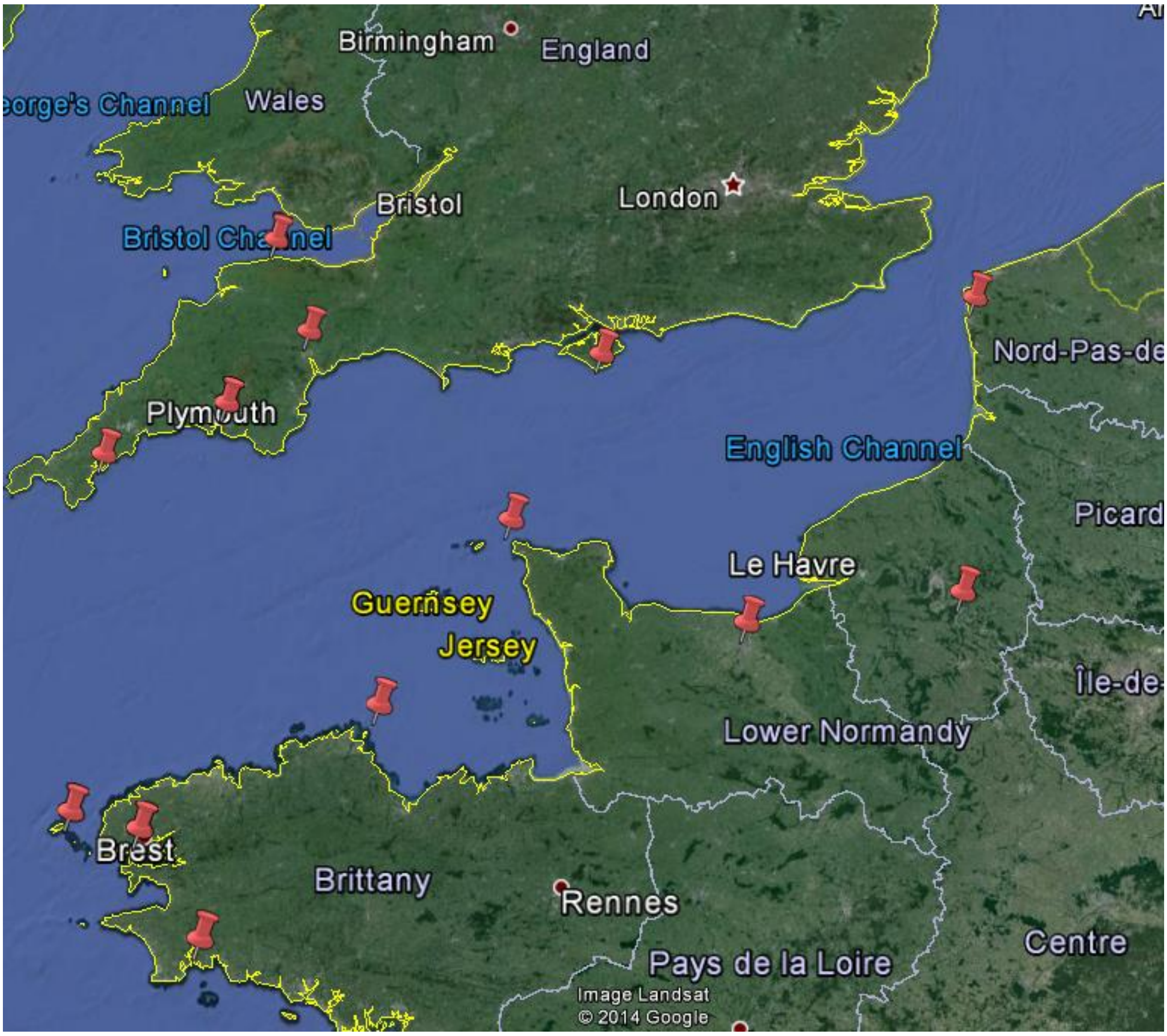


Figure 8: Map of tidal energy activity in the Channel region (demonstration sites- red pins)[14]

[14] There was no longitude and latitude data collected for other types of sites, meaning this map is dominated by demonstration/ test sites and facilities.

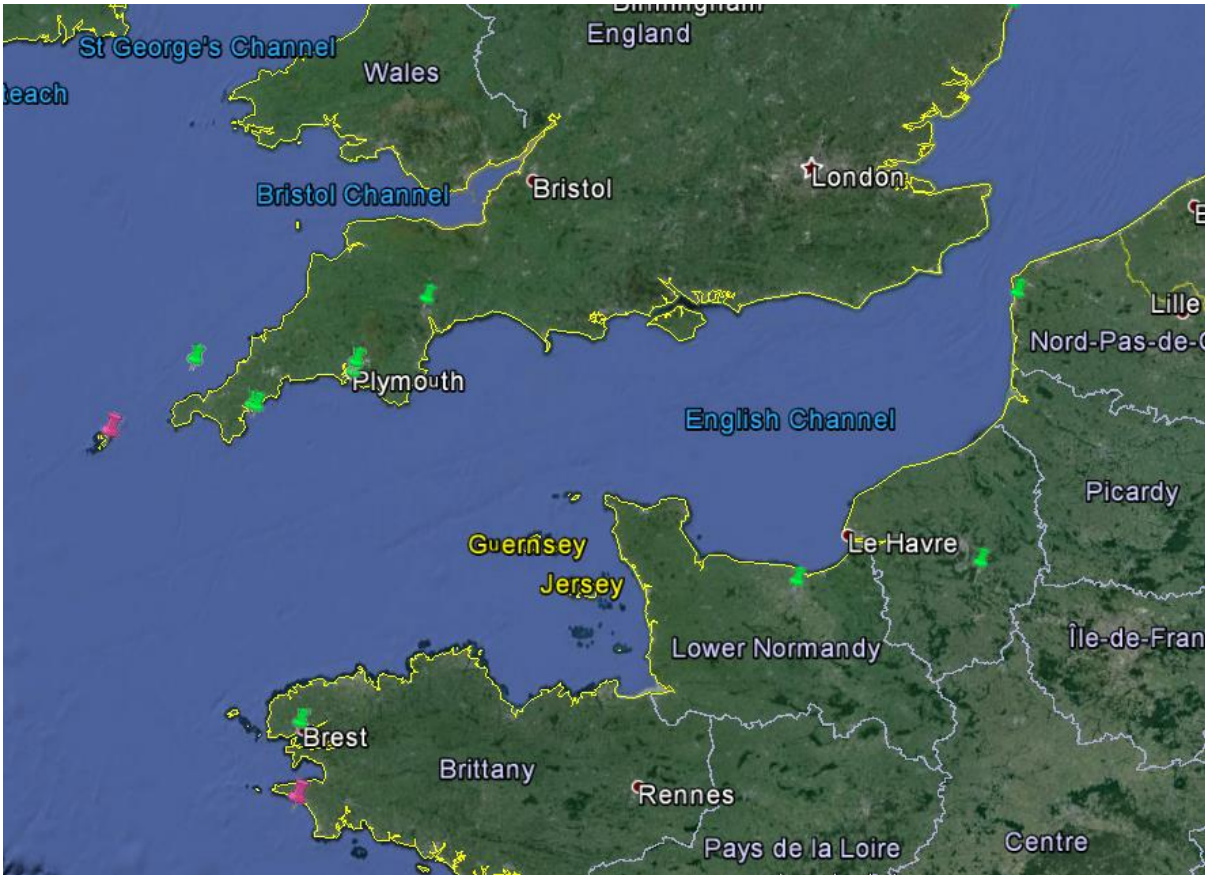


Figure 9: Map of wave energy installations in the Channel region (demonstration sites – green pins, planned sites - pink pins)

As indicated by the level of MRE activities in Table 9 and the Figures above, it is clear that the Channel region has the potential to develop MRE as a priority activity. In terms of OSW, there is a range of activity across a number of phases on development – for example, there is evidence of installed arrays, in addition to significant evidence of planned and projects sites. In terms of wave and tidal energy, the focus is predominantly on planned and projected activity, with a significant level of demonstration site based activity in the tidal sector (see Figure 9). Figure 10, below, presents a SWOT analysis of this activity and highlights the potential opportunities available to the region as it continues to develop its MRE expertise.

<table>
<tr><th colspan="2">SWOT Analysis of MRE sector in the Channel Region</th></tr>
<tr><th>Strengths</th><th>Weaknesses</th></tr>
<tr><td>
The Channel region holds a strategic place within Europe, with easy access to both London and Paris, good transport connections with a number of deep water ports and appropriate infrastructure, providing the region with a strong position in terms of support services for the sector (Portsmouth, Caen-Ouistreham, Le Havre)
Areas of strong OSW, wave and tidal energy resources (including areas in Brittany, Normandy, Cornwall, Devon and the East of England)
Existing clusters and technopoles already active in supporting the progression of the MRE sector in the Channel region (including Energies Haute Normandie, Cornwall Marine Network, CEVEO, Le Madrillet Research Centre in Rouen)
Numerous training and education opportunities available within the Channel region (including: Campus des Metiers et des Qualifcations, Falmouth Marine School, Plymouth University, Maritime Centre of Excellence, University of Southampton).
Existing test facilities that are accessible to developers for testing new technologies and components, including pre-consented space in FabTest, Cornwall, UK.
Easy access to more developed MRE markets across Europe, including activity in the North of England and Scotland.
</td><td>
In general, the Channel region is lacking in sufficient grid infrastructure to support wave and tidal energy progression.
Lack of local content in current installations making it difficult for SMEs to engage with existing and developed supply chains,
A complex and lengthy planning and consenting process poses an investment risk for SMEs,
Lack of standardised training and qualification requirements across the sector, making it difficult for SMEs to prepare for effective engagement with the industry, as well as new workers coming into the market.
Uncertainty around SME capacity to deliver into the MRE supply chain without additional support.
</td></tr>
<tr><th>Opportunities</th><th>Threats</th></tr>
<tr><td>
There is an increasing emphasis on the need for local content (and therefore, positive economic impact on local communities) within MRE developments. Associated with this is an opportunity to develop more transparent support for SMEs working to enter the MRE market.
Interest in the formation of a Channel MOR community to support collaboration and cooperation between SMEs and the wider MRE sector, increasing the visibility of the expertise and skills available in the Channel region.
Development of standardised training programmes and requirements that can be made available across the region, with support from the relevant industry trade bodies, MRE developers, local authorities, training organisations, and higher education institutions.
</td><td>
Lack of certainty around the level of political support that will be afforded to MRE developments following the upcoming elections in the UK (2015).
Insufficient research conducted into the social acceptability of MRE and their socio-economic impact - public and political rejection of MRE developments has been listed as the reason for cancelled or delayed MRE projects, and could have an impact on how the sector develops in the future.
A lack of appropriately skilled new workers entering the sector.
</td></tr>
</table>

Figure 10: SWOT analysis of the Channel/ Le Manche's MRE activity[15]

5.1.3. TRENDS IN DEVELOPMENT

As the MRE sector continues to develop, the industry is seeking to exploit all sources of energy available. This has caused a change in device and installation design and development; for example, a move towards larger turbines being deployed in OSW arrays, use of different mooring types, arrays being deployed further from shore and new areas becoming engaged in the MRE sector. These trends are examined for each of the marine renewable energy technologies included in the Channel MOR project.

5.1.3.1. Trends in OSW Energy

As the OSW energy sector continues to develop, it is worth understanding how the sector has grown and its current status. Table 10 provides an indication of the global average installation size based on number of devices, energy production and budget[16]. Of particular interest is the Channel region; Table 11 presents a summary of the current information available on the Channel regions' MRE activity, including the average, maximum and minimum figures for a number of factors such as: size of array (number of devices), energy generation, potential energy, distance from the shore, depth of installation and budget.

	Average	Maximum	Minimum
Size of Array – Number of turbines	65.25	1400	1
Size of Array – actual energy produced (MW)	74.323	0	0
Size – potential energy production (MW)	709	250,000	1
Budget (in Millions of Euros)	116,415	24,850,000	3
Depth of installations and arrays (metres)	26	0	0
Distance from shore (kilometres)	35	0	0

[15] A detailed SWOT analysis for each region included within the Channel MOR project region has been produced by CMN and BDI as part of the project Communication Strategy. For more information, please contact Tim Bowerbank at tim.bowerbank@cornwallmarine.net.

[16] Specific information about each MRE installation can be obtained through the search function provided by the Channel MOR Energy portal. Available at www.channelmorenergy.eu It should also be noted that the research team were not able to collect data for each of these components for every MRE installation. Therefore, the information presented here is a representation of the sector.

Table 10: Summary of current status information for the global OSW market [17]

	Average	Maximum	Minimum
Size of Array – Number of turbines	60	240	1
Size of Array – actual energy produced (MW)	206	630	12
Size – potential energy production (MW)	433	1,800	3.5
Budget (in Millions of Euros)	4674	116,415	32
Depth of installations and arrays (m)	24	92	1
Distance from shore (kilometres)	19	91	1

Table 11: Summary of current status information for the Channel OSW market

Comparison of Tables 10 and 11 suggest that activity within the Channel region in the OSW market is on par with that happening in other areas of global OSW activity, with the average size of OSW farms seen to be relatively similar.

- Mooring Type

Within OSW there are a number of mooring technologies used by developers. Analysis of the data collected (presented in Table 8) indicated that monopile technology is the most commonly employed mooring type utilised within the OSW sector. However, there is a clear movement towards the use of floating mooring technologies. This technological advancement will support the exploitation of OSW energy in areas that were previously considered too difficult to reach due to their distance offshore, or incompatible substrate types. This is a potential opportunity for SMEs aiming to enter the MRE market as there will be an increased need for appropriate cabling, and new O&M processes will need to be developed for the floating structures.

	Mooring Technology					
	Jacket	Monopile	Gravity	Floating	Other	Unknown
Number of installations using each technology type	44	114	29	81	63	989

Table 11: Mooring technology used in global installations

[17] More information is available on individual installations and arrays at www.channelmorenergy.eu

- Location

Analysis of the global MRE activity also indicated that new markets for MRE are emerging as the sector continues to develop. Tables 5 and 6 present a summary of where OSW energy activity is currently under some form of development, although it should be noted that this information also includes cancelled and/or delayed developments. Based on the global activity, it is clear that there are many opportunities available to SMEs operating within the Channel region; however, there is a need for these companies to raise their visibility, making potential collaborators or customers aware of their expertise and creating links both across the Channel region, and on a more international scale.

5.1.3.2. Trends in Tidal Energy

As discussed, tidal energy is a growing MRE sector; therefore, investment in development costs and number of devices/ installations is lower than those seen in the OSW sector. Table 12 presents a summary of the information available on the global tidal energy sector, providing an indication of average budget, size of array/ installation and energy generation. As the sector continues to develop, it is expected that investment and array size/ power generation will increase. Table 13 presents a summary of the general information available on tidal energy development in the Channel region, including size of arrays, numbers of devices, energy potential and budget.

	Average	Maximum	Minimum
Size of Array – Number of devices	102	4400	0
Size of Array – actual energy produced (MW)	16.4	260	1
Size – potential energy production (MW)	16.4	87,100	3
Budget (in ’00,000s of Euros)	18639.39	304	13
Depth of installations and arrays (m)	15	55	.6
Distance to shore (Km)	5	24	.15

Table 12: Summary of current information available regarding size of tidal arrays, investment and energy production

	Average	Maximum	Minimum
Size of Array – Number of devices	4	24	1
Size of Array – actual energy produced (MW)	60.1	240	0.01
Size – potential energy production (MW)	65	400	1
Budget (in '00,000s of Euros)	6668	23294	598
Depth of installations and arrays (m)	12	55	0.6
Distance to shore (Km)	3	3.5	2.5

Table 13: Summary of the information available on current Channel tidal energy activity.

Comparison of Tables 12 and 13 show that, currently, the tidal energy activity within the Channel region is not at the same scale of that happening in other areas (as indicated by the average size of array and energy generation). However, it is clear through the budgets allocated to this sort of energy generation (as indicated in Table 13), that significant R&D effort is being attributed to furthering tidal energy as a viable and marketable renewable energy source.

5.1.3.3. Trends in Wave Energy

Like tidal energy, wave energy remains an immature market and is approximately 5 -10 years behind the development/ commercialisation projections for tidal energy (based on expert discussions at the Channel MOR Workshop held at Sea Tech Week, Brest, October 2014). Table 14 provides an indication of current array size, energy generation and investment in the sector, while Table 15 presents a summary of information specifically relating to wave energy activity in the Channel region.

	Average	Maximum	Minimum
Size of Array – Number of devices	19.05	800	1
Size of Array – actual energy produced (MW)	0.68	6	0
Size – potential energy production (MW)	19.9	200	0
Budget (in '00,000s of Euros)	209.93	1658.26	1.86
Depth of installations and arrays (m)	17	60	0.75
Distance to shore (Km)	6	61.12	0.1

Table 14: Summary of current information available regarding size of wave energy arrays, investment and energy production.

	Average	Maximum	Minimum
Size of Array – Number of devices	2	4	1
Size of Array – actual energy produced (MW)	0.12	0.24	0
Size – potential energy production (MW)	6.9	30	20
Budget (in '00,000s of Euros)	295	500	90
Depth of installations and arrays	11	48	0.5
Distance to shore (Km)	9	16	3

Table 15: Summary of general information available relating to Channel wave energy activity

Again, as with the tidal energy, it is evident from a comparison between Tables 14 and 15 that Channel activity in the wave energy sector is not matching the same scale as that happening in other areas of the global MRE market. It should also be noted that there is a great deal of activity occurring across all elements of MRE in other areas of the UK, and in some places (for example, Scotland, Northumberland and areas of Wales and Northern Ireland), this activity is quite developed. There could be opportunities for Channel based SMEs to engage with these more mature and active areas.

An evaluation of Tables 10-15 further supports the consensus that OSW is a more developed market, on both a global and Channel scale. However, it is clear from the data available that wave and tidal energy are growing in effort within the Channel region, and further analysis of the business capacity (in Section 5.2) highlights the area's potential to be a market leader in these sectors.

5.2. Business Opportunities for SMEs within the MRE sector

The second phase of the research aimed to evaluate the current business capacity in the Channel region for engagement across the MRE lifecycle. A comprehensive database of all businesses, with specific focus on SMEs, either already involved or with the potential to be involved in the MRE sector, both within the Channel region, as well as the global market, was developed (as outlined in Section 2.3). Analysis of the data collected to date indicates that there are over 4549 businesses across the Channel region with capacity for involvement in the MRE sector in some way. While it is recognised that there are gaps in the business information, business users of the Channel MOR portal will be encouraged to take ownership of their own business information and actively include it on the portal, creating a living resource.

In spite of the balance issues around the data, it is evident that there are many companies currently operating within the Channel region that could potentially enter, or are already active within, the MRE supply chain, supporting diversification and growth of SMEs. Figures 11-13 present an illustration of the spread of potential suppliers across the Channel region, with 3841 businesses found on the English side of the Channel region, and 301 businesses on the French side[18]. Although it is recognised that the data capture exercise was not as rigorous in France as on the English side of the Channel, this lack of business data may also be influenced by the fact that MRE is still a developing sector in France.

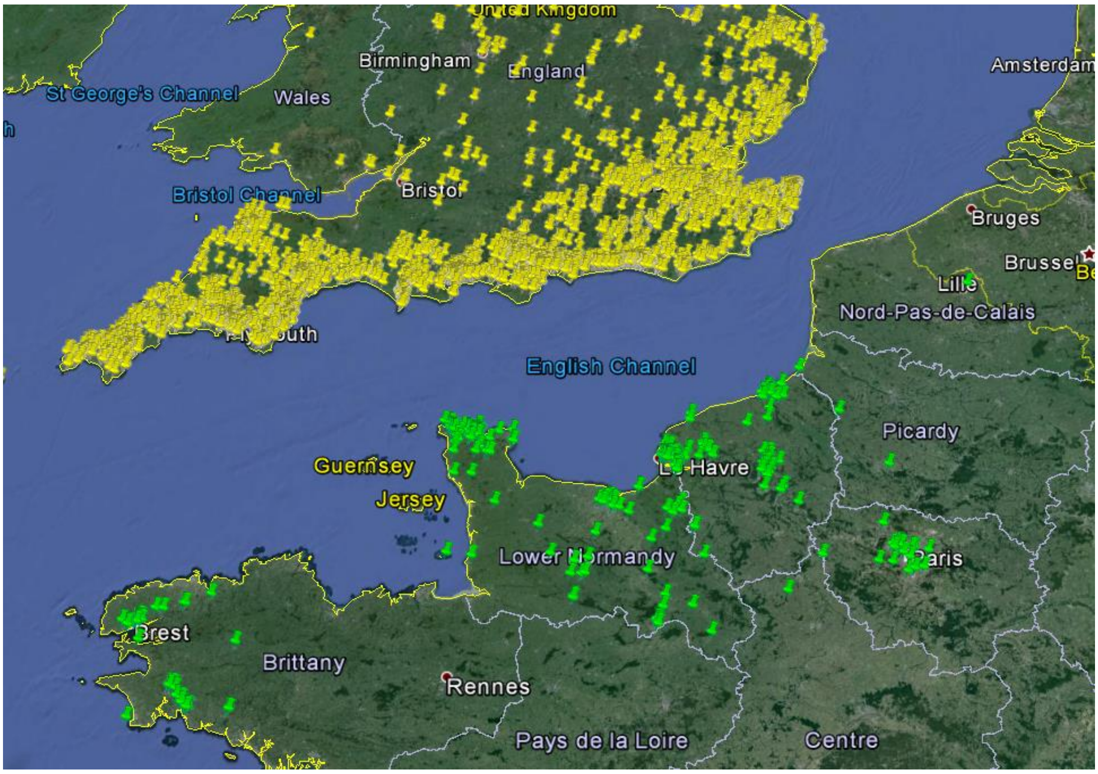


Figure 11: A map of all businesses identified as having the capacity to engage in the MRE supply chain (OSW, wave and tidal).

[18] This discrepancy in numbers creates a clearly unbalanced picture of activity within the Channel region – the low numbers are due to gaps in the data collection process rather than a lack of business capacity for engagement in the MRE supply chain.

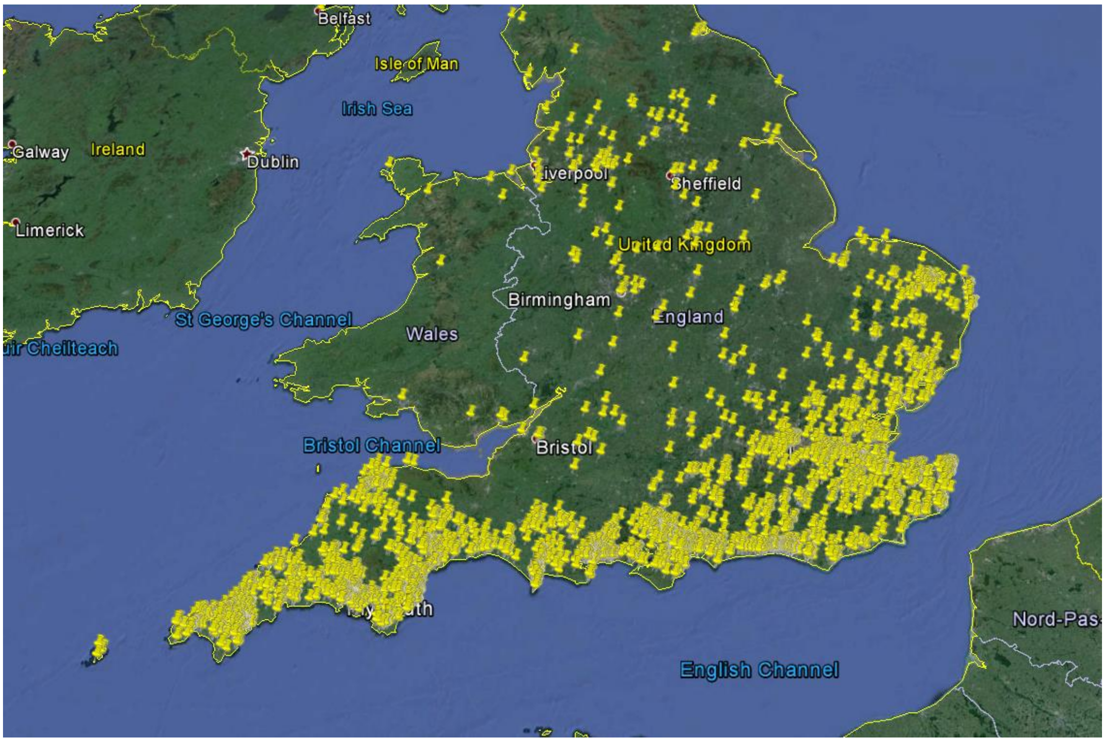


Figure 12: A map of English businesses with the capacity for engagement with the MRE supply chain

Figure 13: A map of French businesses identified as having the capacity for engagement with the MRE supply chain.

	Tier O	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
Total number of companies operating within each Tier	4	140	598	639	241	56

Table 16: Indication of the number of companies already operational or with the capacity to engage within the MRE supply chain in the Channel region across each of the lifecycle tiers.

Table 16 provides an indication of the number of businesses that are currently, or have the future potential, to work within the MRE supply chain (OSW, wave and tidal energy technologies) within the Channel region, based on the list of activity codes (presented in Appendix 1). Clearly, there is a limited amount of capacity for engagement in Tier 0 activities, which include the construction of OSW turbines and other devices, with greater capacity evident in the lower tiers (these activities could feed into higher tier activities – including the construction of devices, cabling and surveying). Despite the apparent capacity gap in higher tiers, there is evidence of a significant level of capacity across all activity tiers[19] meaning the Channel is well placed to participate actively within a locally driven MRE supply chain. Given the economic importance of the Tier 1 activities, additional analysis has been conducted and is presented in Section 6.2.

6. CASE STUDIES

In order to build a thorough understanding of some of the market opportunities for MRE within the Channel region, a number of thematic case studies have been carried out. The case studies focused on:

1) New spaces – new opportunities for SMEs as the MRE sector continues to develop.
2) Gap and Tier 1 Analysis – Identification of current gaps in SME capacity across the Channel region, coupled with analysis of the current Tier 1 capacity.

6.1. New Spaces

Within the theme of New Spaces, five areas were identified as being new opportunities for SMEs and the wider MRE market as it continues to develop. These new spaces were: Wave Energy, Tidal Energy, Electrical Connections, Condition Monitoring and Surveying[20]. These themes were underpinned by the themes highlighted by the literature review, and through the two expert workshops. A Porter's Five Forces framework (Porter, 2008) is employed to analyse the opportunities and structure of each of the new spaces being outlined in the project case studies.

[19] It should be noted that one business may have the capacity to engage in more than one activity on the supply chain so may be counted twice or more – this means there is a total number of 10

[20] The case studies are available as individual documents from the University of Chichester: please email semalresearch@chi.ac.uk

6.1.1. CASE STUDY ONE: Wave energy

As mentioned above, wave energy is a developing technology that could offer SMEs opportunities to engage within the marine renewable energy (MRE) industry. Due to its position as an emerging market, the feasibility phase and progression from test sites to commercial arrays have been identified as an area with particularly high potential for SME engagement including activities such as geological surveying, human activities and feasibility assessment (MERiFIC, 2013). Some key observations about the developing wave energy sector are listed below:

- Globally there are 167 known wave energy technology/ device developers, with 31 developers from the UK and 4 from France (EMECa, 2014).
- There are currently eight main types of wave energy devices, which are: attenuator, point absorber, oscillating wave surge converter, oscillating water column, overtopping/terminator device, submerged pressure differential, bulge wave, rotating mass (EMECb, 2014 and SI Ocean, 2012).
- Capital funding and private sector investment will be necessary for the wave energy industry to develop from the concept to full commercial stages (Carbon Trust, 2011 and Energy and Climate Change Committee, 2012), although it should be noted that not all technologies are expected to progress to commercial deployment.
- However, the costs and risks for private investors alone are too high. This risk could be reduced by receiving financial support and agreements from the public sector (Energy and Climate Change, 2012).
- As an emerging sector, wave energy has the potential to support significant rates of competition and innovation, due to the immaturity of the sector. However, the number of businesses capable of engaging in this process could be limited by the high capital investment required for conversion from test sites to commercial deployment.
- It should be noted that wave energy is probably the least developed of the three technologies covered by the Channel MOR project, and as such, it may be undermined by quicker progression within the tidal energy sector.

Market Size

This case study used the Channel MOR installation database[21], developed for the Channel MOR project, to estimate the market size for all known wave energy projects in the regions UK, France, rest of Europe and rest of the World. Table 17 illustrates the number of wave energy demonstration

[21] The Channel MOR installations database is available for use at www.channelmorenergy.eu

sites and planned developments that have been identified from the database. The following equations illustrate how the market size was estimated:

Market size = number of planned projects X estimated average CAPEX costs.

Market size = number of demonstration sites x estimated average CAPEX costs.

The CAPEX costs represent the capital expenditure costs, which includes balance of plant (the infrastructural components), project' management and installation and commissioning. The estimated average CAPEX price of a planned wave energy development (combined offshore and near shore) is £3,385,000/MW (Ernst & Young, 2010). Whereas the estimated average CAPEX price of a wave energy demonstration site is £4,940,000/MW (Ernest & Young, 2010).

Region	Demonstration sites	Planned sites
UK	38	9
France	19	3
Rest of Europe	91	6
Rest of the World	55	2

Table 17: Number of wave energy demonstration sites and planned developments.

Results from Table 17 and Figure 14 illustrate that the wave energy industry has a high number of demonstration sites when compared to planned developments. This could suggest that wave energy technologies are less mature or developing, especially when compared to other forms of offshore renewable energy such as wind.

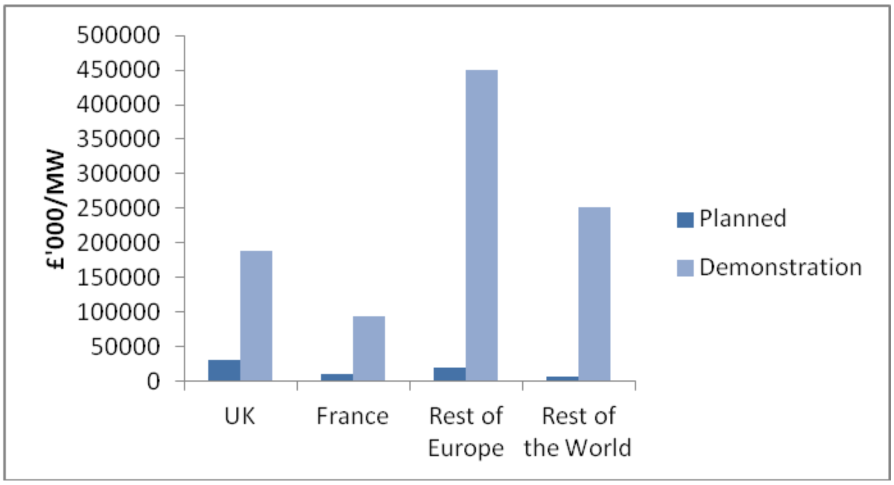


Figure 14: Market size in £'000/MW for wave energy demonstration sites and planned development CAPEX costs.

Key Challenges

Wave energy is in the conceptualisation, early development and demonstration stages. Therefore there are some key challenges that could affect a SMEs accessibility and engagement into the industry. This section will highlight current key challenges in the wave energy industry including technical, financial, commercial, legal and social (presented in Table 18).

Technical	Financial	Commercial	Legal	Social
Predictability – wave energy output is a challenging risk due to the unpredictability of wave height and wave period (Si Ocean, 2012).	High capital costs are the main financial challenge for SMEs.	Commercialisation directly linked to financial constraints, with most being SMEs.	A need to ensure wave energy is developed in a way that supports and protects the marine environment, adhering to national and international legislation (DECC, 2012)	Social acceptance of wave energy is unknown and could be a risk for new projects.
Manufacturing – there is limited design consensus amongst wave energy convertors (Si Ocean, 2012).	Perception as a high risk sector	Sector needs public and private financial support to move to commercialisation of devices (DECC, 2012)	Changing policy landscape could impact political and public support for MRE development.	Need for greater promotion of the benefits of wave energy (Renewable UK, 2013)
Instability of wave energy convertors depends on its location. Shore and near shore wave energy convertors need foundations and infrastructure, while medium to deep water need to be towed (Si Ocean, 2012).	Investor preference for proven technologies (Energy and Climate Change Committee, 2012).	Support from the EMR would benefit the sector's developers.		Competition with other marine resources and users could cause conflict (e.g. fishing and shipping).
Operability –wave energy convertors still need to be tested in highly intensive sea states (Si Ocean, 2012).	Perception of wave energy being behind other marine energy technologies = high risk	Cost of wave energy needs to be reduced by 50-75% to £100/MWh to be competitive (LCICG, 2012)		
Survivability – wave energy convertors require over engineering to be able to survive storms and exceptional operational loads (Si Ocean, 2012).	4 factors have been suggested to increase in investors' confidence: policy certainty, risk sharing, confidence of a future market, removal of other barriers (lack of grid connections/ manufacturing sites) (ECCC, 2012)			
Reliability – Life expectancy is unproven. Furthermore, increased reliability will reduce unplanned maintenance				

(Si Ocean, 2012).				

Table 18: Summary of the key challenges facing the wave energy sector.

Potential Players and Moving Forward in Wave Energy

As discussed earlier, there are number of SMEs with the potential capacity to engage with the wave energy sector. Table 19 shows the number of SMEs that have the potential or are currently engaged in producing or supplying wave devices and the foundation works within the regions represented by the Channel MOR project.

Region	# of companies with Wave device design/ construction capacity	# of companies with Foundation works capacity
Basse Normandie	0	0
Bretagne	1	12
Cornwall	3	5
Devon	2	1
Dorset	0	0
East Sussex	2	1
Essex	17	7
Hampshire	1	0
Haute Normandie	2	0
Isle of Wight	0	0
Kent	9	9
Nord Pas de Calais	0	0
Norfolk	6	3
Other	15	9
Suffolk	7	2
West Sussex	2	1
Total	**67**	**50**

Table 19: Number of companies with current or potential capacity for involvement in the wave energy sector.

The wave energy industry is clearly still in the early stages of development; it is unlikely that it will significantly contribute to energy supplies before 2020 (Energy and Climate Change Committee, 2012). However, electricity generated from wave energy could make a substantial contribution between 2020 and 2050 (Energy and Climate Change Committee, 2012). England (the wider UK) and France have the potential to take a lead position within this market, capitalising on first mover advantage and raising their profile as experts within the wave energy sector. In order to be successful, the sector and its related technologies will need to be appropriately configured to a useful energy supply. Opportunities could arise for SMEs within this area of development; however, SMEs will need to know that there is a long-term viable market for the products that they may produce.

6.1.2. CASE STUDY TWO: TIDAL ENERGY

Alongside wave energy, tidal energy is a fast developing technology, which as an emerging market has the potential to offer opportunities for SMEs. Areas of opportunity for SMEs include: integration design, device design and development, turbine installation, operation and maintenance, electrical power system, turbine fabrication and assembly, onshore works and specialist environmental consultancy. The key points about this new opportunity were identified as:

- There are 98 globally known developers/suppliers of tidal energy convertors (EMEC, 2014c), with no dominating company among the 32 developers in the UK and 5 in France (EMEC, 2014d) with six leading types of tidal devices: horizontal axis turbine, vertical axis turbine, oscillating hydrofoil, enclosed tips (ducted), helical screw and tidal kite.
- There are threats to tidal energy development from more mature lower cost, renewable energy sources, such as offshore wind, but also existing sources of oil and gas based energy.
- Alternative energy companies are creating more of a demand for renewably sourced energy, which could be a driver for the development of tidal energy.
- As with wave and OSW energy, capital costs for tidal energy are currently high and expected to remain so; progression of the sector will require private investment (Renewable UK, 2013; Energy and Climate Change Committee, 2012).
- For the most part, tidal energy technologies (such as device designs) are patented, which could be a challenge for new companies to enter the market (e.g. the Tidal Energy Ltd DeltaStream model has four patents including Predictive Control, Rock Foot, Tidal Flow Structure (Main Base Frame) and Thrust Control (Tidal Energy Ltd, 2014)).
- It should be noted that as with other areas of renewable energy, cost reduction is a key driver in progressing the sector to a commercial status – costs will be influenced by, among other things, distance to the grid, further adding to the argument for improved access to the national grid infrastructure for both England and France.

Market Size

Table 20 illustrates the number of tidal energy demonstration sites and planned projects found from the database. The following equations illustrate how the market size was estimated:

Market size = number of planned projects X estimated average CAPEX costs.

Market size = number of demonstration sites x estimated average CAPEX costs.

The estimated average CAPEX price of a planned tidal energy (stream, shallow) is £3,220,000/MW (Ernst & Young, 2010). Whereas the estimated average CAPEX price of a tidal energy stream demonstration site is £4,292,000 (Ernest & Young, 2010). Costs for tidal stream in shallow waters based energy technology, which is deployed at less than 50 metres deep were used as it is expected that this type of technology will develop at a faster rate than that of deeper tidal stream devices (Ernst & Young, 2010).

Region	Demonstration sites	Planned sites
UK	39	15
France	17	1
Rest of Europe	51	2
Rest of the World	33	13

Table 20: Number of tidal energy demonstration site and planned projects.

Table 20 illustrates that there are more tidal energy demonstration sites than planned sites for each region. It could be suggested that this is a reflection of the current state of the technology which is not yet fully matured.

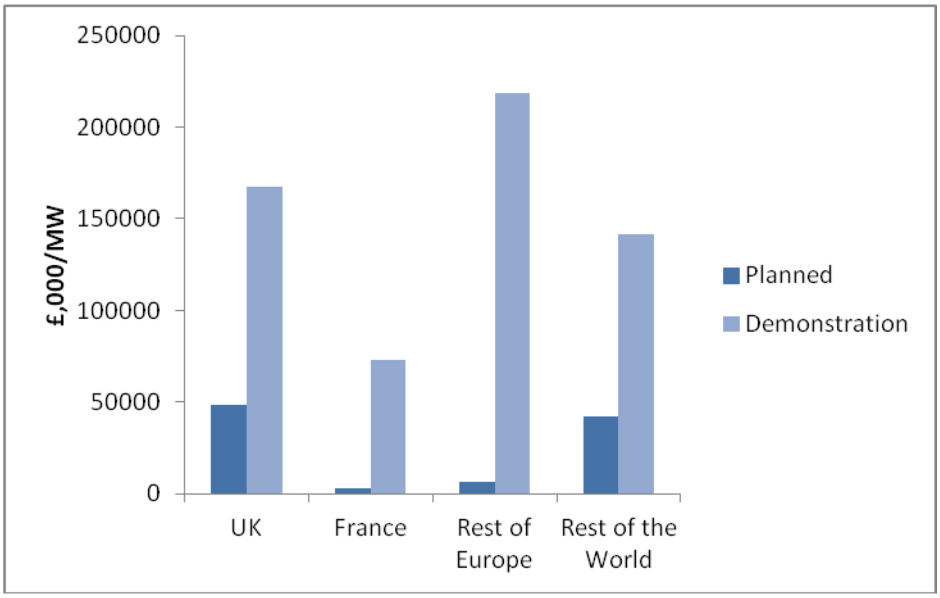


Figure 15: Market size for planned projects and demonstration sites.

Figure 15 shows that the UK currently has the greatest CAPEX market potential for planned tidal energy projects. Additionally, the rest of Europe has the greatest CAPEX market potential for demonstration sites. Ernst & Young (2010) estimated that by 2030 tidal energy cumulative of 1000MW will be deployed in the UK.

Key Challenges

Most tidal energy projects are in the concept, early development and/or demonstration stages, and as such, a number of key challenges are present that could affect an SMEs accessibility and engagement into the industry (outlined in Table 21). It should be noted that most challenges identified are tier 1 issues but could have a consequent effect on the wider supply chain.

Technical	Financial	Commercial	Legal	Social
Predictability – a greater understanding of the effects of turbulence on component life fatigue is required (SI Ocean, 2014).	Reduction in cost of energy (SI Ocean, 2012 and SI Ocean, 2014) including capital costs, operating costs and annual energy production.	Delays to grid connection due to location and high grid costs could have a negative impact on the tidal energy industry (RenewableUK, 2013).	Marine Conservation Zones could limit the area available for MRE sectors. (Department of Energy and Climate Change, 2011).	Public and marine user's perceptions are of growing importance. Emphasis needs to be placed on the value of social science research (Kerr *et al*., 2013).
Manufacturability – the design of devices will be important for creating opportunities for ease of access for installation and operation and maintenance (SI Ocean, 2012).	High capital cost of tidal energy could affect an SME from entering the tidal energy industry.	Grid costs for marine energy be higher (per MWh) than that of an onshore wind site (RenewableUK, 2013).	Engaging with the Marine spatial planning process.	Lack of skilled individuals for the tidal energy sector (Energy and Climate Change Committee, 2012).
Installability – the main challenge of installability is the process that can be carried out quickly and economically. Current tidal installation techniques are financially intensive (SI Ocean, 2012).	SMEs have limited financial resources, which could affect their projects moving from demonstration to commercial deployment (Department of energy and Climate Change, 2011).	Delayed and costly installation and maintenance due to tidal races and limited vessels.	Unclear which licences are required for testing and deployment due to the unknown environmental impact of ocean energy parks (SI Ocean, 2014).	
Operability - tidal energy convertors still need to be tested in highly intensive sea states (SI Ocean, 2012).		Need for an effective commercialisation strategy.		
Survivability – tidal energy convertors require increased over engineering to be able to survive storms and exceptional operational loads (SI Ocean, 2012).				
Reliability – the challenge of long term reliable operation is a requirement for tidal energy developers (SI Ocean, 2014).				
Affordability –reduction				

in costs to become competitive with other renewable energy sources (SI Ocean, 2014), as well as affordable installation vessels and techniques (SI Ocean, 2012).				

Table 21: Key challenges facing SMES within the tidal energy sector.

Potential Players and Moving Forward in Tidal Energy

As suggested above, as tidal energy continues to develop as a sector, there could be viable future opportunities for SMEs in the Channel region. Analysis of the database showed a number of businesses that could potentially engage in the tidal energy industry, within tidal device design/ construction and foundation work (presented in Table 22). However, other opportunities could arise for SMEs in the tidal energy industry during other stages of the lifecycle: including the project development, operations and maintenance, and installation and commissioning phase. A total of 116 companies have been identified from the MRE business supply chain, which represents 2.55% from a possible 4548 companies. This low number of businesses suggests there is a genuine gap in current SME activity within this area, and could be a future opportunity as the sector continues to progress.

Region	Tidal device (957)	Foundation works (958)
Basse Normandie	0	0
Bretagne	3	12
Cornwall	4	5
Devon	1	1
Dorset	0	0
East Sussex	2	1
Essex	17	7
Hampshire	1	0
Haute Normandie	1	0
Isle of Wight	0	0
Kent	9	9
Nord Pas de Calais	0	0
Norfolk	6	3
Other	13	9
Suffolk	7	2
West Sussex	2	1
Not classified	0	1
Total	**66**	**50**

Table 22: Businesses that could potentially engage in the tidal energy industry across the Channel region.

6.1.3. Case Study THREE: Surveying

An early requirement for MRE developers is to assess the environmental, economic and social impact that developments could have on the affected areas and regions, through surveys which take place during the feasibility/ pre-construction phase. These surveys were identified as an area of opportunity for SMEs during an expert workshop organised through the Channel MOR project. This is supported by a recent publication that identified geological surveying, human activities and feasibility assessment as areas that are not easily available to MRE developers (MERiFIC, 2013). Key observations about this potential new space for SMEs include:

- MRE projects require multiple surveys, including coastal processes, geological surveying, environmental assessment, human activity assessment, resource evaluation, feasibility studies.
- UK is a market leader for OSW with large companies including Fugro Gardline (BVG Associates, 2014) – skills and knowledge could be applied to tidal and wave sectors, limiting access to new markets. Further to this, the UK's shipyards are also well placed and equipped to modify vessels if necessary (BVG Associates, 2014); services which would be provided across the Channel region for all MRE developments.
- There are also possibilities for synergies and knowledge exchange from the oil and gas sector, meaning SMEs with experience in these areas could apply their skills to the MRE sector.
- SMEs may be negatively impacted by the larger companies already operating within the surveying field as they may be able to offer more competitive prices and tenders; this adds to the risk for SMEs as already discussed in previous sections.
- New opportunities associated with the growing emphasis on social acceptability of MRE technologies (Kerr, 2014): economic impacts, wealth distribution, community benefits, knowledge and communication flow, consultation, risk and uncertainty, marine planning and public perceptions to MRE are all future areas requiring more research.

Market Size

Surveys take place during the development and consenting phase of marine renewable energy projects. Four survey types were included to estimate the market size for offshore wind energy farms, including: environmental surveys, met station surveys, sea bed surveys and human impact studies (see Table 23 for further detail).

Survey type	Components	Average cost (for a typical 500MW wind farm)
Environmental surveys	Benthic, Pelagic, Ornithological, Sea mammals, Ornithological & mammal survey craft, and Onshore environmental survey	£4million
Met station surveys	Met station structure, Met station sensors, Met Station auxiliary systems	£5million
Sea bed surveys	Geophysical surveys & vessels, and Geotechnical surveys	£9million
Human Impact studies	Visual assessments, noise assessments, socio-economic studies	£100k

Table 23: Survey types and their average cost for a 500MW wind farm.

The following equation illustrates how the market size for wind energy was estimated:

Market size = Size potential power generated (MW) per region / example wind farm size (500MW) x average cost of surveys (£18,100,000).

Region	Number of planned projects	Potential Size (MWs)	Estimated market size (£)
UK	20	23175.4	838,949,480
France	1	(Unknown)	
Rest of Europe	103	35190.4	1,273,892,480
Rest of the World	29	5022.551	181,816,346.2

Table 24: Estimated market size for planned offshore wind energy projects.

The estimated market size figures in Table 24 suggest that there is a good economic potential for offshore wind surveys, especially in Europe. This could also be a positive indicator for SMEs aiming to access the survey market.

The average estimated cost of the development and consenting phase for wave and tidal energy projects is £10million per project (The Crown Estate, 2011). The Crown Estate (2011) suggested that development and consenting costs do not change significantly in relation to total capacity installed. Estimated costs for surveys of wave and tidal projects are only available for environmental (£2million) and met station surveys (£1million) (The Crown Estate, 2011). Therefore, this market size estimation will use the overall development and consenting cost to estimate the market size. The following equation illustrates how the market size for wave and tidal energy was estimated:

Market size = number of planned projects x average cost of development and consenting phase (£10,000,000).

Table 25 shows that there is economic potential for survey services in the wave and tidal energy industry.

Region	Number of planned wave projects	Estimated market size (£)	Number of tidal planned projects	Estimated market size (£)
UK	9	90,000,000	15	150,000,000
France	3	30,000,000	1	10,000,000
Rest of Europe	6	60,000,000	2	20,000,000
Rest of the World	2	20,000,000	13	130,000,000

Table 25: Estimated market size for planned wave and tidal energy projects.

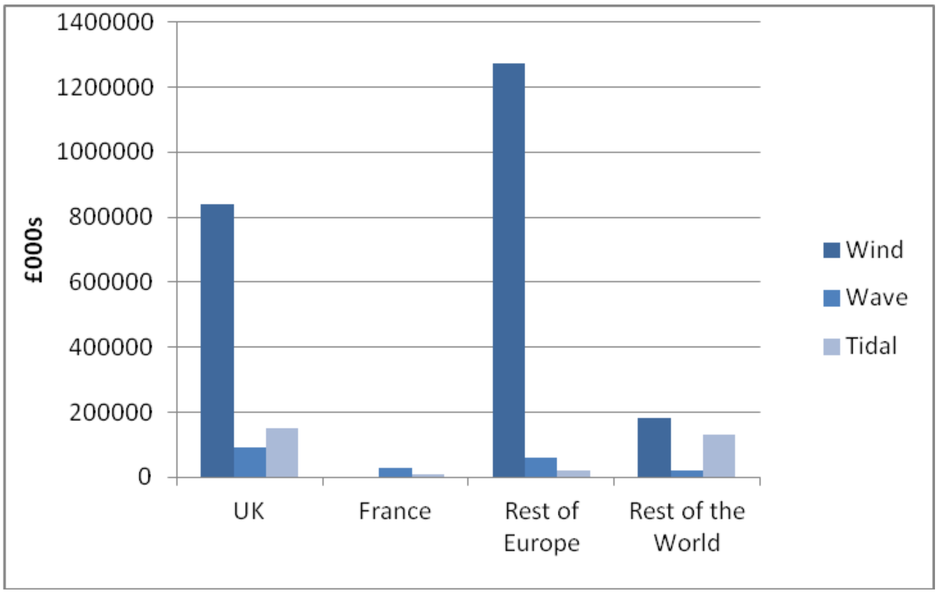


Figure 16: Estimated survey market size for wind, wave and tidal energy developments.

<u>Key Challenges</u>

Surveys are an integral part of the feasibility phase as MRE developments in France and the UK would not gain permission without this service. However, there could be key challenges that could stop a SME from pursuing the opportunities with this new space. This section will highlight the key financial, commercial and social challenges that a SME could face if they were providing, or had the ability to provide, survey work to the MRE industry. There was no evidence to suggest that there are any challenges associated with expertise in this field.

Technical	Financial	Commercial	Legal	Social
No clear technical challenges were identified.	The data acquisition process could cost 20% to 25% more for tidal energy surveys than compared to offshore wind (MERiFIC, 2013), meaning while there is an opportunity for SMEs, it may require costly investment.	There is a concern that public opposition could be an obstacle for the commercialisation of MRE projects (Kerr *et al.*, 2014). Need to identify the economic, social and cultural impact of MRE	The surveys themselves act as an assessment of the developments' adherence to national and international legislation and guidance.	Historically, social science has been of limited importance to MRE development. However, emphasis on the value of this is growing, with social acceptability identified as a future area for MRE development.
		Important to ensure that SMEs are aware of all survey opportunities required.		

Table 26: Challenges facing SMEs aiming to enter the MRE sector through surveying related activity codes.

<u>Potential Players and Moving Forward in Surveying for MRE</u>

Analysis of the MRE lifecycle identified 36 activity codes related to survey work (see Table 27) representing 5.1% of MRE activities. However, this represents just 0.2% of the lifetime cost for a wind farm development, and it is likely that similar costs would be applicable for wave and tidal energy. The activities required for survey work are diverse, and if the potential business value to SMEs is to be realised, it should be a priority to ensure that SMEs are aware of all opportunities associated with this component of the MRE development process.

Activity code	Short Description	Number of companies	Parent ID
100	**Environmental survey**	**92**	**470***
503	Archaeological desk-based assessment (onshore)	3	100
102	Benthic environmental survey	10	100
103	Benthic environmental survey craft	1	102
104	Laboratory analysis	3	102
521	Contaminated Land Assessment	14	100
522	Contaminated Land Assessment - Intrusive Surveys	3	100
524	Chemical Analysis	1	522
525	Drilling and Sampling	5	522
101	Environmental survey management	17	100
528	Tree Surveys and Arboricultural Implication Assessment	10	100
526	Flood Risk Assessment	13	100
501	Marine Archaeology Study (offshore)	1	100
110	Marine mammal environmental survey	11	100
111	Sea mammal environmental survey craft	3	110
112	Onshore environmental survey	20	100

107	Ornithological environmental survey	17	100
109	Aircraft for aerial survey	2	107
108	Ornithological environmental survey craft	3	107
105	Pelagic environmental survey	6	100
106	Pelagic environmental survey craft	1	105
519	Underwater Noise Impact Assessment	9	100
155	**Geophysical surveys**	**36**	**470***
156	Geophysical survey vessels	7	155
157	**Geotechnical surveys**	**34**	**470***
158	Geotechnical survey vessels	7	157
920	Laboratory Analysis	2	157
165	**Human impact studies**	**6**	**470***
517	Aviation Impact Studies	2	165
520	Commercial Fisheries Assessment	3	165
471	Maritime Traffic Surveys and Navigation Risk Assessment	9	165
472	Onshore Fishery Liaison	37	165
504	Seascape and landscape visual impact assessment	5	165
921	Socio Economic Studies	1	165
507	Traffic impact assessment	9	165
117	**Met station surveys**	**15**	**470***

* Number 470 represents the Project Management phase in the MRE supply chain activity list.

Table 27: Number of companies that provide a type of survey service identified in the Channel/ Le Manche region.

It should be noted that, although 418 entries have been identified as survey related activity, this does not represent 418 individual businesses as some companies may be able to offer multiple services. Furthermore, the MRE supply chain database is not an exhaustive list and it is expected that the number of companies active in this sector is higher, with information expected to increase following the launch of the Channel MOR Energy portal. Despite the perceived high competition and the threat of large companies dominating the market, this report suggests that there are opportunities for SMEs within this sector of the MRE development process. For example, SMEs with local knowledge could have enhanced value and advantage for the environmental impact assessment (BVG Associates, 2014). SMEs may also have an advantage due to their ease of access to local staff and vessels required to complete the EIA (BVG Associates, 2014).

Additionally, a recent study has stated that there is a need to understand the economic, social and cultural impact of MRE technologies and developments (Kerr *et al.*, 2014). This statement is supported by the fact that human activities and feasibility assessments were identified as services that MRE developers struggle to access (MERiFIC, 2013). Ideally these issues need to be addressed by policy makers to ensure that a comprehensive environmental, economic and social understanding of MRE projects is covered during the project management phase, identifying a relatively under-exploited business area within the MRE development process.

6.1.4. CASE STUDY FOUR: Condition Monitoring

While OSW is a developed energy technology in comparison to wave and tidal energy projects, all MRE installations and devices are relatively young, and therefore require on-going monitoring and maintenance to ensure high levels of energy generation and disrupted operation. There are many opportunities for SMEs to engage in the MRE sector (MERiFIC, 2013), with condition monitoring identified as a new space through expert consultation. Most literature available on condition monitoring and MRE has focused on the wind energy industry, with limited evidence available for wave and tidal energy installations. Therefore, this case study will predominantly reference the wind energy industry and offer suggestions for condition monitoring in the wave and tidal industry.

A condition monitoring system (CMS) plays a critical role in increasing the efficiency of MRE devices by reducing downtime (Hameed, Ahn, and Cho, 2010). Furthermore, it has been suggested that a condition monitoring system could work in parallel with scheduled and corrective maintenance (Hameed *et al*., 2010), as faults can be detected while components are operational (Garcia Marquez, Tobias, Perez and Papaelias, 2012).There are many techniques to monitor the condition of MRE devices. Examples from the wind energy industry include vibration analysis, acoustic emission, ultrasonic testing techniques, oil analysis, strain measurement, electrical effects, shock pulse method, process parameters, performance monitoring, radiographic inspections and thermography (Garcia Marquez, *et al*., 2012). Key points regarding this new opportunity for SMEs in the Channel region include:

- CMSs are already fitted to the majority of large wind turbines in Europe (Yang *et al*., 2014) so the market opportunities may be bigger for SMEs in the developing wave and tidal energy sectors, although there may be some opportunities for engagement with the OSW sector as there is no consensus on standards for design and deployment.

- Two types of wind turbine CMSs are available, which are Supervisory Control and Data Acquisition (SCADA) and the second is a purpose designed CMS specifically for wind turbines (Yang, Tavner, Crabtree and Fen, 2014) meaning opportunity for SME entry to the OSW market may be limited.

- There are 4 UK and 2 French companies that providing commercially available CMSs for wind turbines. (Crabtree *et al*., 2014). However, there have been concerns expressed that UK suppliers are not delivering components to an acceptable standard/level, resulting in manufacturers importing components from abroad (Professional Engineering, 2014).

Market Size

This section will estimate the market size for wind turbine condition monitoring systems. It has been suggested that wind turbine condition monitoring system costs are generally less than £5,000 per unit (Yang *et al.*, 2014). Therefore, this market size will use £5,000 as a baseline for the average cost of a wind turbine condition monitoring system, although it should be noted that these costs could change with technology developments.

The following equation illustrates how the market size for condition monitoring systems was estimated:

Market size = number of turbines for planned wind energy projects x average cost of wind turbine condition monitoring system (£5,000).

Region	Number of turbines	Estimated market size
UK	1904	9,520,000
France	1	5,000
Rest of Europe	5833	29,165,000
Rest of the World	544	2,720,000

Table 28: Estimated market size for wind turbine condition monitoring systems.

Table 28 suggests that Europe offers the greatest economic potential for manufacturers/suppliers of condition monitoring systems. However, it is important to note that these estimations are not inclusive of all known wind energy developments. Therefore it could be suggested that these figures should increase.

Key Challenges

The main roles of condition monitoring systems in MRE devices are to reduce downtime and costs, and to increase reliability and availability. This section will highlight the key technical, financial, commercial and social challenges that condition monitoring could face (presented in Table 29).

Technical	Financial	Commercial	Legal	Social
New patented technologies, such as condition-based turbine health monitoring systems (Crabtree *et al.*, 2014), which could lead the way forward in CMS's.	Data confidentiality has also led to a lack of publicly available cost justification for development of CMS systems (Crabtree *et al.*, 2014).	Two types of commercially available wind turbine CMSs: SCADA and CMS.	CMS could help developers to ensure they are consistently meeting national and international legislation/ objectives.	Not applicable.

A condition-based health turbine monitoring system combines diagnostic and prognostic software that enables identification of both source and cause of fault (Crabtree *et al.*, 2014).	Current wind turbine CMSs prices vary but are generally less than £5000 per unit (Yang *et al.*, 2014).	EMEC is seen as a world leader for testing marine energy technologies and uses a SCADA tool to monitor the health of the devices.		
New CMSs need to be universal, applicable to the MRE technologies and capable of detecting mechanical and electrical faults (Yang *et al.*, 2014)	Future CMSs may need to be more cost-effective (Yang *et al.*, 2014), especially if MREs are deployed on a large scale.			
Future CMS's need to be more reliable, especially due to the offshore environment (Yang *et al.*, 2014).				
Interpretation complexity of wind turbine CMSs has discouraged wind turbine operators from making wider use of them (Yang *et al.*, 2014).				
Data confidentiality could be a major hindrance in the development of CMSs (Crabtree *et al.*, 2014).				
The main focus of condition monitoring in wind turbines is on gearboxes, generators and bearings. However, key sub-assemblies, such as the electrical and power electronic systems and yaw and pitch systems, suffer more problems and require greater monitoring to reduce long downtimes (Yang *et al.*, 2014).				
Wave and tidal CMSs could encounter greater technical challenges than offshore wind as the devices will face harsher conditions and				

constantly changing loads that could lead to intense mechanical stress.				

Table 29: Summary of the key challenges facing SMEs entering the MRE market in the field of condition monitoring.

Potential Players and Moving Forward

Tables 30-32 illustrate that there is a limited number of SMEs in the current business supply chain database that have the ability to provide condition monitoring products and services to the MRE industry in the Channel region. This is an opportunity for SMEs interested in entering the MRE market, and it could be an area that increases in activity as the sector continues to develop. In particular, the wave and tidal industry is the area which could offer the greatest opportunities for SMEs. There could be a demand to increase the reliability and efficiency of wave and tidal devices if there is an increase in the deployment in MRE. Purpose built condition monitoring systems in wave and tidal devices could support the advancement of these developing technologies.

Company Name	Location (County)
C-Sense	Bretagne
Imtax Control Limited	Kent
BS Rotor Technic UK Limited	West Sussex
Moog Insensys Ltd	Hampshire

Table 30: List of potential suppliers of control monitoring systems within the Channel region.

Company Name	Location (County)
BS Rotor Technic UK Limited	West Sussex
Red 7 Marine	Norfolk
Omnisens	Kent
Osiris Marine Services Ltd	Other (Yorkshire)
Vestas Offshore UK Ltd	Other (Warrington)
Moog Insensys Ltd	Hampshire

Table 31: List of potential Condition monitoring system maintainers in the Channel region.

Company Name	Location (County)
A & P Falmouth	Cornwall
BS Rotor Technic UK Ltd	West Sussex
CWIND	Essex
Dieppe Navals	Haute Normandie
Eriks UK	Kent
Eticq	Haute Normandie
Express Rewinds	Norfolk
Eyre Electrical	Norfolk

GEV Offshore Limited	Norfolk
3 SUN Group	Norfolk
Herbosch-Kierre Marine Contractors	Other (London)
Intertek METOC	West Sussex
Larssen Engineering	Essex
LEC Marine (Kylne Ltd)	Suffolk
Osiris Marine Services Ltd	Other (Yorkshire)
Red 7 Marine	Norfolk
Site operative Solutions	Essex

Table 32: List of skilled technicians for the operation and maintenance phase currently operating within the Channel region

6.1.5. CASE STUDY FIVE – Electrical Connectors: Wet Connectors

The final area highlighted as a new space and opportunity for the MRE industry is electrical connectors, which are vital for the electrical connection phase of development. Electrical connection, which is also referred to as grid connection, is present during the planning, design, manufacture, installation and operation phases of MRE and makes up 5% of the lifetime costs, for wave and tidal energy (SI Ocean, 2013).

Improvements and advancements of electrical connection are perceived as highly important for the sustainable growth of the MRE industry. A key advancement, especially as wave and tidal energy projects move from developing prototypes to full-scale devices, is a reduction in the cost of installation and the cost of energy produced by marine devices. Wet-mate connectors have been identified as a possible area of cost reduction (SI Ocean, 2012, SI Ocean, 2013, Carbon Trust, 2011 and Wood Group Kenney, 2014). The benefits of wet mate connectors are that the systems have the ability to remove the cable or device underwater without the need to lift significant length of cable. Furthermore, the deployment of wet mate connectors could result in a reduction in offshore vessel requirements. This case study will focus specifically on wet connectors, and will provide information for SMEs that have the ability, or have the potential, to support the electrical connection phase in the MRE industry. Initial observations about electrical connectors as a new opportunity for SMEs within the Channel region are:

- In particular, companies with existing experience from the oil and gas industry are well placed to supply the marine renewable energy industry within this activity (Wood Group Kenny, 2014).

- Electrical connection for OSW is established, which could limit the opportunities for SMEs to produce or support this action (HM Government, 2013). However, as the wave and tidal energy sectors continue to grow, there will be opportunities to supply wet connectors.

- Wood Group Kenny’s (2014) market study identified 9 companies: Deutsch, Hydro Group, GE Oil and Gas, MacArtney, POWERSEA, RMSpumptools, SEA CON Group, Siemens, Teledyne ODI.
- Current technologies associated with wet connection are very expensive, so new options need to be examined to reduce costs, suggesting there is an opportunity for new design and innovation within this field.

Market Size

As this case study has focused on the wet connector element of electrical connections, which are not required for OSW, the market size has been calculated using only information for the wave and tidal energy sectors. The calculations have suggested that one wet mate connector will be required for each device. According to a global marine renewable energy database there is only one planned tidal energy project in the Arc Manche region (Marenergie/Sabella in Brittany, France). Table 33 includes all planned tidal energy projects for France and the UK where number of devices is known.

Tidal project name	Location	Number of Devices
Marenergie / Sabella	Brittany, France	5
Kyle Rhea	between Isle of Skye and west coast of Scotland, Scotland	4
Brough Ness	Broughness, South Ronaldsay, Orkney, Scotland	66
Esk Estuary	Montrose, Scotland	15
Ramsey Sound, near St David's Head	Pembrokeshire, Wales	8
St David's Head	Pembrokeshire, Wales	9
Westray South	Westray Firth, Orkney, Scotland	200

Table 33: Planned tidal energy projects and their number of device in the UK and France.

Similarly to tidal energy projects, the only wave energy project identified from the global marine renewable energy database that is planned in the Arc Manche region is from Brittany, France. However, their number of devices is not known. Table 34 includes all the wave projects in the UK and France that the number of devices is known.

Wave project name	Location	Number of Devices
Brittany Wave Energy Project	Brittany	
Marine Harvest Albatern Test Site	Isle of Muck, Scotland	6
Farr Point	Off the Sutherland coast, by Bettyhill , Scotland	10
Marwick Head	West Coast of Orkney, Scotland	66
West Orkney South	West coast of mainland Orkney, Scotland	79
Shetland Wave Farm	South West Shetland, near St Ninian's Isle, Scotland	12

Table 34: Planned wave energy projects and their number of devices in the UK and France.

For the purpose of this market size section wet mate connector costs represent the recently developed MacArtney 11KV (7.6MW) wet-mate connector, which costs an estimated £250,000 (excluding termination work) (Wood Group Kenny, 2014). It should be noted that other planned wave and tidal projects exist but information about number of devices were not available so it is expected that market size for this activity will grow.

Region	Wave	Tidal
UK	44,000,000	78,000,000
France	250,000	1,250,000
Rest of Europe	250,000	0
Rest of the World	7,000,000	84,750,000

Table 35: Market size for wet mate connectors in the wave and tidal energy industry.

It can be suggested, from Table 35 and Figure 17, that the tidal energy industry offers the greatest potential for suppliers/producers of wet mate connectors. It can also be assumed that the UK is the clear market leader with regards to wave energy. SMEs that have the potential to manufacture or supply wet mate connectors in the Arc Manche region could take advantage of the UK’s future wave and tidal energy plans.

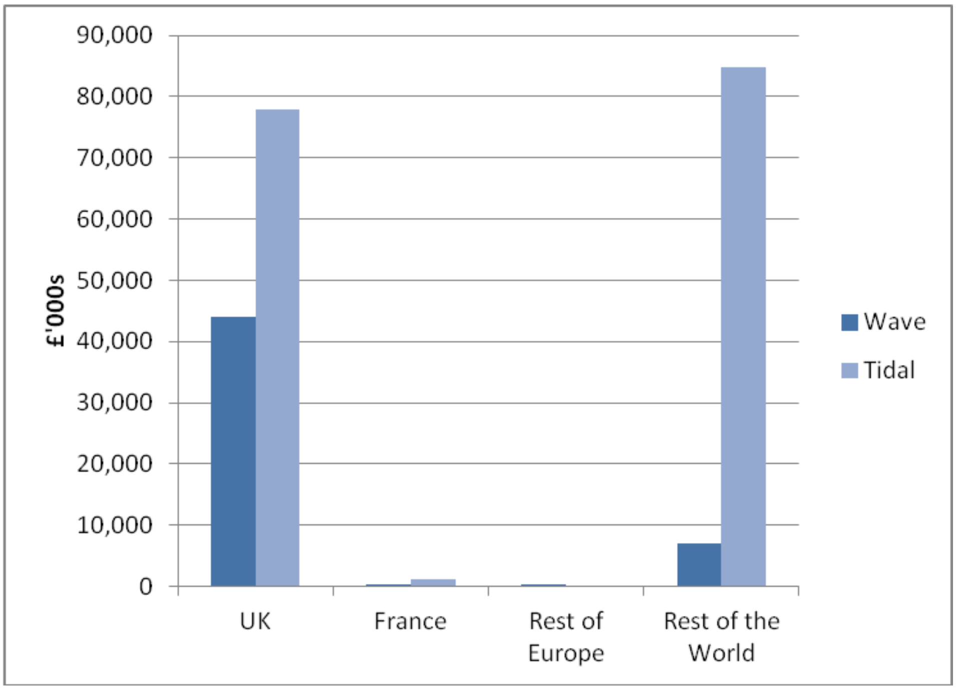


Figure 17: Market sizes for the UK, France, Europe and Global opportunities based on planned wave and tidal energy developments.

As with each of the potential opportunities for SME engagement with the MRE sector, there are a number of possible challenges that may influence activity – these are summarised in Table 34.

Technical	Financial	Commercial	Legal	Social
The following points are the most common failure modes for a wet mate connector: Corrosion, Elastomer degradation, Damage, Premature unlatching, Seal failure, and inadequate long-term protection (Wood Group Kenny, 2014).	Electrical, grid, connection costs for wave and tidal energy could be very high due to location (Renewable Energy UK, 2013). Costs could be ten times higher than that of onshore wind energy (Renewable Energy UK, 2013).	Delays to grid connection for wave and tidal energy are high impacting project deployment (Renewable Energy UK, 2013)	Risk of environmental damage and ecosystem degradation through the laying of undersea cables – impact would need to be assessed prior to installation.	Need for an appropriately skilled and trained workforce
High tidal velocities and scoured sea beds could create challenges for the electrical connection of wave and tidal energy (Carbon Trust, 2011).	Connection charges vary between different countries and also between different networks[22] (Dalton, 2009).	Grid availability is a potential barrier to large scale deployment of marine renewables (Energy and Climate Change Committee, 2012).		Risk of damage to the marine environment through the laying of undersea cables
Specialised substations will need to be designed	High financial commitments for	Wet-mate connectors will be		

[22] There are two connection charges methods, which are 'deep connection' and 'shallow connection' (Dalton, 2009). For a deep connection method the developer pays for the majority of the electrical connection and maintenance costs (Dalton, 2009). Whereas shallow connection charges are financially supported by a government or network and the developer pays for the on-going cost of connection to the network (Dalton, 2009).

for wave and tidal arrays. Additionally, tidal and wave energy convertors are to be transportable then simple connection and disconnection methods are required (SI Ocean, 2012).	developers to sign before consents and planning is in place (Renewable Energy UK, 2013) could result in delays or cancellations of wave and tidal energy projects (Renewable Energy UK, 2013).	more expensive than dry-mate connectors (Wood Group Kenny, 2014)[23].		
Wood Group Kenny's (2014) market study suggests that there is wide range of mating and de-mating operations for connectors, ranging from 50 and an unlimited amount, although there is a concern that this will ultimately require replacement.		Connector costs could also vary depending on the size of the purchase order. For example, SEA CON could offer a 15% discount for orders of large quantities. This type of competitive activity may not be possible for SMEs.		
Research is required to establish potential impact of marine growth on connector materials.				

Table 34: Summary of the key challenges associated with SME engagement with electrical connectors supply for MRE devices and installations

Potential Players and Moving Forward

Analysis of the business supply chain database with 4548 entries found that there was currently no activity code for wet mate based connector activity. Therefore, no businesses were identified that could provide wet mate connector services in the Arc Manche region. However, desk based research has identified a company from the Wood Group Kenny (2014) market study that could provide this wet mate connectors in West Sussex called Teledyne ODI. The lack of activity code for this process in the MRE lifecycle supports the identification of this activity as a new opportunity for the MRE sector and SMEs within the Channel region. SMEs with related experience and knowledge could exploit the gap in the market, transferring their skills to the development of electrical connectors. There are a number of large global companies, such as Siemens and MacArtney, which offer commercial available wet mate connectors or have products that are under development, suggesting that the competition for business is high for wet mate connectors.

[23] For example, estimated cost POWERSEA for the 20kV connector is £120,000 (this connector comes with a £6000 a day for the installation tool) compared to £250,000 for an 11kV connector (excluding termination work) from MacArtney. POWRESEA have been able to reduce connector costs by implementing a specific tool for the installation.

6.2. Capacity Gap Analysis and Tier One Analysis

In addition to the case studies, the project aimed to evaluate the gaps in SME capacity to engage with the MRE sector based on the activities undertaken across all five tiers of the MRE lifecycle. Analysis of the business supply chain database developed through the Channel MOR project found that there are only 69 activity codes which do not have evidence of SME current or potential capacity for engagement (representing 9.8% of total activity codes). Therefore the evidence suggests that French and English businesses in the Arc Manche region are well positioned to engage within the MRE industry. Table 35 below identifies gaps in the marine renewable energy industry supply chain based on current capacity within each activity code. Analysis of the business supply chain and current business capacity within the Channel region (from the data available) highlighted a small number of genuine gaps in capacity, with the rows highlighted in green representing activities that could be potential new spaces (opportunities) for SMEs.

Supply Chain Activity Code	Short Description	Reason
14	Tuned damper	Tier 2. Non specialist
22	Support Structure	Linked to Tuned damper (No.14)
23	Liquid container.	Linked to Tuned damper (No.14)
24	Damping liquid	Linked to Tuned damper (No.14)
26	Power take off	Linked to towers (No.1) Redundancy with another code (207)
118	Met station structure	Predominately monopiles. Tier 2. Redundancy with other codes.
119	Met station structure	Predominately monopiles. Tier 3. Redundancy with other codes.
120	Foundation (Met Station)	Redundancy with another code (357).
121	Platform (Met Station)	Redundancy with another code (402).
132	Visibility	Very detailed level 5 activity.
137	Bird Radar	Very detailed level 4 activity.
138	Hydrophones	Very detailed level 4 activity.
148	Illumination number panel	Redundancy with another code (953).
150	Telemetry	Redundancy with another code (955).
171	Sg iron casting or fabricated steel	Redundancy with another code.
173	Metal sprayed	Redundancy with another code (311).
180	Forged rolled ring	Very detailed level 3 activity.
183	Rolling element (spherical, crowned, cylindrical/tapered)	Very detailed level 3 activity.
184	Rolling element support	Very detailed level 3 activity.
187	Sg iron bearing housing	Very detailed level 3 activity.
189	Forged shaft	Very detailed level 3 activity & redundancy with other fabrication

		code.
194	Sg iron castings	Redundancy with other codes.
199	Castings.	Very detailed level 3 activity.
200	Windings.	Very detailed level 3 activity.
202	Lubrication - insulating	Redundancy with other codes.
204	Slip rings for DFIG generators	Very detailed level 3 activity.
205	High-speed shaft coupling	Very detailed level 3 activity.
216	Safety and emergency systems.	Tier 3. Speed and vibration sensors are necessary
218	Yaw motors and gearboxes	Very detailed, refer to Yaw system (217)
220	Yaw brakes.	Very detailed, refer to Yaw system (217)
223	Forged rings, machined, hardened and surface finished.	Redundancy to other codes.
226	Balls	Very detailed refer to Yaw bearing (222)
233	Anemometry	Very detailed. Refer to Nacelle auxiliary systems (229). Also redundancy to other code, such as Wind speed (127).
244	Drip trays	Very detailed. Refer to small engineering components (241)
245	Other fixed maintenance aids	Very detailed. Refer to small engineering components (241)
259	Glass fibre, in mat and/or prepreg form.	Very detailed. Refer to Structural composite materials (258).
260	Carbon fibre (in some cases; generally in prepreg form).	Very detailed. Refer to Structural composite materials (258).
262	Adhesive.	Very detailed. Refer to Structural composite materials (258).
263	Closed-cell foam or balsa bulk fill.	Very detailed. Refer to Structural composite materials (258).
271	Data capture	Very detailed level 4. Refer to Lightning protection (268)
272	Aviation lights	Very detailed and redundancy to other codes. Refer to Blades (257).
276	Castings.	Very detailed. Refer to Hub Casting (275).
281	Forged rings, machined, hardened and surface finished.	Very detailed. Refer to Blade bearings (280).
282	Balls	Very detailed. Refer to Blade bearings (280).
287	Power pack.	Very detailed. Refer to Hydraulic pitch system (286).
289	Rotating union.	Very detailed. Refer to Hydraulic pitch system (286).

290	Manifold blocks	Very detailed. Refer to Hydraulic pitch system (286).
291	Accumulators	Very detailed. Refer to Hydraulic pitch system (286).
293	Electrical slip rings	Very detailed. Refer to Hydraulic pitch system (286).
303	Fibreglass mouldings.	Very detailed. Refer to Spinner (302).
307	Blade load measurement system	Very detailed. Refer to Rotor auxiliary systems (305).
351	J-tube seals.	Very detailed. See Cable Protection (350).
352	Bend restrictors	Very detailed. See Cable Protection (350).
353	Stiffeners	Very detailed. See Cable Protection (350).
406	Deployment methods	Very detailed. Refer to Scour Protection (403).
427	Control room	Very detailed. Refer to Facilities (412).
444	Transformers	Very detailed. Refer to Electrical Systems (439).
445	Reactive Compensation	Very detailed. Refer to Electrical Systems (439).
468	Transformers	
469	Static VAR Compensators	Very detailed. Refer to Electrical Systems (439).
476	Foundation design (Met Station)	Redundancy due to other codes (880)
477	Foundation Installation (Met Station)	Redundancy due to other codes (575)
478	Foundation manufacture	Redundancy due to other codes (356)
551	Development of Capital and Operating costs budgets	Firms are positioned at a higher level
624	Pin-piles	Redundancy due to other codes (623)
628	Dynamic positioning	Very detailed. Refer to Turbine Installation (580).
629	Propulsion systems	Very detailed. Refer to Turbine Installation (580).
768	Other Rotor Costs	Limited information. Refer to Rotor (168).
770	Landfall Operations	Firms are positioned at a higher level
774	Sealing of duct	Very detailed. Refer to Landfall Operations (770)
835	Tanks + other specialist equipment	Very detailed. Refer to Transport (822).
875	Survey Spread	Very detailed. Refer to Array cable-laying vessel (602).
876	Dive Spread	Very detailed. Refer to Array cable-laying vessel (602).
879	Monopile Foundation	Redundancy due to other codes (357)

892	Grout	Firms are positioned at a higher level
898	Other costs	Limited information. Refer to Scour Protection (887).

Table 35: Analysis of gaps identified in current capacity for engagement with the MRE sector, outlining genuine gaps and the reasons identified for these gaps.

It is worth noting that due to the size of the project region, it is likely that there will always be at least one company that can engage in each activity code. Therefore, the gaps are more around capability and capacity to deliver/ supply, and issues relating to IP and commercial relationship clauses, rather than knowledge/ expertise gaps. The research suggests the key gaps exist in terms of companies' capacity to deliver on an order at short notice; the only regions where those won't exist are those that have had engagement with the oil and gas sector. It is therefore difficult to make recommendations as to how these gaps can be addressed, with SMEs requiring support to deliver rather than knowledge/ skills/ training.

Analysis of the existing capacity relating to the MRE supply chain highlighted the production of tuned dampers as a possible new space for SME, as currently there are no businesses in the region that can work within this activity code[24]. Tuned dampers are also referred to as vibration absorbers or vibration dampers, and are used in wind turbines to reduce low and high frequency vibrations, noise, and impact load from waves and wind.

In terms of Tier 1 capabilities, activity codes were developed using the Product Breakdown structure developed by 4COffshore[25]. However, as this is a hierarchical breakdown of all activities within the MRE lifecycle, it is possible that it does not map effectively to the real world Tier 1 structure used by MRE development. Given this, the Tier 1 activities suggested by Statoil and Dudgeon Offshore Wind Farm (2014) have been used to provide an indication of the current Tier 1 capacity in the Channel region, with number of companies within each category presented in Table 36. It should be noted that the activities listed in the table are parent activities, and also include a number of sub-categories of activities.

[24] It should be noted that although a desk based evaluation of business capacity within the Tuned Dampers activity code was undertaken, this was predominantly focused on the English side of the Channel. It is possible that there may be French companies that have the capacity to engage with this activity code.

[25] Accessible at http://www.4coffshore.com/

Tier One activity	Number of companies with Tier 1 capacity within the Channel region
Device generation (Wind turbine for OSW, OR wave and tidal device development)	188
Subsea export cable	5
Inter array cables	5
Onshore export cables	2
Offshore substation	12
Onshore substation	10
Foundation	80
Civil works	68
Marine logistics	49
Marine installation	25
O&M	16
Decommissioning	0
TOTAL	**460**

Table 36: Current business capacity for engagement within the Tier 1 activities relating to the MRE sector.

As mentioned above, there are currently 460 (just over 10% of companies included within the business supply chain database) companies that have been identified as having the capacity to enter the Tier One supply chain (see Table 3). Analysis of the Tier One activities found that the only real Tier 1 gap is in terms of wind turbine construction for OSW energy in the UK as there are currently no companies operating within this field. However, this is likely to change with the recent amendments to supply chain requirements. A major OSW developer has suggested that UK companies have the potential to supply and tender for between 75% -80% of activity within the supply chain across the whole MRE lifecycle (Grow: Offshore Wind, 2014). Although analysis of the data suggested that English and French companies could provide wind turbine generator and subsea export cables, these activities were identified as one of two major Tier 1 gaps by an industry association (Grow: Offshore Wind, 2014). It should also be noted that currently there are no SMEs identified as having the capacity to engage in the decommissioning phase of MRE technologies – this is an area that will grow in importance as the sector continues to develop and devices/ arrays need to be decommissioned and replaced.

7. OPPORTUNITIES FOR THE CHANNEL'S MRE SECTOR

As with all new and growing sectors, while there are many challenges to success, there are also a number of opportunities for SME involvement in the MRE sector. It is evident through the research that there are a number of key new spaces providing opportunities to SMEs across the Channel region. These have been outlined through the case studies presented above. However, it should be noted that in addition to these new spaces, there are a number of other opportunities for SMEs engaging with the sector.

7.1.1. Market Opportunities

For the sector to continue moving forward, it is important that stable, long term markets are established, supported by sustainable and effective supply chains that include local content (input from SMEs). An evaluation of the current and future market (using Channel MOR databases) has suggested that although there may be limited opportunities in places around the Channel region, international export opportunities for businesses operating within the Channel region should also be considered. Analysis of the data found that the capacity gaps within the Channel region tend to be around delivery capacity (i.e. ability to complete an order without any additional intervention or within a limited time period) rather than knowledge, skills or expertise.

Research conducted by RenewableUK (2013) showed that UK developed wave and tidal energy devices have already been deployed in other countries, including the Bay of Fundy, Canada, off the Portuguese coast and are being used in test site development in India. Clearly, there are opportunities for the export of skills and technology, and SMEs across the Channel region need to be made aware of local, regional and international opportunities available to them as businesses. Indeed, research done by the ORECCA project suggests that in order to meet global energy targets, a number of deployments will take place outside Europe; representing a significant market opportunity for the Channel's MRE sector to export knowledge, expertise and technology.

7.2. Employment Opportunities

As with many sectors, the MRE sector has faced a number of challenges, particularly linked to the economic downturn impacting both the English and French markets (RenewableUK, 2013). However, with recent policy support and an on-going demand for renewable energy production, the MRE sector has the potential to mature across the Channel region. As such, it is expected that as the support for the sector grows, so will the employment opportunities. RenewableUK (2013) predict over 16,000 direct jobs achieved by 2023 (with the potential for many more), with up to 49,000 further indirect jobs projected for the UK. The Channel region is in an optimum position to exploit these employment opportunities, attracting individuals to careers within the MRE sector. A number of projects have evaluated the skills and training facilities currently available within the Channel region to support these future employment opportunities, and this work has been collated through WP 3.1. In addition, it should be noted that the BEEMS project has worked to promote the need for standardisation of qualifications and training requirements across the MRE sector[26]. Standardisation in this way would make it clear to businesses when/ where specific training or qualifications were required and how this could help them to enter specific activities within the MRE lifecycle.

7.3. Supply Chain Development

In order for the sector to continue to develop, opportunities for businesses to engage with the sector need to be identified for SMEs. Evidence from onshore wind energy, and the oil and gas sector shows that successful supply chains can grow alongside the growth of the sector. Therefore it stands to reason that as political and financial support for the sector grows, an effective supply chain will develop simultaneously. Although challenges continue to face the wider MRE sector, research has suggested that there is the potential to build an effective supply chain across southern England and northern France, which can help to support MRE development within the Channel region and further afield. In addition, recent changes to MRE development guidelines have increased the level of local content (% of development supported by the local area/ SMEs) required within the supply chain. This emphasis on local content has the potential to support many smaller companies that have, to date, struggled to enter already established supply chains.

While SMEs and local businesses may not be able to contribute to the major components of the installations or devices (for example, wind turbine blade construction, which was identified as a key gap in Tier 1 activities, particularly for the English side of the Channel region), many businesses are in an optimum geographical position to provide support services, as well as being engaged in operations and maintenance (O&M) (KARIM, 2012). It should also be highlighted that there are opportunities for Channel based companies to export into more international supply chains, in addition to contributing to local content within Channel based MRE installations.

Clearly, opportunities exist for companies that have been associated with the oil and gas industries to transfer their knowledge and expertise to the offshore MRE sector. In addition, research has

[26] For more information on this, please go to the BEEMS project website at http://www.marinerenewableskills-beems.eu/uk/

found that developing effective and more competitive supply chains will be of mutual benefit to developers, suppliers and the customer as it has the potential to reduce costs of technology development and energy generation (The Crown Estate, 2012).

Alongside the work being done through the Channel MOR project to identify opportunities for businesses to enter the supply chain, other initiatives have been put in place across England and France. For example, the UK Trade and Investment provide an end-to-end support service to SMEs aiming to enter the UK supply chain (CORE, 2012). As the MRE market in the UK and France continues to develop, it would be expected that the supply chain will also grow – in order for a sustainable supply chain to form, local input across the Channel region will be vital. With this growth will come different levels of risk, and companies looking to get involved in the MRE sector should be aware of the need to ensure Availability, Reliability and Maintainability (ARM) of their components or services. The ARM model, designed and used by Siemens (Stiesdal and Madsen, 2005), is a clear model for efficiency and reliability that could be used for any component of the MRE supply chains, whether it be offshore wind, wave or tidal. It is possible that this kind of model could be used to support the development of standard components/ design requirements supporting SMEs efforts to enter the market.

7.4. Advancing Technology and Increasing Affordability

Clearly affordability of energy is one of the primary challenges facing progression of the technology. CAPEX costs currently remain high, and are higher than those associated with onshore wind energy; however, it is expected that these costs will continue to decrease as technology advances, and successful devices are manufactured and installed (RenewableUK, 2013). It has also been suggested that in a bid to increase the affordability of advancing MRE technologies, particularly in the wave and tidal energy sector, integration and collaboration across the entire industry should be encouraged. All MRE technologies are based on similar engineering techniques, and there are substantial opportunities for SMEs, currently involved in other sectors, to use their knowledge and skill base to enter the MRE sector (EU-OEA, 2009; Bergmann, et al, 2006). However, it should be noted that even technologies that have already been implemented in offshore energy development will most likely require further optimisation to increase cost effectiveness and energy efficiency.

There are also opportunities for further progression in the development of floating wind energy devices. The MERiFIC project discussed these opportunities and found that current research goals are centred on the design, construction and deployment of demonstration turbines (Bailey et al., 2012). While this technology is still very much in its early stages, it is something that should be considered for the future and could be an option when developing combined platforms or combined technologies. A report produced as part of the MERiFIC project discussed three of the main floating wind projects, highlighting this type of technology as an ideal candidate for cross-border collaboration between England and France (Bailey et al., 2012). Floating technologies are a growing component of OSW on an international scale, and there could be an opportunity for SMEs to engage in this emerging part of the MRE market. In addition, it should be noted that opportunities for research and development have been set out in the EU Strategic Energy Technology Plan (SET-Plan) as a mechanism to stimulate R&D across the low carbon energy sector, which has the potential to include MRE technology development.

7.5. Energy Storage

Development of efficient energy storage devices has the potential to have a positive impact on the functionality of the market. As the MRE sector continues to develop, the challenges of intermittent energy supplies and the need for effective storage will need to be addressed if clean, renewable energy and continuous supply to the customer is to be achieved (Hall, 2008). Energy storage facilities would allow energy to be stored and used at times when generation exceeds demand; for example, high wind output during times of low demand (DECC, 2012).

Currently intermittent supplies and inefficient loads for offshore wind, wave and tidal energies mean that energy production rates are not as high as they could be. For each of the marine energy technologies, there will be times when there will no energy generation. As the % energy generated by these technologies increases, it will be necessary for MRE generators to be able to store energy for release at a later time. Research has suggested that no single storage technology would currently be suitable for the energy generated from MRE (Hall, 2008) – this is a clear gap in the current market, and an opportunity for future development within the MRE sector, and points to the need for national energy strategies supporting on-going development of OSW, wave and tidal energy generation.

7.6. Combined uses, Combined platforms and co-location

Studies have suggested that some of the installations designed for energy generation could have a secondary function as a coastal defence mechanism, with the European funded project, HESEUS, examining the potential opportunities for combining wave energy generators with coastal protection (OES, 2012).

In addition, while the MRE sector is still relatively immature (with the exception of offshore wind technologies), recent projects have suggested that there may be opportunities to co-locate MRE technologies, to ensure as much energy as possible is being generated (Jeffrey and Sedgwick, 2011). It has been suggested that this kind of co-location could result in significant benefits for developers, particularly in terms of infrastructure development and long term O&M of installations. In particular, there would be very real benefits in terms of grid access, as installations would benefit from combined access to the grid infrastructure. Currently efforts are being focused on co-location, rather than combined platforms; however, it is clear this is a space for on-going technology advancement. It is noted that there may be circumstances that mean it is not possible to combine or co-locate technologies as the conditions may not be appropriate for both wind and tidal, for example. However, further R&D could potentially identify solutions to these challenges, resulting in a more efficient MRE sector. The ORECCA project road map suggests that there are a number of generic technology areas that could facilitate collaboration across the MRE sectors, including: foundations, moorings, power take off, grid infrastructure installation, operations and resource assessment, as well as installation and O&M vessels (Jeffrey and Sedgwick, 2011).

7.7. Opportunities for collaboration between SMEs

Although MRE is still a developing sector, there is significant evidence to suggest that there are opportunities for knowledge and skills exchange/ transfer from other industries, such as offshore engineering or the oil and gas industries (Jeffrey and Sedgwick, 2011). If successful supply chains are to continue to develop for the MRE sector, opportunities for local SMEs that may not have historically been connected to the MRE sector should be identified and promoted. By identifying these opportunities, it will be possible to develop cost effective solutions for building effective supply chains across the MRE sector. In particular, local companies, including SMEs, will have a geographical advantage over other companies who may be located further afield, regarding the supply of support services, as well as operations and maintenance activities (Karim, 2012).

Associated with the development of effective supply chains to ensure local content has a place in MRE advancement is the need to identify skills gaps, and provide training and standardised qualifications to ensure a skilled workforce is available to these sectors. This issue will be addressed through the mapping of skills requirements and the MRE supply chain research being conducted through other activities undertaken through the Channel MOR project.

In order to identify where SMEs can fit into the MRE sector, it could be useful to work on identifying priority areas for the sector – work conducted on the ORECCA project highlighted key priority activities across offshore wind, wave and tidal energy technologies. It has also been suggested that furthering the development of the MRE sector across the Channel region could lead to the successful formation of port clusters; groups of local businesses that have the potential to act as manufacturing bases, assembly locations, as well as O&M or service hubs. Formation of clusters of this nature would mean that promoting MRE technologies and developing effective supply chains across the Channel region has significant positive effects for communities and businesses. Previous research done through the CAMIS project identified this type of port centric activity as a significant opportunity for ports across the Channel region (McKinley and Robins, 2013). Developments in Hull suggest that the UK is already working towards the formation of MRE centred port activities (Karim, 2012). It should also be noted that there may be overlaps in the technology development for hydroelectric power generation and tidal energy, and there could be opportunities for SMEs to work together across these sectors.

There are existing projects which have aimed to strengthen the MRE sector across Europe, fostering collaboration between R&D businesses, building effective networks within the sector to support developers and supply chain businesses in overcoming technology, policy and market barriers currently impacting the sector (Henley, 2013). The EU-OEA recommend developing a 'gold standard' for projects across Europe, implying that greater collaboration between the member states can only serve to benefit the MRE sector.

The formation of improved links between businesses operating within the Channel's MRE sector would allow stakeholders to take a more cooperative approach to addressing challenges and developing mutually beneficial solutions that would support a sustainable industry. The Channel MOR portal will be a mechanism through which SMEs and other stakeholders can find out information about developments within the MRE sector, can communicate and collaborate together and identify opportunities to enter the MRE supply chain.

It should also be noted that there may be opportunities for SMES, skills and training organisations and R&D focused companies to collaborate outside the Channel region. For example, the MARINET facility led by University College Cork, Ireland, has facilities to support company testing of innovative devices and new technology designs with no additional costs to the R&D developer. This type of facility could be of use to companies currently operating with the Channel region – the facility is within the EU (so similar standards will apply) and is in a convenient geographical location close to the Channel region. Given that it is likely that testing in the future will focus on innovative concepts and designs around MRE technologies, and it is expected to be a major component of the continuing development of the sector, collaboration in this area would appear to be a sensible option.

7.8. *Other MRE technologies*

While the Channel MOR project focuses on the offshore wind, wave and tidal MRE sectors, it should be noted that there are a number of other marine energy technologies currently in the R&D phase, including thermal gradient energy, salinity gradient energy, solar energy, deep water technologies, as well as further developments into the floating wind capacity. Clearly there is significant potential for marine energy sources to contribute to the call for increased dependence on renewable energy sources. It is possible that as offshore wind, wave and tidal energy matures as a sector, more efforts can be put into developing combined technology strategies that efficiently and sustainably exploit all marine energy sources.

8. CONCLUDING COMMENTS AND RECOMMENDATIONS FOR THE FUTURE OF MRE ACROSS THE CHANNEL REGION

MRE is continually growing as an energy technology, with increasing emphasis on the use of renewable energy for energy security in the future. Key challenges facing the sector focus on a complex, lengthy and costly consent process, perception as a high risk investment for financiers and limiting attractiveness for SMEs, a need to reduce associated costs both for suppliers and customers, and a lack of certainty around social acceptability of MRE and its impact on the overall growth of the sector.

It is evident that there is little difference between the two countries support mechanisms for MRE development, with both operating on a market pull approach, utilising guaranteed pricing and competitive tendering systems in place for cost-effective renewable energy development. Both countries must adhere to the same international and European legislative obligations, and must be seen to reduce their carbon footprint and dependence on fossil fuels. It should be noted, however, that the MRE sector in the UK is far more developed than its French counterpart, and the disparity of funding availability should not be a limiting factor when considering potential collaboration across the Channel region.

Offshore wind is more developed as a technology than wave and tidal energy; as such, it should be noted that there are lessons that could be learned from the experience of the wind energy sector (EU-OEA, 2009).

Analysis of the current and future market opportunities both across the Channel region and on a more global scale found that, on the whole, SMEs have the knowledge and expertise to engage with most activities across the MRE lifecycle. In addition, working alongside a number of industry experts, five new spaces/ opportunities were identified:

- Wave energy
- Tidal energy
- Electrical connectors
- Surveys
- Condition monitoring

Each of these identified spaces is a growing area within the MRE sector. It should be noted that there are other areas of potential for development, including advancing technologies around energy storage, combined use of platforms, and combined devices.

Through this research, a number of requirements/ recommendations for the future success of the Channel's MRE sector have been identified.

- EU-level action which should support the advancement of technology and innovation across the sector, the development of successful and sustainable supply chains and the provision of accessible and reasonable planning and consent processes. Additionally, it is recommended that further recognition of the MRE sector as a strategic priority for Europe, supporting economic regeneration across the region, while addressing energy concerns. A collaborative initiative of this type could serve a number of purposes: supporting installations, but also supporting supply chain and skills development.

- More progress needs to be made in terms of providing connections to the national grids in England and France, and ensuring that the necessary supporting infrastructure is in place.

- It is clear that there are still a number of risks associated with investing in and developing MRE technologies, particularly the emerging markets of wave and tidal energy. In order to support the sector going forward, it will be necessary to provide evidence that the sector will have long-term and sustainable financial stability over time. This will require appropriate funding support, grant opportunities and market pull initiatives that support both developers, but also the SMEs within the wider supply chain.

- Standardisation of device and array design, training and skills qualifications and other sector requirements would provide SMEs with more information about the requirements for entry into the MRE sector, helping them to understand the process.

- The research found that capacity gaps across the Channel region were related to an ability to answer orders on short timescales, rather than a lack of knowledge, skills or expertise. It is suggested that support be put in place to help SMEs identify where their capacity gaps are, and to encourage collaboration between SMEs to enhance overall capacity for delivery (perhaps through the formation of regional clusters or networks).

- Through the research, it became evident that a key challenge facing SMEs is a lack of understanding of the complex commercial processes associated with tendering, procurement of tenders, entry into the supply chain, quality standards (for technologies, training, skills and health and safety requirements), among other areas. It is the recommendation of this research that clear, transparent information be provided to SMEs; particularly as the emphasis on local content within the MRE supply chain continues to grow.

- Overall, it should be recognised that the real opportunities for Channel based businesses, particularly SMEs, will not be limited in the Channel region itself, which in some instances already has strong, existing supply chains (OSW, for example). The opportunities for businesses going forward will be based on the region identifying itself as an area of MRE expertise and skill, working on a wider European and, even international scale. It is evident that by working together through the Channel MOR Community (launched by the Channel MOR project to stimulate growth across the MRE sector and foster collaboration across the Channel region), SMEs interested in engaging in the MRE sector could raise their profile and visibility on a local, regional and international scale, creating a more coherent and supportive supply chain.

9. REFERENCES:

AMEC Environment & Infrastructure UK Limited. (2012). Carbon Trust: UK wave energy resource.

Bailey, I., de Groot, J., Whitehead, I., Vantoch-Wood, A., and Connor, P. (2012) Comparison of National Policy Frameworks for Marine Renewable Energy within the United Kingdom and France. A report prepared as part of the MERiFIC project.

BBC. (2014). Who are the "big six" energy companies? Available at: http://www.bbc.co.uk/news/business-24670741

Bergmann, A., Hanley, N., and Wright, R. (2006) Valuing the attributes of renewable energy investments. Energy Policy 34:1004-1014

BVG Associates. (2014). UK offshore wind supply chain: capabilities and opportunities: A report prepared by BVG Associates for the Department for Business, Innovation and Skills. Available at: http://www.bvgassociates.co.uk/Portals/0/publications/BVGA%20BIS%20UK%20offshore%20wind%20supply%20chain%20capabilities%201402.pdf

Carbon Trust (2011). Accelerating marine energy.

Chen, B., Zappala, D., Crabtree, C.J. and Tavner, P.J. (2014). 'Survey of commercially available SCADA data analysis tools for wind turbine health monitoring.', Technical report. Durham University School of Engineering and Computing Sciences.

CORE: Centres for Offshore Renewable Engineering (2012) Building Offshore Wind in England

Crabtree, C.J., Zappala, D. and Tavner, P.J. (2014) 'Survey of commercially available condition monitoring systems for wind turbines.', Technical Report. Durham University School of Engineering and Computer Sciences and the SUPERGEN Wind Energy Technologies Consortium.

Dalton, G.J. (2009). Non-technical barriers to wave energy in Europe.

Department of Energy and Climate Change (2012) Electricity Market Reform: policy overview: November 2012

Department of Energy and Climate Change (2013) Annual Energy Statement: October 2013

Department of Energy & Climate Change (DECC). (2013). Wave and tidal energy: part of the UK's energy mix. Available at: https://www.gov.uk/wave-and-tidal-energy-part-of-the-uks-energy-mix

EMEC, (2014a). Wave Developers . Available at: http://www.emec.org.uk/marine-energy/wave-developers/

EMECb, (2014b). Wave Devices. Available at: http://www.emec.org.uk/marine-energy/wave-devices/

EMEC (2014c). Tidal Devices. Available at: http://www.emec.org.uk/marine-energy/tidal-devices/

EMEC (2014d). Tidal developers. Available at: http://www.emec.org.uk/marine-energy/tidal-developers/

Energy and Climate Change Committee. (2012). The Future of Marine Renewables in the UK.

European Commission. (2011). Europe 2020 Targets. Available at: http://ec.europa.eu/europe2020/europe-2020-in-a-nutshell/targets/index_en.htm

European Ocean Energy Association (2009) Oceans of Energy: European Ocean Energy Roadmap 2010- 2050

European Commission. (2014). The 2020 climate and energy package. Available at: http://ec.europa.eu/clima/policies/package/index_en.htm

Inger, R., Attrill, M., J., Bearhop, S., Broderick, A., C., Grecian, W., J., Hodgson, D., J., Mills, C., Sheehan, E., Votier, S.,C., Witt, M., J., and Godley, B., J. (2009) Marine Renewable Energy: potential benefits to biodiversity? An urgent call for research. Journal of Applied Ecology. 46: 1145-1153

Garcia Marquez, F.P., Tobias, A.M., Perez, J.M., and Papaelias, M. (2012). Condition monitoring of wind turbines: Techniques and methods. *Renewable Energy*. 46: 169-178.

Gill, A., B. (2005) Offshore Renewable Energy: Ecological Implications of Generating Electricity in the Coastal Zone. Journal of Applied Ecology 42: 605-615

Grow: Offshore Wind. (2014). Realising the Offshore Wind Opportunity. (page 22).

Hall, P., J. (2008) energy-storage technologies and electricity generation. Energy Policy 36 (12): 4352-4355

Hameed, Z., Ahn, S.H., and Cho, Y.M. (2010). Practical aspects of a condition monitoring system for a wind turbine with emphasis on its design, system architecture, testing and installation. Renewable Energy, 35 (5): Pages 879-894.

Henley, S. (2013) Ocean Energy in Europe’s Atlantic Arc: An overview of policy and market conditions in Denmark, France, Ireland, Portugal, Spain and the United Kingdom. RenewableUK.

HM Government. (2013). Offshore Wind Industrial Strategy: Business and Government Action.

Jeffrey, H., and Sedgwick, J. (2011) ORECCA European Offshore Renewable Energy Roadmap.

Kerr, S., Watts, L., Colton, J., Conway, F., Hull, A., Johnson, K., Jude, S., Kannen, A., MacDougall, S., McLachlan, C., Potts, T., Vergunst, J. (2014). Establishing an agenda for social studies research in marine renewable energy. Energy Policy, 67, pages 694-702.

Knowledge Accelration and Responsible Innovation Meta-network (2012) Report 1: Marine and Offshore energy. Opportunities for European SMEs (KARIM)

London Array. (2014a). Who’s behind London Array? Available at: http://www.londonarray.com/about-us-2/

London Array. (2014b). Accessing the Array. Available at: http://www.londonarray.com/about-us-2/travelling-to-site/

Low Carbon Innovation Coordination Group (2012). Technology Innovation Needs Assessment (TINA): Marine Energy Summary Report.

Melo, A., B., Sweeney, E., and Villate, J., L. (2013) Global review of recent ocean energy activities. Marine Technology Society Journal 47(5): 97- 103

MERiFIC (2013). Procurement Code of Practice: A guide for businesses entering the marine renewable energy industry.

Mueller, M., and Wallace, R. (2008) Enabling Science and Technology for Marine Renewable Energy

National action plan for the promotion of renewable energies 2009-2020. In accordance with Article 4 of European Union Directive 2009/28/EC

National Renewable Energy Action Plan for the United Kingdom: Article 4 of the Renewable Energy Directive 2009/28/EC.

Newbury, D. (2012) Progress on the UK Electricity Market Reform. Cambridge Energy Policy Research Group. Available on line: http://www.eprg.group.cam.ac.uk/wp-content/uploads/2012/10/Progress-on-Electricity-Market-Reform-R1acc.pdf Accessed on 6th March 2014.

Ocean Energy Systems (2012) Annual Report: Implementing Agreement on Ocean Energy Systems.

Offshore Renewable Energy Catapult. (2013). GENERATING ENERGY AND PROSPERITY: Economic Impact Study of the offshore renewable energy industry in the UK. Available at: https://ore.catapult.org.uk/documents/2157989/0/ORE+Catapult+UK+economic+impact+report/2c49a781-ff1e-462f-a0c7-b25eb9478b0f?version=1.0

Professional Engineering. (2014). Turbine maker blasts UK suppliers.

RenewableUK (2013) Wave and tidal Energy in the UK: Conquering Challenges, Generating Growth. Issue 1- Feb 2013.

RenewableUK (2013) Working for a Green Britain and Northern Ireland 2013-23: Employment in the UK Wind and Marine Energy Industries.

Saunders Energy Limited. (2014). Power Tube HD. Available at: http://www.saundersenergy.co.uk/wp-content/uploads/2014/04/10112-2-PowerTube-HD-flyer-Arial.pdf

SI OCEAN (2012). Ocean Energy: State of the Art.

Smit, T., Junginger, M., and Smits, R. (2007) Technological learning in offshore wind energy: Different roles of the government. Energy Policy. 35:6431-6444

Stiesdal, H., and Madsen, P., H. (2005) Design for Reliability: Copenhagen Offshore Wind Conference 2005

The Crown Estate (2012) Offshore Wind Cost Reduction Pathways Study.

The Crown Estate (2012). UK Wave and Tidal Key Resource Areas Project: Summary Report

Tidal Energy Ltd (2014). TEL Intellectual Property. Available at: http://www.tidalenergyltd.com/?page_id=1321

Toke, D. (2011) The UK offshore wind power programme: A sea change in UK energy policy? Energy Policy 39(2): 526-534

Vantoch-Wood, A., de Groot, J., Connor, P., Bailey, I., and Whitehead, I. (2012) National Policy Framework for Marine Renewable Energy within the United Kingdom. A report prepared as part of the MERiFIC Project “Marine Energy in Far Peripheral and Island Communities”.

West Normandie Marine Energy, (2014). Energy from tidal stream turbines. Available at: http://www.west-normandy-marine-energy.fr/en/energy-from-tidal-stream-turbines-gc8.html.

Which? (2014a). E.ON. Available at: http://www.which.co.uk/switch/energy-suppliers/eon

Which? (2014b). British Gas. Available at: http://www.which.co.uk/switch/energy-suppliers/british-gas.

Which? (2014c). Energies Companies Rated. Available at: http://www.which.co.uk/switch/energy-suppliers/energy-companies-rated

Wood Group Kenny. (2014). Wet mate Connector Market Study. Available at: https://ore.catapult.org.uk/documents/2157989/0/Wet+mate+connector+market+study/9dde02e6-7fe3-489c-a60e-2fefcdcb08c6?version=1.0

World Energy Council (2014). Marine in United Kingdom. Available at: http://www.worldenergy.org/data/resources/country/united-kingdom/marine/

Yang, W., Tavner, P.J., Crabtree, C.J. and Fen. (2014). Wind turbine condition monitoring: technical and commercial challenges. Wind Energy, 17 (5): 673-693.