September 2014

Offshore renewable energy standardization review

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Contents

Figures

Tables

Executive summary

Driven by issues of climate change, security of energy supply and economic development potential, the UK Government has established ambitious plans for the growth of offshore wind by 2020 decade. In addition, the UK Government has provided targeted support to realize the potential of wave and tidal power generation.

The development and delivery of standards is important for driving the industrialization of offshore renewable energy. Appropriate standards create a foundation for growth based upon recognized benchmarks of quality and promote UK competitiveness by reducing barriers to international trade. For these reasons, the British Standards Institution (BSI) has been at the forefront of developing offshore renewable energy standards via its membership on IEC's renewable energy committees. However, BSI believes further work can be done. Thanks to support from Innovate UK (the new name for the Technology Strategy Board), BSI is undertaking a strategic review that will inform its direction and actions as it relates to the future needs of offshore renewable energy. The overarching aims of this current phase of the work were to:

- research the needs of the offshore renewable sector via a programme of engagement with the supply chain,
- identify the opportunities to transfer or to adapt pre-existing standards that have been developed by other branches of the maritime and power generation sectors,
- build consensus within the supply chain and key stakeholders as to the strategic direction of BSI as it seeks to develop new standards that serve the needs of the offshore renewables sector.

Offshore renewable energy is a generic term to group and describe wind, wave and tidal stream-derived forms of marine renewable energy. However, each of these marine environment-harnessed energy sources, particularly wind as distinct from wave and tidal, are at different stages of commercial maturity and exploitation. From the very outset of this work it has been appropriate to conduct the study in a manner that allows the differing offshore renewable energy concerns of wind, wave and tidal to be captured accordingly.

In order to satisfy the strategic objectives of the project, it was clear that a structured mechanism capturing the views of a broad range of offshore renewable energy practitioners was required. A questionnaire was developed in order to obtain four main types of information from telephone interviewing. The questionnaire was emailed to a representative selection of 50 organizations in the offshore renewable energy industry and the recipients were invited to participate in a telephone interview. Interviews were conducted and completed questionnaires were received from 33 organizations. These respondents identified 185 standards, guidelines and other similar documents that they used in their offshore renewable energy-related activities.

Independent of the interviews, BSI conducted a literature search of standards and similar documents that are or could be of relevance to the offshore renewable energy industry. This search produced a list of 200 standards and similar documents. Combining the industry information and the BSI review information indicates that there are at least 335 standards and similar documents that are of relevance to, and could be used by, the offshore renewable energy industry. A comparison of these two sources of information on standards used in offshore renewable energy revealed that there are 50 key standards documents that are both used by industry and referenced by the BSI review.

Resulting from the views provided by the offshore renewable energy supply chain it was possible to identify a number of both general and specific themes for the development of new standards. Key generalized points were that from several quarters the desire was expressed for new standards that place great emphasis on defining 'safety exceedance thresholds' based upon function and operational environment, rather than prescriptive requirements. Another line of opinion was that 'route maps', 'indexing' or 'search' tools would be of great help in accessing and choosing from the large number of standards and similar documents that already exist.

The possibility of developing new standards for the offshore renewable energy industry should be tempered with the view expressed by a few people that no new standards are needed – only increased harmonization of existing standards, with improvements and revisions where necessary. However, the view of 'no new standards' needs to be balanced with the responses from the wave and tidal communities in particular; these communities were interested in developing standards specific to their industries, reflecting the different requirements of wave and tidal devices to existing offshore industries. In addition, the view of 'safety exceedance thresholds' needs careful consideration when applied to wave and tidal technologies as the relative absence of operational running hours means that the knowledge needed to determine such safety thresholds is not readily available.

Further topics that were highlighted as potentially requiring new or improved standards, along with an indication of what type of standard and whether it is new or revision of existing documents, are as follows:,

Tidal and wave devices.

- Load cases for both wave and tidal devices that are based upon correctly represented environmental conditions (new, specification or guide);
- Guidelines on best practice installation techniques for the range of marine infrastructure being used in the deployment of Tidal Energy Converters (TECs) (new, specification or guide);
- Seabed rock stability and capacity to bear the static and dynamic loads resulting from placing large items of equipment on the seabed. This includes guidance on the measurement and qualification of geotechnical conditions related to the nature of the equipment and environmental loads (new, specification);
- Parameters for modelling turbulence and equipment requirements for its measurement in the marine environment (new, guide);
- Corrosion, abrasion and erosion of material and its degradation resulting from prolonged application in highly energetic tidal stream conditions (revised where available or new, specification);
- Consistent Health and Safety (H&S) qualifications and practices across different maritime sectors;
- Route map and indexing exercise for standards that are relevant to wave and tidal applications.

Wind turbines.

- Control systems for wind turbines and farms (new, guide);
- Blade repair (new, specification);

- In-service maintenance and repair (all systems) (new, guide);
- Shipping, stowage and clamping of wind turbine components (new, guide or specification);
- Data exchange (improved, specification);
- Lightning protection (improved, specification);
- Environmental impact assessment, offshore renewable energy statutory stakeholder criteria (new, route map or guide).

Having identified this range of topics that the contributors believed were eligible for consideration as areas where new standards would assist their business activities, the relative prioritization associated with developing that theme was scored against both ease of implementation and potential impact against a 2020 time scale. This is summarized in the figure below.

Potential Implementation Difficulty	LOW (Potential ORE 2020 Impact)	MED (Potential ORE 2020 Impact)	HIGH (Potential ORE 2020 Impact)
HIGH	**Load cases for WECs**	**Load cases for TECs**	
MED	**Tidal stream material selection**	**TEC installation** **TEC seabed stability** **TEC turbulence and measurement**	**OWT control systems for turbines and farms**
LOW	**OWT sea fastenings** **OWT data exchange**	**H&S qualifications and practises harmonisation**	**OWT lightning strike** **EIA guidance** **Route map and indexing existing standards**

The following standardization areas were recommended as either medium or high priority topics for UK effort:

- The topic of standards for the installation of TECs was felt to be of medium impact and moderately easy to implement. The scope of this best practice-type document would cover recommendations about the use of the range of different marine vessels and infrastructure that can be used when installing TECs. An indication of safety thresholds for different types of vessels could be included within the context of installation station-keeping scenarios. The majority of TECs installed worldwide are clustered within the Falls of Warness at the European Marine Energy Centre (EMEC) test site. It is likely that this standard development activity should be closely linked with EMEC. UK effort into this topic was recommended as being of medium to high priority.

- Guidance on the topic of tidal stream turbulence and measurement was felt to be of medium impact and medium difficulty in terms of implementation. In developing this standard it is recommended that the UK builds upon the framework of PT 62600-201, *Tidal Energy Resource Assessment and Characterization* with the objective of extending the definition for the requirements of turbulence mathematical modelling and physical measurement equipment. UK effort into this topic was recommended as being of medium to high priority.
- Improvements in standards in offshore renewable energy H&S covering construction and Operation and Maintenance (O&M) of offshore installations were felt to be of medium impact and easy to achieve. The goal of this standard would be to harmonization the range of different H&S competency and training requirements to a uniform level within the wider maritime sector. This would require a risk-based categorization of different offshore activities and a ranked graduation to training, equipment and support infrastructure. This activity should be undertaken in conjunction with the Maritime and Coastguard Agency (MCA) and RenewableUK. UK effort into this topic was recommended as being of high priority.
- Standardization in the areas of control for offshore wind turbines and farms was felt to be of high impact and moderately difficult to implement. It is recommended that, because of the maturity of the sector and the long-standing establishment of IEC Technical Committee (TC) 88, the UK considers a New Work Item Proposal. UK effort into this topic was recommended as being of medium to high priority.
- Improved standardization in the area of offshore wind lightning protection is of high impact and easy to implement. It is recommended that, because of the maturity of the sector and the long-standing establishment of IEC TC 88, the UK should consider a New Work Item Proposal. As the UK is the world's leading offshore wind marketplace, UK effort into this topic was recommended as being of high priority.
- Increased standardization in the Environmental Impact Assessment (EIA) for offshore renewable energy was felt to be of high impact and easy to implement. It is recommended that in conjunction with the cooperation of EIA statutory bodies an exercise is undertaken to determine requirements for the International Energy Agency study and reporting methodologies. It is felt that this may reduce the cost of the EIA and potentially compress consenting timescales. UK effort into this topic was recommended as being of high priority.
- The development of a standards indexing exercise to provide a route map to guide the development of Wave Energy Converters (WECs) and TECs was felt to be of high impact and easy to implement. UK effort into this topic is recommended as being of high priority.

Offshore renewable energy standards were in common use. In addition, the following standards developed by Det Norske Veritas (DNV), International Electrotechnical Commission (IEC) and Germanischer Lloyd (GL) relating to the offshore environment and offshore wind were held in high regard:

- DNV-OS-J101, *Design of Offshore Wind Turbine Structures*;
- DNV-OS-J201, *Offshore Substations for Wind Farms and DNV-RP-H103, Ship Transit Accelerations*;
- GL-IV-1, *Guideline for the Certification of Wind Turbines*;

- IEC 61400-22, *Wind turbines – Part 22: Conformity testing and certification*.

The combination of the industry questionnaire and the BSI review has provided a good view of the numerous standards and similar documents, both used currently by the industry and available for use. It was interesting to note that there were only a few standards that were consistently selected for use by industry. Many standards had only one industry user; this indicates that the offshore renewable energy industry has had to piece together the suite of standards it uses.

1 Introduction

Driven by issues of climate change, security of energy supply and economic development potential, the UK Government has set ambitious plans for the growth of offshore wind by 2020.the end of this decade. In addition, the UK Government has provided targeted support to realize the potential of wave and tidal power generation.

The development and delivery of standards is important for driving the industrialization of offshore renewable energy. Appropriate standards create the basis for growth based upon recognized benchmarks of quality and promote UK competitiveness by reducing barriers to international trade. For these reasons, BSI has been at the forefront of developing offshore renewable energy standards via its membership of IEC's TC 88 (Wind turbines) and TC 114 (Marine energy – Wave, tidal and other water current converters) committees. However, BSI believes further work can be done. Thanks to support from the Innovate UK, BSI is undertaking a strategic review that will inform its direction and actions as it relates to the future needs of offshore renewable energy. The overarching aims of this current phase of the work were to:

- research the needs of the offshore renewable sector via a programme of engagement with the supply chain;
- identify the opportunities to transfer or to adapt pre-existing standards that have been developed by other branches of the maritime and power generation sectors;
- build consensus within the supply chain and BSI's stakeholder steering group as to the strategic direction of BSI as it seeks to develop new standards that serve the needs of the offshore renewables sector.

1.1 Offshore renewable energy background

Offshore renewable energy is a generic term used to group and describe wind, wave and tidal stream-derived forms of marine renewable energy. However, each of these marine environment-harnessed energy sources, particularly wind as distinct from wave and tidal, are at different stages of commercial maturity and exploitation. In order to provide an appropriate context for this report, the following sections provide a brief background of some of the key technical and financial drivers underpinning offshore renewable energy.

1.1.1 Wave and tidal background

As reported in the Feb 2013 RenewableUK publication *Wave and Tidal Energy in the UK – Conquering Challenges, Generating Growth*, the potential benefits of wave and tidal energy development to the UK have been forecast as being worth £6.1 billion to the economy by 2035. Additionally, the implementation of these benefits could create nearly 20,000 jobs. Over the last decade, the wave and tidal energy industry has progressed to a stage where single-device demonstrators have been successfully installed and the industry is moving towards installing multi-device arrays in UK waters. Industry capability, supported by UK Government commitment, has resulted in the UK hosting the majority of world-leading technology development companies, with many of the technologies being built and demonstrated in the UK. Prompted by this, the UK has seen the beginnings of a supply chain developing in the sector. Over recent years strong indicators have increasingly pointed towards a widening gap between the commercial exploitation prospects of wave streams and tidal streams. At present, both streams have costs that make them far removed from the commercial competitiveness of other forms of power generation. However the sense of confidence that has seemingly been attached to the opportunities to drive down tidal energy costs is not as evident for wave energy. This point is well-illustrated when considering the leading tidal energy development companies who, almost without exception, have been subsumed into large international engineering companies – namely Siemens, Alstom, Voith, Andriz and DCNS. However, when considering the leading wave energy development companies, the same trend is not evident.

The matter of predicting the growth rate of the wave and tidal energy sector over the coming years is not straightforward. There are very many factors to consider, such as the sector's place within both a renewable energy industry and, wider still, the power generation market. The Crown Estate has granted seabed licences for 1.8 gigawatts (GW) of wave and tidal stream power generation and this is split around 1:4 in favour of tidal over wave. *In Wave and Tidal Energy in the UK – Conquering Challenges, Generating Growth*, several 2020 growth scenarios are provided based upon differing levels of UK Government financial support. A baseline prediction of around 70 megawatts (MW) of projects are identified as being in advanced planning and have already been allocated some form of publicly funded market stimulation financing. A further 70 MW, making a total of 140 MW of projects, could potentially be installed by 2020 subject to the sector receiving additional financial incentives in the form of a sufficiently high strike price, through the provisions of the UK Government's *Contracts for Difference* energy policy. A breakdown of a split between wave and tidal projects is not provided in the RenewableUK's report. However, similar to the division found in The Crown Estates licences, it is reasonable to assume a split of at least 1:4 in favour of tidal over wave.

1.1.2 Wind background

Offshore wind in the UK is a world-leading industry in terms of installed capacity, which is approaching 3.7 GW. The main activities have been associated with licensing rounds operated by The Crown Estate. Round 1 is complete; Round 2 is well underway and nearing completion; and Round 3, with around 20 GW of licences offered, is in its early planning and start-up phases. Overall, the UK has nominal targets for around 20 GW of installed offshore wind by 2020; this level of capacity is required to help deliver the UK's carbon reduction targets through the de-carbonization of electricity production – a means of achieving an overall 15% reduction in carbon-based energy use.

The wind turbines installed offshore have increased in size from 2 MW-sized turbines used in the early 1990s, through 2.3 MW and 3.6 MW-powered machines in Rounds 1 and 2, to the 5 MW turbines installed in several UK farms. There are plans for 6 MW and larger-powered turbines, with prototypes in the process of being installed at test-sites in the near future.

This positive outlook for offshore wind in the UK is balanced by some of the difficulties in obtaining sufficient finance to deliver all of the planned offshore wind farms. The installation and operating costs are high; installation costs are around £3 million/MW, compared with £1 million/MW for onshore wind. Offshore wind farms are highly innovative yet difficult to install and maintain and many of the developers have had to slow down or delay the installation of their offshore wind farm fleets. In some cases there have even been high-profile announcements of cancellation, e.g. the RWE and its Atlantic Array project in November 2013.

The continuation of offshore wind within the UK is not in dispute, since the provision of a wider diversity of electrical power sources will help secure the country's power supplies. However, the problems of cost and delay are causing concern and any activity that can assist the industry – such as the provision of better-suited standards – will be beneficial in ensuring progress continues.

2 Methodology

In order to satisfy the strategic objectives of the project, it was clear that a structured mechanism of capturing the views of a broad range of offshore renewable energy contributors was required. A variety of options were considered as to how best to undertake this activity. Whilst data collection techniques such as Survey Monkey-type approaches are time-efficient on the part of those gathering the information, a more interactive approach was thought to be better suited to this project. The desire was to gain the subtleties of points of view that cannot be measured using simplistic 'tick-box' answers. This took the form of a questionnaire that was conducted via telephone interviewing.

2.1 Questionnaire

A questionnaire was developed based on a four-part structure. The intention was to use each of these sections to assist in gaining the required information with sufficient granularity to adequately address the project's overarching aims. A full copy of the interview template used has been provided in Appendix A.

2.1.1 Characterization of contributors

Section 1 of the questionnaire was intended to provide context for the information in the subsequent sections. The questions in Section 1 asked about:

- the relative seniority of the contributor within their organization to be indicatively gauged by job title;
- the area(s) in which the contributors operated within offshore renewable energy;
- the identification of the contributor's position in the supply chain;
- the influence of the contributor's organization in the offshore renewable energy market as suggested by the number of employees and annual turnover.

It was convenient to provide a range of options for the contributors in answering some of the Section 1 questions. For example, the 'number of employees' categories comprised numbers that are typically used within the public sector to identify a business as either Micro, a Small to Medium Enterprise (SME) or Large Organization. A similar approach was used in grouping employee numbers and annual turnover responses.

2.1.2 Standards use and perceptions

Section 2 of the questionnaire was designed to explore both the status of standards used and their suitability within the offshore renewable energy sector. The questions in Section 2 invited the contributors to:

- list standards, guidance and any best-practice documents presently being used within their organization;
- rank the usefulness of these documents against how well they supported their business needs;
- highlight specific business challenges their organization faced in developing offshore renewable energy;
- comment on whether or not the development of new standards would assist to resolve their specific business issues;

- provide recommendations for areas they saw as important and relevant for the development of new standards.

Again, it was convenient to provide a range of options for the contributors in answering some of the Section 2 questions. This approach was used to allow contributors to rank how well the standards currently used by their organization served business needs. A scoring scale of 1 to 5 was used with 1= poorly; 3= adequately; and 5= extremely well.

2.1.3 Market trends

Section 3 of the questionnaire explored the contributor's views of the growth trends that will be seen in offshore renewable energy over the coming years. This was the most qualitative and subjective of all the topics explored by the questionnaire. The intention of this section was to provide guidance about the relative prioritization of the wind, wave and tidal areas within offshore renewable energy when planning future offshore renewable energy standards development activities. The contributors were encouraged to comment on the growth trends they anticipate within offshore renewable energy, based primarily upon their own organizational business plans and sale pipelines rather than third-hand information.

2.1.4 Dissemination preferences

Section 4 of the questionnaire was included to provide BSI with relevant information to assist in the planning of one or more offshore renewable energy standards development dissemination and workshop events. Contributors were asked yes/no questions regarding:

- their desire to attend a standards development workshop;
- their preferences regarding the format of this type of event and whether a webinar or a face-to-face meeting would be better.

2.2 Target groupings

In order to achieve the aims of the project, it was highly desirable to engage with a broad range of organizations involved within the offshore renewable energy supply chain. A list was developed that allowed, in a relatively few number of headings, the entire cross-section of the offshore renewable energy supply chain to be conveniently summarized. This list was defined as follows in Table 1:

Table 1 Offshore renewable energy supply chain groupings

Offshore renewable energy supply chain grouping	Target indicators
Original Equipment Manufacture (OEM)	The manufacturing and systems integrator of offshore renewable energy power generation equipment. For convenience this category was further sub-divided into wind, wave and tidal OEMs.
Supply chain specialist	The organization providing some form of specialist offshore renewable energy support typically of a practical, technical or engineering nature.
Utility	The producer of electricity via operation and ownership of large-scale power generation assets.
Project developer	The organization involved in the development of power generation schemes. Often a utility will take on this role in addition to those functions noted above.
Consultant	The organization providing some form of specialist offshore renewable energy support typically of a knowledge-based nature.
Financial services	The organizations involved in the commercial aspects of offshore renewable energy typically the financing and insuring-type functions.
Test Centre	The organization hosting offshore renewable energy test facilities and providing offshore renewable energy testing services.
Academic	The organization undertaking fundamental offshore renewable energy research & development and teaching.
Other	General category

2.3 Telephone interviews

At the conception of the project the limitations regarding the type of information that could be derived from surveys was considered. It was decided that wherever possible, interviews would be conducted verbally. Ideally these would have been conducted face-to-face; however, in order to conduct the interviews in a timely manner, a phone interview approach was more appropriate. This provided significant advantages over written contributor responses. The strategy was to use the verbal interview as a method of gaining a deeper insight into the views of the contributor in a way that was not possible from a simple written response; therefore, the questionnaire was used a script for a structured conversation about offshore renewable energy standards issues.

2.4 Contributor selection

Based upon a pre-existing network of contacts within offshore renewable energy organizations, 50 individuals were contacted by email and provided with a summary of the project and a copy of the questionnaire. In selecting these potential contributors, care was taken to ensure that all the categories identified in Table 1 were represented. Following the initial email correspondence, follow-up telephone calls were made to request a convenient time for the full telephone interview to take place. In preparation for the interview, contributors were asked to collate a list of standards used within their organizations.

2.5 List of contributors

The following organizations kindly contributed their time and knowledge in responding to the questionnaire:

- Areva;
- Aquamarine;
- Atlantis Resources Corporation;
- AWS;
- BMT;
- Black & Veatch;
- DNV (2 responses – one wind-orientated and one wave & tidal orientated);
- EDF;
- EMEC;
- ESBi;
- Gamesa;
- GL;
- Gurit;
- Hammerfest;
- IT Power;
- Loughborough University;
- Lloyds Register (2 responses – one wind-orientated and one wave & tidal orientated);
- McLaughlin & Harvey;
- MOJO;
- Narec;
- Narec Capital;
- Natural Power;
- Partrac;
- PDL Solutions;
- SeaRoc;
- Siemens;
- Strathclyde University;
- Tidal Energy Ltd;
- Vattenfall;
- Vestas;
- Wavehub.

2.6 BSI Knowledge Centre literature survey

The BSI Knowledge Centre was engaged to perform a standards search and analysis on offshore renewable energy. This resulted in the BSI authored report, *Offshore Renewable Energy and Structures – Due diligence research into existing standardization*. The aim of the research was to conduct a due diligence check for existing standardization activities that may be applicable to this topic. The objectives were to identify:

- formal British (BSI), European (CEN) and international (International Standards Organisation [ISO]) standards relevant to the scope of the topic as well as formal standards in France, the USA, Germany, Norway, Denmark and Spain;
- private organizations who provide standards on this topic;
- a broad brush of legislation in this area.

The method employed was desktop research, using BSI's internal standards database PERINORM and the I.H.S Standards Expert database, to identify formal standards relating to offshore renewable energy. Searches were carried out for international standards (ISO, IEC and others), national standards (from the UK, France, the USA, Germany, Norway, Denmark, Spain) and informal standards from those countries. A brief review on possible legislation affecting offshore renewable energy structures was also undertaken. Web searches were also carried out for relevant organizations that might publish informal standards or guidelines relevant to the topic. PERINORM is a bibliographic standards reference database that indexes worldwide standards. All the countries specified above are represented, but publications from more informal bodies are limited. I.H.S Standards Expert is a standards reference database that allows a user to search the full text for some standards bodies but only keywords or titles of others. As well as the standards bodies on PERINORM, it also allows some less formal bodies such as GL and DNV to be searched. I.H.S Standards Expert does not have a 'keyword in context' function, so it was not possible to see where search terms appear in the documents (except for BSI publications, which BSI has full access to on the system). Complete details of the research results are available in *Offshore Renewable Energy and Structures – Due diligence research into existing standardization*, which is 36 pages in length.

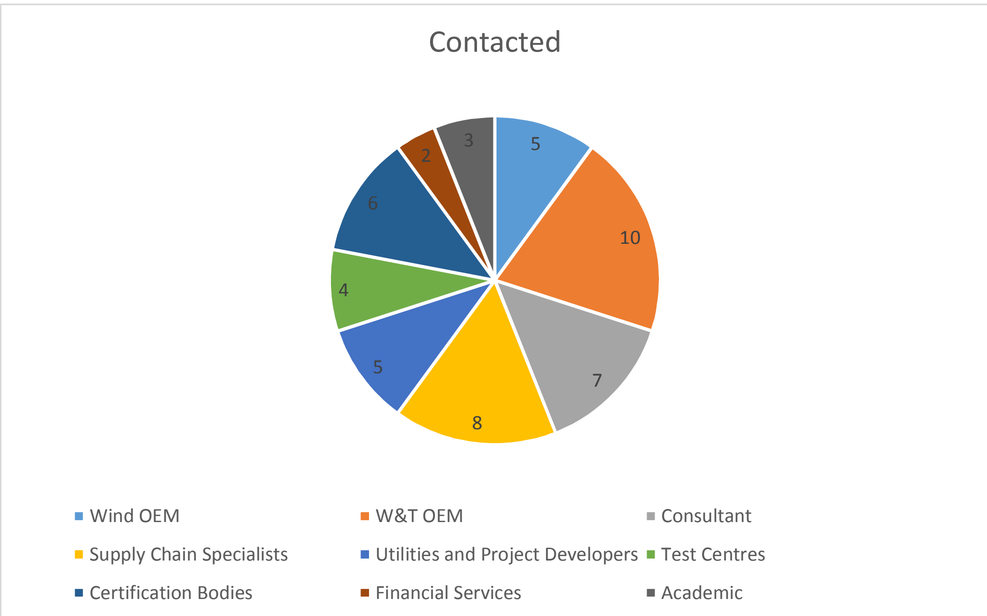
3 Results

The phone interviews were conducted by Jamie Grimwade and/or Richard Court during October and November 2013. The interviews typically lasted between 20 and 30 minutes with the information and comments of the contributors recorded by the above two individuals. The exceptions to this process were the contributors Areva, Black & Veatch and Gamesa who, after a preliminary phone conversation, preferred to complete the questionnaire independently. In these cases oral interviews did not take place.

3.1 Contributor statistics

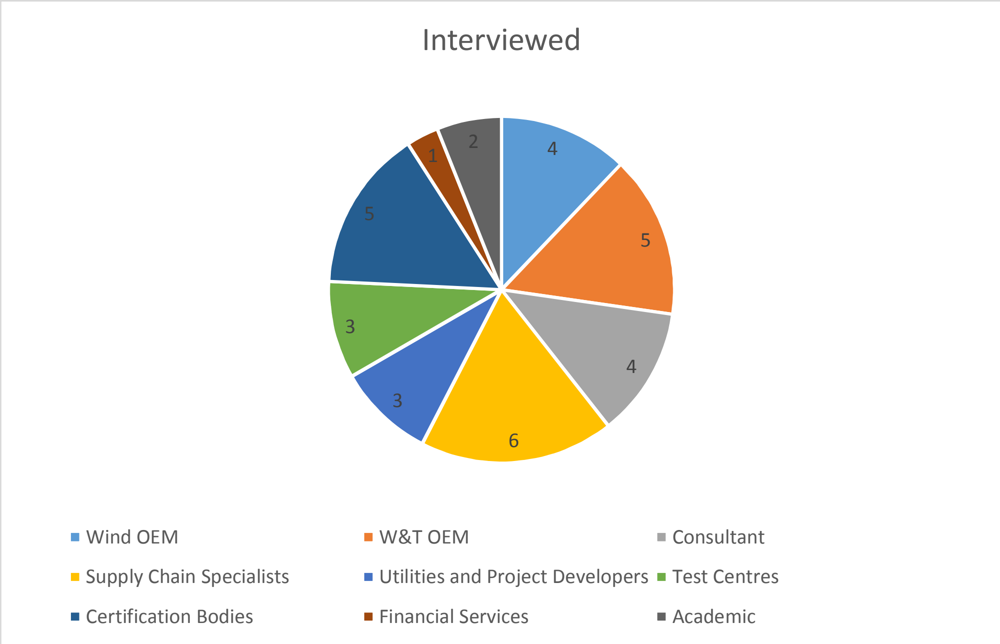
A range of organizations were contacted across all 9 denoted offshore renewable energy industry areas and invited to contribute to the research by completing the questionnaire. Fifty contacts were made, and the breakdown of the numbers for each type of business area is shown in Figure 1.

Figure 1 – Numbers of organizations contacted in the 9 selected business areas



Following these 50 initial contacts, 33 questionnaires and interviews were completed – a response rate of 66%. The breakdown for the total number of each type of business area for these 33 interviewees and contributors is shown in **Error! Reference source not found.**.

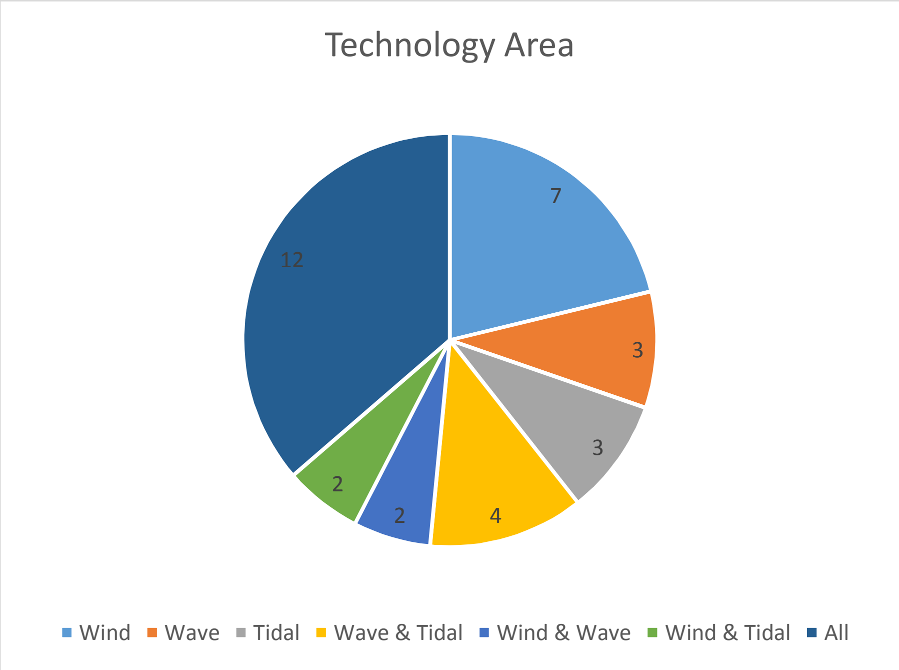
Figure 2 – Numbers of contributing organizations by business areas



There was a fairly even spread of business types that were able to contribute to the interviews, with perhaps only the Academic and Financial Services business areas being under-represented. However, these lower numbers are perhaps indicative of the lack of in-depth involvement of these types of organizations in standards related activities, hence these organizations did not feel they could usefully contribute or would prefer not to spend their time engaging in this project.

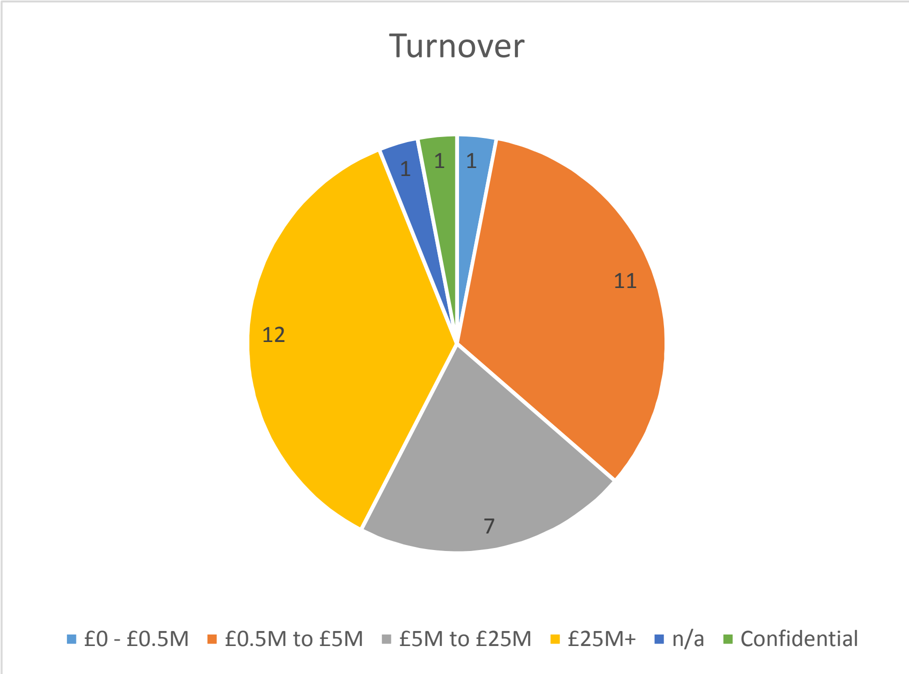
Information on the technology area that each of the organizations is involved in is shown in Figure 2. The largest group comprised organizations that are involved with all three technologies of wind, tidal and wave, with the next largest group being those involved solely with wind energy. It is interesting to note that of the 33 contributors there are 23 organizations that have some involvement with wind energy; 21 organizations involved with tidal; and 21 involved with wave energy. This shows that although the three technology areas are inter-related, there are also differences that allow for specialization in the skills that organizations deploy.

Figure 2 – Numbers of organizations in each of the device technology areas



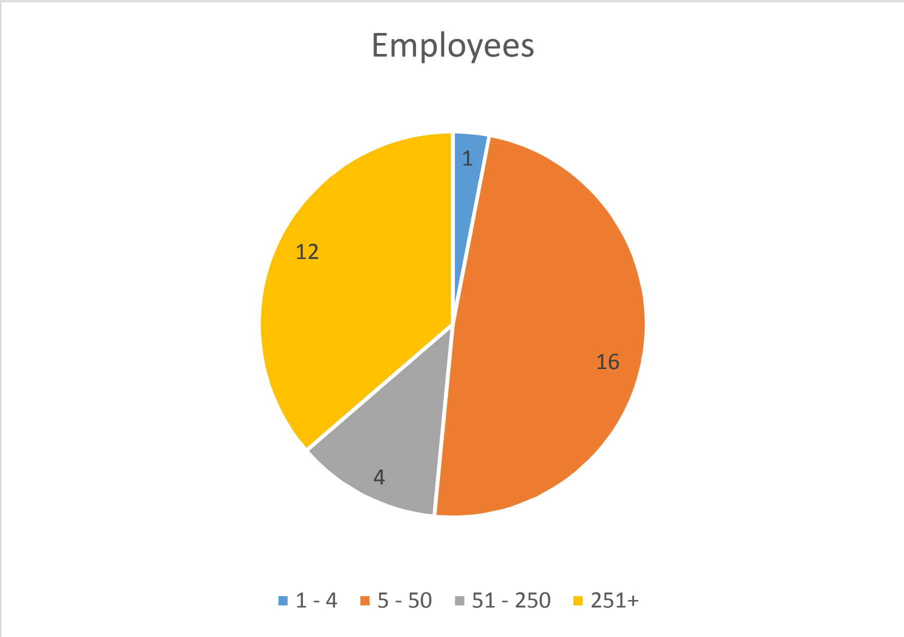
The contributing organizations provided information on their turnover in the offshore renewable energy sector; this information is presented in Figure 4. There is a fairly even distribution of turnover sizes, apart from at the micro-business scale with turnover less than £0.5 million, with just one organization in this category. Twelve of the 33 organizations have turnovers greater than £25 million; 7 organizations have turnovers in the £5 million to £25 million range; and 11 organizations have turnovers in the £0.5 million to £5 million range. One organization felt that turnover values were confidential information and one organization (academic) thought that turnover was not an applicable measure for their activities in offshore renewable energy.

Figure 3 – A breakdown of contributors by turnover



The contributing organizations also provided information on their number of employees active in the offshore renewable energy sector; this information is presented in Figure 4. The majority, nearly half of the 33 organizations, have between 5 and 50 employees working on offshore renewable energy activities. The next largest number is the 12 organizations with over 251 employees, which are the same 12 organizations with turnovers greater than £25 million. This range of business sizes by both turnover and employee number is useful as it shows that the information from both the survey and questionnaire is representative of a range of views, and is not dominated either by large or small organizations and their particular concerns or points-of-view.

Figure 4 – A breakdown of the contributors by numbers of employees in the business



3.2 Use of standards

A key component of the research performed on standardization in offshore renewable energy is the collation of the information gained from Question 2.1 in the questionnaire, which asked what standards or similar documents were used by the interviewee's organization. In this research report the information obtained from industry is compared with the literature search on relevant documents performed by BSI.

The BSI Knowledge Centre literature search and subsequent report, *Offshore Renewable Energy and Structures – Due diligence research into existing standardization,* lists 200 standards, guidelines and similar documents related to offshore renewable energy. The survey of the offshore renewable energy industry reveals that 185 standards and guideline type documents are actively being used. From these lists of 200 and 185 documents, there are 50 documents that are reported as being both listed by BSI and used by industry. The combination of the industry questionnaire and the BSI review provides a good view of the numerous standards and similar documents both used currently by the industry and available for use. Combining the two sources of information indicates that there are at least 335 standards or similar documents that are and could be used by the offshore renewable energy industry. A full listing of these 335 standards is presented in Appendix B. A shortened version is presented here as Table 2. The information is presented in six columns:

- Column 1 is the Document Reference Number;
- Column 2 is the Document Title or an Abbreviation;
- Column 3 has colour coding, with coloured cells indicating use of the document by both industry and being listed by BSI;
- Column 4 shows those documents listed by BSI;

- Column 5 show documents reported as being used by industry;
- Column 6 gives the number of industry entities reporting the use of the document.

The 50 standards both used by industry and found in the BSI listing are from the following organizations:

- American Society of Mechanical Engineers (ASME);
- DNV;
- EMEC;
- EN (Euro Norm standard);
- GL;
- IEC;
- IEEE (Institute of Electrical and Electronic Engineers);
- ISO;
- RenewableUK.

Table 2 – Shortened version of Appendix B showing BSI listed and industry-used standards

Standard or Document Reference No.	Title
ASME PTC 18:2011	Hydraulic Turbines and Pump-Turbines
ASME PTC 29:2005	Speed Governing Systems for Hydraulic Turbine Generator Units
BS 6349-1:2000	Maritime structures. Code of practice for general criteria
BS 6349-5:1991	Maritime structures. Code of practice for dredging and land reclamation
DNV-OS-C201:2012	Structural Design of Offshore Units (WSD Method)
DNV - C205	Subsea engineering
DNV-OS-C401	Fabrication and Testing of Offshore Structures
DNV OS-C501	Composite Components.
DNV OS-C502	Offshore Concrete Structures
DNV OS-D201	Electrical Installations
DNV-OS-E301	Position Mooring
DNV-OS-E402:2010	OFFSHORE STANDARD FOR DIVING SYSTEMS
DNV-OS-J101	Design of Offshore Wind Turbine Structures
DNV-OS-J102	Wind turbine blades
DNV-OS-J103:2013	Design of Floating Wind Turbine Structures
DNV-OS-J201	Offshore Substations for Wind Farms
DNV-OSS-312	Certification of Tidal & Wave Energy Convertors
DNV-OSS-901	Project Certification of Offshore Wind Farms
DNV-RP-B401	Cathodic Protection Design
DNV-RP-C201	Buckling Strength of Plated Structures
DNV-RP-C202	Buckling Strength of Shells
DNV-RP-C203:2012	Fatigue Design of Offshore Steel Structures
DNV-RP-C204	Design against Accidental Loads
DNV-RP-C205	Environmental Conditions and Loads
DNV-RP-C207	Statistical Representation of Soil Data
DNV-RP-F302	Structural code
DNV-RP-H103	Ship transit accelerations
DNV-RP-J101	Use of Remote Sensing for Wind Energy Assessments - Incorporates Amendment: November 2011
DNV RP V41	Cathodic protection
DNV	Marine ship design aspects
DNV	Guidelines for offshore project planning
EMEC	Guidelines for Project Development in the Marine Energy Industry
EMEC	Guideline for marine energy certification schemes
EMEC	Guidelines for Reliability, Maintainability and Survivability of Marine Energy Conversion Systems
EMEC	Guidelines for Grid Connection of Marine Energy Conversion Systems.
EMEC	Tank Testing of Wave Energy Conversion Systems
EMEC	Guidelines for Manufacturing, Assembly and Testing of Marine Energy Conversion Systems.
EN 12495:2000	Cathodic protection for fixed steel offshore structures
EN50082-2	EMC: Electromagnetic Compatibility
EN 50308 (FprEN 50308:2013)	Wind turbines - Protective measures - Requirements for design, operation and maintenance
EN 50308:2005	Wind turbines - Protective measures - Requirements for design, operation and maintenance

EquiMar	Protocols / FP7 project
Eurocodes, e.g. -3	Various e.g. fabrication in steel and concrete
GL-IV-1	Guideline for the Certification of Wind Turbines, Edition 2010
GL IV-2-1/13	Wind / Guideline for the Certification of Offshore Wind Turbines
Gl-IV-4	Guideline for the Certification of Condition Monitoring Systems for Wind Turbines, Edition 2013
GL IV-6-3:2007	Rules for classification and construction - IV: Industrial services - Part 6: Offshore technology - Chapter 3: Fixed offshore installations
GL IV-6-4:2007	Rules for classification and construction - IV: Industrial services - Part 6: Offshore technology - Chapter 4: Structural Design
GL IV-6-7:2005	Rules and guidelines - IV: Industrial services - Part 6: Offshore installations - Chapter 7: Guidelines for the construction of fixed offshore installations in ice infested waters
GL	'Guideline for the Certification of Ocean Energy Converters, Part1: Ocean Current Turbines'
GL-TN	Technical Note Certification of Training Programs and Training Systems in the Renewable Energy Industry, Edition 2013
GL-TN 065	Technical Note 065 (TN 065) Grid Code Compliance Certification procedure, Revision 7, Edition 2010
GL-TN 066	Technical Note 066 (TN 066) Grid Code Compliance (GCC) Test procedure for Low Voltage Ride Through (LVRT), Revision 7, Edition 2010
GL-TN 067	Technical Note 067 Certification of Wind Turbines for Extreme Temperatures (here: Cold Climate), Scope of Assessment, Rev 4, Edition 2011
GL-TN	Technical Note Certification of Fire Protection Systems for Wind Turbines, Certification Procedures, Revision 2, Edition 2009
GL-TN	Technical Note Certification of Service Providers in the Wind Energy Industry, Scope of Assessment, Revision 6, Edition 2009
GL - Nobel Denton	Offshore lifting regulations and transportation
GL - Nobel Denton 007ND	Marine operations
HM Government	Offshore Wind Strategy - Business and Government Action
HSE	Various
IEA (International Energy Agency)	OES (Ocean Energy Systems)
IEC (General)	Electrical
IEC 60034	Rotating electrical machinery
IEC 60076	Power transformers
IEC 60193:1999	Hydraulic turbines, storage pumps and pump-turbines - Model acceptance tests
IEC 60308:2005	Hydraulic turbines - Testing of control systems
IEC 60439	Low voltage switchgear and control gear assemblies
IEC 60545:1976	Guide for commissioning, operation and maintenance of hydraulic turbines
IEC 60609-1:2004	Hydraulic turbines, storage pumps and pump-turbines - Cavitation pitting evaluation - Part 1: Evaluation in reaction turbines, storage pumps and pump-turbines
IEC61000-5-2	EMC - Cable routings
IEC61000-6-2	EMC: Electromagnetic Compatibility
IEC61000-6-4	EMC - Electronics in blades
IEC 61400-1:2007	Wind turbines - Part 1: Design requirements
IEC 61400-11:2012	Wind turbines - Part 11: Acoustic noise measurement techniques
IEC 61400-12-1:2005	Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines

IEC 61400-12-2:2013	Wind turbines - Part 12-2: Power performance of electricity producing wind turbines based on nacelle anemometry
IEC 61400-2:2006	Wind turbines - Part 2: Design requirements for small wind turbines
IEC 61400-21:2008	Wind turbines - Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines
IEC 61400-22:2010	Wind turbines - Part 22: Conformity testing and certification
IEC 61400-24:2010	Wind turbines - Part 24: Lightning protection
IEC 61400-25-1	Wind turbines - Part 25-1: Communications for monitoring and control of wind power plants
IEC 61400-3	Wind turbines - Part 3: Design requirements for offshore wind turbines
IEC 61400-4	Wind turbines - Part 4: Design requirements for wind turbine gearboxes
IEC/TS 61400-13:2001	Wind turbine generator systems - Part 13: Measurement of mechanical loads
IEC/TS 61400-14:2005	Wind turbines - Part 14: Declaration of apparent sound power level and tonality values
IEC/TS 61400-23:2001	Wind turbine generator systems - Part 23: Full-scale structural testing of rotor blades
IEC/TS 61400-26-1	Wind turbines - Part 26-1: Time-based availability for wind turbine generating systems
IEC/TS 62600-1:2011	Marine energy - Wave, tidal and other water current converters - Part 1: Terminology
IEC/TS 62600-2	Guidelines for Design Basis of Marine Energy Conversion Systems
IEC/TS 62600-10:2013	Marine energy - Wave, tidal and other water current converters - Part 10: Assessment of mooring system for Marine Energy Converters
IEC/TS 62600-100:2012	Marine energy - Wave, tidal and other water current converters - Part 100: Power performance assessment of electricity producing wave energy converters
IEC/TS 62600-101:2011	Marine energy - Wave, tidal and other water current converters - Part 101: Wave energy resource assessment and characterization (IEC 114/70/CD:2011)
IEC/TS 62600-200:2013	Marine energy - Wave, tidal and other water current converters - Part 200: Power performance assessment of electricity producing tidal energy converters
IEC/TS 62600-201:2011	Marine energy - Wave, tidal and other water current converters - Part 201: Tidal energy resource assessment and characterisation
IEEE 1095:2012	IEEE Guide for the Installation of Vertical Generators and Generator/Motors for Hydroelectric Applications
IEEE 125	Recommended practice for preparation of equipment specifications for speed-governing of hydraulic turbines intended to drive electric generators
IEEE 1580	Recommended Practice for Marine Cable for Use on Shipboard and Fixed or Floating Facilities
IOS 14001	Environmental management standard
ISO 17020	Verification body standard
ISO 17025	Testing laboratory standard
ISO 19901-1:2006	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1: Metocean design and operating considerations
ISO 19901-1:2013	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1: Metocean design and operating considerations
ISO 19901-2	Petroleum and Natural Gas Industries - Seismic design procedures and criteria.
ISO 19901-3	Petroleum and Natural Gas Industries - Specific requirements for offshore structures - Part 3: Topsides structure
ISO 19901-4	Petroleum and Natural Gas Industries - Specific requirements for offshore structures - Part 4: Geotechnical and foundation design considerations
ISO 19901-5:2003	Petroleum and natural gas industries. Specific requirements for offshore structures. Weight control during engineering and construction
ISO 19901-7	Station keeping

ISO 19901-8	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 8 : marine soil investigations
ISO 19902:2007	Petroleum and natural gas industries. Fixed steel offshore structures
ISO 19903	Petroleum and Natural Gas Industries - Fixed concrete offshore structures.
ISO 19904-1	Petroleum and Natural Gas Industries - Floating Offshore Structures - Part 1: Monohulls, semi-submersibles and spars.
ISO 19906:2010	Petroleum and natural gas industries - Arctic offshore structures
ISO 281	Rolling bearings -- Dynamic load ratings and rating life
ISO 4354:2009	Wind actions on structures
ISO 76	Rolling bearings -- Static load ratings
ISO 799:2004	Ships and marine technology - Pilot ladders
ISO 9001	Standard for Quality Management
Lloyds Register	Marine ship design aspects
Lloyds Register	Offshore lifting and transportation
Lloyds Register	Lloyd's Register Rules and Regulations for the classification of Floating Offshore Installations at a Fixed Location
Lloyds Register	Conformity scheme
MCA	(Several / general)
NORSOC	Oil & Gas codes
NORSOC M120	Marine operations
NORSOC N001	Marine operations
NORSOC N006	Fatigue
NORSOC NEK606	Cables
OHSAS 18001	Health & Safety Standard
Renewable UK	H&S Guidelines: Onshore & Offshore H&S
Renewable UK	H&S Guidelines: Vessel Safety
TCE (The Crown Estate)	Guidance on Metocean numerical modelling of offshore wind

3.3 Perception of how well standards support business needs

The 33 contributors were asked to provide information on how they rated the standards in terms of supporting business needs. The majority of contributors (22) rated most standards as adequate or better, giving them scores of 3 or 4 on the 1 to 5 scale offered for ranking. Eleven contributors gave rankings of 2 (less than adequate), 1 (poorly) or 5 (supports business extremely well). In total 46 standards of the 185 listed by industry were felt to be less than adequate or poor, whilst 5 were held to offer good support.

In the context of this report it was considered particularly useful to identify those standards that were ranked at the extremes of the scoring ranges. The list of standards with rankings of 5 or 2 and lower is given in Appendix C. The standards that were rated highly were DNV-OS-J101, *Design of Offshore Wind Turbine Structures*; DNV-OS-J201, *Offshore Substations for Wind Farms*; and DNV-RP-H103, *Ship Transit Acceleration*. GL-IV-1, *Guideline for the Certification of Wind Turbines* was also rated highly, as was IEC 61400-22, *Wind turbines – Part 22: Conformity testing and certification*. The 46 standards that were felt to be less than adequate are presented in detail in Appendix C, and covered a range of different topics including:

- ASME – on piping and hydraulics;
- DNV – marine machinery and subsea engineering;
- EMEC – various guidelines;
- EN – electromagnetic compatibility and wind turbine protective measures;
- GL – guidelines on certification of ocean energy converters;
- IEC – various, such as wind turbine design, lightning protection, marine energy resource assessment;
- ISO – laboratory standards, 19901 series for petroleum and natural gas industries.

This information is extremely useful, as it indicates possible areas and topics for future standards-related activity whereby new standards can be drafted or already-existing standards can be improved/modified/revised. The verbal comments supplied by the contributors along with these rankings were most helpful, since the comments often acknowledged that industry was trying to use an existing standard or document in a new situation. It was perhaps not surprising that it was not always well-suited and that industry felt that it did not adequately support its needs.

3.4 Identification of industry problems

As summarized in Section 2 above, the interview and questionnaire data-gathering activities provided an insight into the business issues faced by the contributors. Given the desire to engage with a wide cross-section of organizations involved in offshore renewable energy, a diverse sample of views was obtained. In order to structure these into thematic areas it was deemed convenient to report these views based firstly upon their fit into the areas captured by the offshore renewable energy term and secondly into common areas of concern. Therefore it can be seen from the data presented in the tables below that in addition to the major headings of wind, wave and tidal, a further grouping was introduced under the subset headings of regulatory; technical; environmental; commercial; and social/political. One complication was that many of the contributors' organizations worked in one or more of the offshore renewable energy areas. It was deemed appropriate to add the additional major heading of 'General' to capture this dimension. Table 3 to Table 6 provide a breakdown of this data.

Table 3 – Summary of contributor business problem comments – General offshore renewable energy areas

Regulatory	None
Technical	• There is uncertainty about data and the limitations of equipment used for data collection for the purposes of characterizing the wind, wave, or tidal resource of a site. • The use of modelling techniques that are not fully validated. • Marine standards limit innovation in design process by introducing arbitrary changes in requirements around parameters such as Length Overall or Length Waterline, rather than functional considerations. • The harmonization of requirements is needed (this is valid for all standards and codes). • Renewable devices often require the control system to function and to limit the loads the device experiences; this requires modelling in the time domain, which can be time-consuming and requires sophisticated computing capability. In other offshore industries frequency response can be used, since there is no need to see the effect of the control system on load reduction – this makes for cheaper and quicker computer modelling.
Environmental	• There is lack of long-term data (Metocean, reliability).
Commercial	• Costs are too great (a general comment about marine energy).
Social/Political	None

Table 4 – Summary of contributor business problem comments – Wave offshore renewable energy area

Regulatory	None
Technical	• Plastic pipe water industry standards not ideal for use (e.g. leaks are considered acceptable). • Products are supplier/vendor-driven and this leads to difficulty in product selection and knowing which manufacturers' claims to believe. • It is difficult to find standards and many gaps exist in these standards. Where standards do exist in other industries they do not transpose well to WEC situations. • Standards currently being developed by TC 114 are too vague to be useful in practical engineering situations as they are too aspirational/ idealistic. • Design of Ladders – there are many different 'standards' that could be used and it is not clear as to which of them should prevail. • There is no roadmap that maps all the existing standards e.g. in oil and gas, shipping. This map would be really helpful.

	• Many standards give conflicting information and it is not obvious how to reconcile them and decide what is best. • There is a need to choose the most appropriate and most cost-effective/safe standards. • From a design point of view, existing design standards are focused on offshore wind and oil and gas industries and are not specific to the intricacies associated with the operation of wave and tidal energy devices in the aggressive marine environment. A level of engineering judgement is required in adopting existing rules to account for additional uncertainties associated with such devices. • There is confusion about the status of IEC Technical Specifications (TSs), such as those issued on Performance Assessment, whereby people feel they have to comply with all aspects of the TS to do a meaningful validation of a test. One contributor had great difficulty convincing people that as long as exceptions are documented and explained, the validation of testing that is not fully compliant is still valid. What follows from this is that if people do not use the TSs to carry out tests and validations, then improvement in the TSs towards full standards cannot ever be achieved, as improvement is reliant on people reporting their experience. • Model scale testing needs better guidance. • There needs to be a better correlation of sea-state to power output. • Guidance is required on actual power measurement. • There is very little standardization at device level and there could be better guidance on how things are tested. • The modelling tasks are unusual – some information on what is needed would be useful. • There is a lack of knowledge/experience in the wave energy field • As the technology and knowledge of technology/metocean environment is constantly evolving, it is sometimes hard to pinpoint the role of standards in this context, as adaptive approach is more important than standardization. • Insufficient consideration has been given to the holding power of the seabed specific to geotechnical conditions. This is a risk/concern area for Wavehub. Additionally, whilst Wavehub requires WEC developers to undertake third party structural integrity verification, they encounter a range of approaches from WEC developers in satisfying this requirement.
Environmental	• Modelling of sea-state,. Numerical techniques used in modelling WEC device and sea-state interactions are prone to significant errors.
Commercial	• The market is very small and for finance and insurance, it is not worth the effort, since the fees do not cover this effort. • There are uncertainties regarding the industry business model as to

	where project liabilities sit. • Investors lack confidence, meaning that it is very difficult to raise finance.
Social/Political	• Development is wholly dependent upon political will.

Table 5 – Summary of contributor business problem comments – Tidal offshore renewable energy area

Regulatory	• Offshore contractors used by SMEs have a choice regarding which offshore regulations to apply. It is not clear which regulations are best for applying to tidal deployment activities. • CDM Construction Design Management regulations are not well defined regarding offshore construction activities, particularly at the interface of differing regulatory organizations like MCA and the Health and Safety Executive. • Requirements of standards must harmonize with demands of UK regulatory consultees.
Technical	• From experience, the majority of today's designs are completed in accordance with standards developed by classification bodies (e.g. DNV, Lloyd's Register and GL) which all differ and are specific to an overarching certification route. There is a clear need for internationally accepted standards (i.e. ISO, IEC) that can be used with confidence and will ensure a level of consistency across designs. Similarly, a consistent approach to certification should also be defined. • There are no standards dedicated to this area. • The applications of DNV risk-centred methodology are difficult when risks are not well understood. • ISO oil and gas standards impose an unsuitable risk culture. • Standards have difficulty remaining up-to-date in an evolving sector. • In some cases (e.g. lifting at sea), existing standards give slightly conflicting results. • It is necessary to 'water-down' oil and gas SFs but there is uncertainty regarding how much. • Existing standards are not well suited to offshore renewables especially tidal applications. • Load cases defined in structural standards are not well suited to offshore renewable application especially tidal turbines. • There are gaps in GL 2010 structural design areas and some common failure modes have not been not considered, e.g. panel buckling in fibre reinforced plastic (FRP)sandwich structures. These are covered in other sectors like small craft, and design empirical equations exist. However amongst these other codes differing coefficients are used and the design

	basis leads to slight conflicts in results when using different methods. • There is confusion about the status of IEC TSs, such as those issued on Performance Assessment, whereby people feel they have to comply with all aspects of the TS to do a meaningful validation of a test. One contributor had great difficulty convincing people that as long as exceptions are documented and explained, the validation of testing that is not fully compliant is still valid. What follows from this is that if people do not use the TSs to carry out tests and validations, then improvement in the TSs towards full standards cannot ever be achieved, as improvement is reliant on people reporting their experience. • There is a lack of standardization of technology solutions.
Environmental	• If tidal resource data is incorrect, consequences will be felt for the lifetime of the project. • When customers asked one contributor about the reliability and accuracy of tidal stream measurement data, there were no standards against which to demonstrate oceanographic compliance. • There is no guideline of procedures to follow that ensure quality assurance is achieved for instrumentation configuration, operations and post-data analysis when conducting oceanographic surveys. • There is a lack of knowledge about the marine environment for which the design is applied, which introduces an inherently large risk factor associated with design. This includes knowledge of boundary layer effect, seabed friction behaviour, turbulence parameters and behaviour, and seabed pollution (neutrally buoyant debris). Information on assumptions for hydrodynamic loads currently exists, but this is largely unknown and is based on more benign (oil and gas) environments. • The measurement of tidal energy resource including aspects of turbulence, is an issue.
Commercial	• Installation is very dominant in capital expenditure (CAPEX) breakdown up to 60% at present. • Oil and gas standards are too risk-adverse and drive up costs to an unacceptably high CAPEX position. • The demands of OEMs for cost reduction is not realistic. • There is a lack of knowledge-sharing in the sector. • Oil and gas codes apply inappropriately high SF and result in 2 or 3 x cost escalation. The market is very small and for finance and insurance, it is not worth the effort, since the fees do not cover this effort.
Social/Political	None

Table 6 – Summary of contributor business problem comments – Wind offshore renewable energy area

Regulatory	• The classification of risks is not equally treated in all projects e.g. the transition piece between foundation and turbine tower on an offshore wind turbine -is it a confined space during construction phase?) • Personnel transfer (pilot ladder versus offshore wind (OSW structure example) is not uniform across different parts of the maritime sector.
Technical	• IEC 61400-24, *Wind turbines – Part 24: Lightning protection* is very ambiguous and customers want more than what is in the standard. Customers often demand more of the product (wind turbine) than the standards dictate. There can be quite a significant divergence between what customers want and what the standards offer them. Customers impose quite a lot of specifications, which may mean different versions of essentially the same product are needed. Standards and other similar documents can be too wordy – a more succinct document would be better. • There are too many oil and gas standards (which can be very conservative due to the need to protect personnel and the value of the assets) and there is a need for dedicated offshore wind standards that are better suited to this industry (e.g. foundation structures, substation, floating). • Industry may find it easier to use guidelines such as DNV or GL rather than standards, because guidelines often offer a set method for performing a requirement, which industry finds easier to comply with. This is unlike a standard, which may require more thought as to how to comply with it. • In regards to IEC 61400 22, *Wind turbines – Part 22: Conformity testing and certification,* there are several issues, due to the way in which IEC operates through its Standards Management Board (SMB) and its Certification Advisory Board (CAB). This is an internal management and systems issue within IEC, where a standard dealing with certification (IEC 61400-22) has somehow been controlled by the SMB rather than the CAB. It has caused some odd, unintended consequences within the wind industry and is gradually being sorted out; however, there is some resentment about how the process is being handled. This probably reflects that wind is now a serious part of the energy industry, whereas before it hardly rated any interest and IEC did not pay attention to the detail of how wind organized itself. Wind is now becoming like the other mainstream sectors, which IEC controls much more rigorously. • There is a problem due to an artificially created de-lineation between certification for turbines/foundations and certification for grid connection and transmission. There are different requirements, but the generator in the turbine is linked in a continuous way to the grid, so there is confusion about where responsibility lies for certifying the interface. It might be easy to state in theory, and for legal documents, but practically

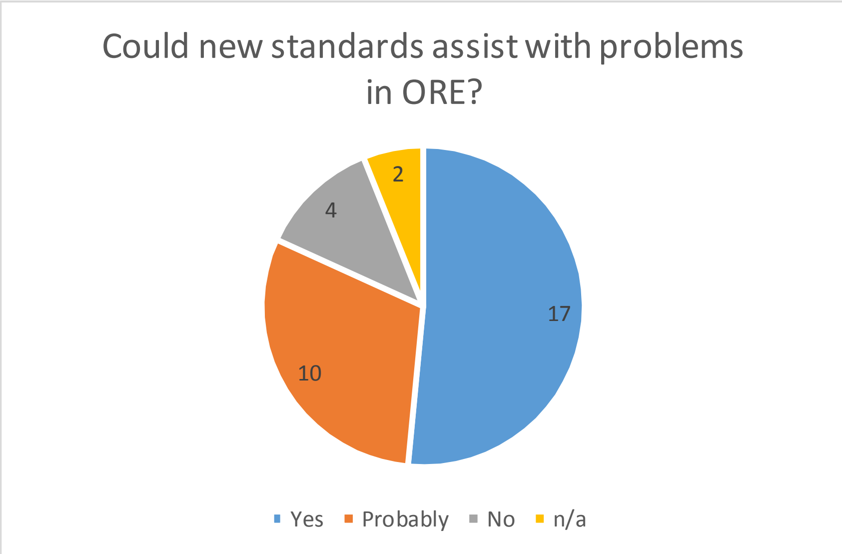
	it can make little sense and causes problems. • Quite often the size of bolts used offshore for wind energy is larger than the industry norm specifications. In these instances, you have to make a judgement about whether you go with company guidelines or calculate from first principles. • Often there is only a small choice (or no choice) regarding the supply of some types of components; this is due to the small size of the market. This also means there is a lack of standardization. The conformity assessment scheme in IEC is a major issue at the present time. There is confusion about IEC 61400-22, *Wind turbines – Part 22: Conformity testing and certification*, which is in the process of being resolved, but which is taking time and creating difficulty for certifying organizations. • Wind energy is an international business and so should ideally require international standards recognized by all the participating stakeholders, e.g. governments, owner's engineers. However, there is often a potential conflict with areas that are felt to be national responsibility, e.g. towers that are often dealt with under national civil engineering codes, driven by a national requirement. Offshore energy has often been easier than onshore since there are fewer organizations involved and much has been driven by American Petroleum Industry and DNV standards/guidelines. • Properties of materials used in cables and bend radius protection products are not well defined in standards. DNV-RPH-103 lacks sufficient information on form coefficients used in linear wave theory wave calculations. • New models and understanding of new models have not been incorporated quickly enough into standards. • There are almost no standards or guidance on control for wind turbines, which might be useful. • There is a requirement for operations and repairs standards for blades offshore. • A significant number of standards from the IEC 62300 series, EN Safety of Machinery and IEC 61400 series provide their users with issues when they apply them to offshore wind. • A key challenge is to match the two different approaches adopted by i) ISO in the oil and gas industry, which uses work and stress design and ii) IEC which uses load reaction/resistance as the basis for design.
Environmental	• The reality of the offshore wind resource and wave loading is not well understood at present. Extreme events need to be characterized better.
Commercial	• It is still too expensive (CAPEX); there needs to be cost-effective solutions for installation and O&M. • There exist supply chain issues: manufacturers (e.g. turbines, foundation, cables) are unlikely to meet the demand. • There are concerns regarding availability of data (commercial

	sensitivities).Different grid codes leads to different turbines meaning higher prices • Different safety codes leads to different turbines meaning higher prices, which confuses service technicians. • The industry should try to avoid national standards wherever possible, since this means that Siemens has to produce country-specific products (turbines) – it is why Siemens invests time and effort in the IEC work that covers more than one country.
Social/Political	• Policy issues – for example, in Germany offshore certification is a legal requirement and Germany has Bundesamt für Seeschifffahrt und Hydrographie (BSH) regulations for this. This is in contrast with the UK, where certification requirement is mainly driven by the need to secure finance. These two differing requirements mean that there are two types of certification schemes that have evolved and this is perhaps less efficient. The problem is also that with different systems for different countries it can be difficult to know which system to use. • The certification process could be improved (e.g. DNV 'monopoly'). • The industry should to avoid national standards wherever possible, since this means that Siemens has to produce country-specific products (turbines) – it is why Siemens invests time and effort in the IEC work that covers more than one country

3.5 Views on developing new standards

A summary of the 33 contributors' responses regarding their views on developing new standards is provided in Figure 5 below. The majority of responses favour the development of new standards. Seventeen answered 'yes', 10 answered 'probably', 4 answered 'no' and 2 declined to answer.

Figure 5 – Summary of contributors' responses about new standards solving business problems



Contributors were asked to provide their views as to whether or not the development of new standards would assist them in addressing the business problems they faced. In answering this question contributors were asked to select from the options of 'yes', 'no' or 'probably'. Many of the contributors opted to conform to the simple question and gave an answer in terms of the options provided. However, some contributors went further and also gave a brief narrative providing a commentary on why they had chosen the particular options. These comments are listed below in Table 7:

Table 7 – Comments regarding the development of new standards

Offshore renewable energy area	Answer	Business problem	Comment
Tidal	Probably	• There is a lack of standardization of technology solutions. • The lack of suitable methods and equipment for the measurement of tidal energy resource, including aspects of turbulence.	• There is concern that the knowledge and track record for tidal energy is absent and therefore it is very difficult to develop standards.
Wind	No	• Harmonization of requirements is needed (valid for all standards and codes).	• Relevant updates of the already-existing standards/codes may be needed.
Wave	Yes	• There are uncertainties regarding where project liabilities sit.	• Industry should avoid danger of duplication with other existing standards. It is better to use existing one than create new one wherever possible. • There are possibly not enough power production running hours to be able to standardize.
Wind	No	• Industry can find it easier to use guidelines such as DNV or GL rather than standards, because guidelines often offer a set method for performing a requirement, which industry finds easier to comply with. This is unlike a standard, which may require more thought as to how to comply with it. • Policy issues – for example, in Germany offshore certification is a legal requirement and Germany has BSH regulations for this. This is in contrast with the UK where the certification requirement is mainly driven by the need to secure finance. These two differing requirements mean that there are two types of certification schemes that have evolved; this is perhaps less efficient. The problem is also that with different	• There are probably enough standards. Should refine what exists; integrate them better; revise and add sections as needed.

		systems for different countries, it can be difficult to know which system to use.	
Tidal	No	No comments	• It is too early to develop standards.
Wave & tidal	Yes	• Renewable devices often require the control system to function and to limit the loads the device experiences. This requires modelling in the time domain, which can be time consuming and require sophisticated computing capability. In other offshore industries, frequency response can be used, since there is no need to see the effect of the control system on load reduction. This makes for cheaper and quicker computer modelling.	• The maturity of the industry defines what can usefully be achieved with standards.
Wind, wave & tidal	No	• There is a lack of standardization in marine (tidal/wave) energy. • The market is very small and for finance and insurance, it is not worth the effort, since the fees do not cover this effort. • The costs are too great – a general comment for marine energy.	• There is uncertainty about whether new standards are needed. For the insurance industry it would be better if existing standards could be used, with these standards better tied together.
Wind and tidal	Yes	• Personnel transfer (Pilot ladder versus OSW structure example) is not uniform. • The classification of risks is not equally treated in all projects e.g. transition piece (is it a confined space during construction phase?)	• In the development of standards developed by H&S professionals, offshore practitioners have not adequately been consulted.
Wave	No	• Business is wholly dependent upon political backing and getting finance is very difficult.	• Demonstration and track record of technology is required. • As the technology and knowledge of technology/Metocean environment is constantly evolving, it is sometimes hard to pinpoint the role of standards in this context as adaptive approach is more important than standardization.

Wind	Probably	• Standards and other similar documents can be too wordy – a more succinct document would be better. • Customers often demand more of the product (wind turbine) than the standards dictate. There can be quite a significant divergence between customers' demands and what standards outline them. Customers impose quite a lot of specifications, which may mean different versions of essentially the same product are needed. IEC 61400-24, *Wind turbines – Part 24: Lightning protection* is very ambiguous and customers want more than what is in the standard.	• Yes – but only in some areas. But also, No – re-write those that can be improved, so as not to introduce even more documents into the industry

3.6 Standards development topics proposed by contributors

As summarized in the methodology section above, the interview and questionnaire data-gathering activities invited the contributors to provide comment on the topics that they thought worthy of standards-development effort. Similarly as for the 'contributor identification of problems' section, a complementary approach of grouping the contributors' comments thematically was adopted in order to characterize the broad spread of feedback. Table 8 to Table 11 provide a breakdown of this data.

Table 8 – Summary of contributor topics for standards development – General offshore renewable energy area

Regulatory	
Technical	• A goal-based approach for safety standards would be better than prescriptive standards. • Innovation in installation, perhaps by large offshore contractors, is a key area – although they will need to see an extensive market and profits before they will enter the market in earnest. • For design-related standards the type of standard that can be written is dependent on whether convergence on a typical design of device has been achieved in the market. For example in the wind industry, turbines are rather similar in design and more proscriptive standards can be possible. However, in wave & tidal, designs are very dissimilar and maybe more goal-based standards need to be produced, since these allow innovation by putting the onus on the designer to show how the device complies with the goal/requirement.
Environmental	• An environmental performance standard (summary of agreements with regulators) was suggested.
Commercial	• It would be better to expand an existing set of standards, rather than write new ones. It could take anywhere between 5 to 15 years for the insurance industry to become comfortable with new standards, which

	would create delay.
Social/Political	None

Table 9 – Summary of contributor topics for standards development – Wave offshore renewable energy area

Regulatory	None
Technical	• The load cases for marine (wave & tidal) devices would be useful to define, as is done for wind in IEC 61400-1, *Wind turbines – Part 1: Design requirements*. • Offshore standards specific to wave and tidal energy devices rather than the use of existing standards are a good idea, e.g. the offshore wind and oil/gas codes. A suite of standards is currently being developed by IEC TC 114/TS 62600. • One contributor would like to see more a widely-recognized uniform approach regarding third party verification. • Standards and design processes are good when considering the elements of mooring systems but sometimes ambiguous regarding seabed connection. • One contributor would like to see a more holistic mooring standard. • Standards will have more of an impact post-2020 when technologies have been demonstrated at a commercial scale i.e. >10 MW farms. • An indexing or search tool would be very helpful to make the most of standards that do currently exist. • It would be good to develop a standard/standards against which to specify flywheel and pelton turbine supply against rotating machinery standards, covering low pressure plastic pipe. • It would be useful to have a route map to help navigate through the many existing standards. • The industry should try to use existing ones, rather than develop new ones.
Environmental	None
Commercial	• The overall goal would be standards that guide towards low-cost high-reliability, unmanned power plant design solutions.
Social/Political	None

Table 10 – Summary of contributor topics for standards development – Tidal offshore renewable energy area

Regulatory	• CDM clarification work should be applied to align differing H&S cultures and training requirements to a uniform level across different maritime sectors.
Technical	Suggested topics included: • Offshore installation guide; • Installation deployment methods; • O&M guide; • Seabed stability; • Improvements in grouted connection; • Anything that would address the matching sensors and measurement tools for collection of suitable data for site characterization (for example for measurement of turbulence). Others comments included the following: • Industry should develop offshore standards specific to wave and tidal energy devices, rather than use of existing standards, e.g. the offshore wind and oil/gas codes. A suite of standards is currently being developed by IEC TC114/ TS 62600. • The load cases for marine (wave & tidal) devices would be useful to define, as is done for wind in IEC 61400-1, *Wind turbines – Part 1: Design requirements.* • The GL certification scheme should be refined. Subsea cables should be used in tidal applications. • Environmental loads for electrical equipment in DNV-OS specifications are weak in specifying shock, vibration and temp conditions. • Recognized turbulence modelling parameters and standardized equations for tidal resource assessment are needed. • IEC/TC 114 is lacking in some areas of expertise (a committee member noted vested interests from some contributors and other constraints which were hindering dove tailing with other IEC 62600 series documents) • There is a preference for design codes that contain a highly prescriptive process, either with high safety factors (SF) or with the option to engineer from 1st principles and then justify that the design solution is OK. This would be a mix of the methods in the GL2010 and DNV codes. • Standards or guidance on the use of specialist vessels such as jack up and dynamically positioned (DPs) vessels in strong tidal flows may be important for cost effective construction and maintenance of tidal energy projects. • There was concern raised that the knowledge and track record for tidal

	energy is absent and therefore it is very difficult to develop standards.
Environmental	• Tidal environment-appropriate topics were suggested (e.g. GEOtech, loading, corrosion, abrasion issues). • Corrosion, abrasion and erosion for tidal applications were also highlighted as being important.
Commercial	None
Social/Political	None.

Table 11 – Summary of contributor topics for standards development – Wind offshore renewable energy area

Regulatory	• A suggested topic was wind turbine and farm control, with flexible control options. • Medical requirement ENG1 is too low as offshore wind access is far more strenuous than oil and gas helipad landing. Personnel transfer regulations are not adequate. • There is a conflict with culture of other sectors e.g. pilot ladders • There is a need to define acceptable ways of working on blades offshore. • Specific H&S issues need to be addressed.
Technical	Suggested topics included: • Lightning protection; • Control of in-service repair and maintenance to ensure it is at the correct level/standard; • Control systems for turbines (these interact to mitigate some load cases); • Offshore turbines and wakes; • Expansion of DNV-RPH-103 coefficients for ship accelerations via new experimental work performed in testing tanks; • Polymer and Plastic properties, fatigue, and environmental degradation; • Unmanned non-hydrocarbon offshore structures; • Wind turbine condition monitoring, wind turbine performance, wakes, wind resource; • Shipping of wind turbines components, stowage and clamping; • Survival and rescue systems; • Characterization of corrosion in electrical equipment, installations and electronics; • Ice loads on sub-structures; • Lightning protection;

	• Ability to require a blade repair to reach a defined standard; • Standards that facilitate the interchange of information e.g. wind supervisory control and data acquisition standard protocol. Others comments included the following: • Standards need to be able to cope with innovation, and this means that standards must not be to proscriptive about how a particular requirement must be met. • From a design engineer perspective there is already an adequate set of standard/guidelines for designing a wind turbine, therefore more are not needed. • More harmonisation would really help, e.g. for using new standards to tie existing ones together in a coherent structure.
Environmental	None
Commercial	• National standards will not be helpful. The industry needs international standards to drive down costs and ensure a high personal safety level. • There should be more standard template contracts for commercial documents like non-disclosure agreements.
Social/Political	• Understanding the social aspects of how offshore wind farms will benefit communities – through the provision of long-term jobs, e.g. for O&M – is important

3.7 Industry direction

As summarized in the methodology section above, the interview and questionnaire data-gathering activities provided an insight into the growth potential of offshore renewable energy as provided by the contributors. In collating this information it was convenient to group the responses into the offshore renewable energy areas of wind, wave and tidal. Additionally some contributors made comments that they applied with equal weighting to all areas within offshore renewable energy, hence a further combined grouping of Wave and Tidal has also been included. Table 12 to Table 15 provide a breakdown of this data.

Table 12 – Trend comments provided jointly for wave and tidal

Utilities needs to scale back on ambition.
The industry is currently being stemmed by two main factors, the first of which is the grid capacity currently available and the support to develop a transmission network that supports offshore renewables. A developed grid that adequately serves the Highlands and Islands is critical to the industry achieving the full market potential of c. 5% UK demand from wave and tidal energy. An adequate transmission network that is developed quickly and efficiently will allow rapid economic progression to larger-rated units (3 MW and above) and numbers of deployed units that make blue chip investment at array level, worthwhile.
The second major restrictive factor in the offshore renewables industry is the ability to install devices quickly and efficiently using existing installation vessels and technology, due to the harsh nature of the marine environment. This is proving to be a major cost driver that carries risk

throughout the planning, design and installation processes due to many associated unknowns. A standard that is developed with respect to installation parameters and costing may give additional confidence to investors, which will boost the industries chance of success.
Can't see path of anything other than small TEC and WEC arrays this side of 2020.
The worldwide market is large; however, it cannot be accessed until there are a small number of viable ocean energy generation technologies that are proven as reliable. The experience of the next few years is crucial in shaping long-term plans.
Power ratings of many machines will not go above 2 MW; the scale of device even for 1 MW output is substantial and this mitigates against very much larger devices.
Timescales are difficult (the industry thinks in terms of numbers deployed); a few technologies need to be established as operable and reliable.
At present the UK industry will struggle to get to more than some 40 MW – 50 MW deployed by 2020; this is mostly due to the ongoing need for funding.
Access to grid will determine growth rates.
There will be more tidal devices than wave devices.

Table 13 – Trend comments provided only for wave

WECs <20 MW are based upon array scale deployment plans. Present industry capacity figures for 2020 are generally over-optimistic.
Wave technology is not developing very rapidly and this will restrain deployment.
WEC installation will be between 10 to 20 MW by 2020.
By 2020 I anticipate towards 10 MW of wave energy convertors (WECs) will have been installed.
The timescale for deployment of larger numbers of wave devices may be extended to 10+ years.
The wave sector is very unlikely to progress beyond the threshold of 10 MW of projects already in planning.
A few small arrays of wave devices could be deployed in 10 years; however, an optimistic scenario is that it will be a minimum of 10 years before there is any manufacture of devices in significant numbers,
By 2020, WEC installations will be <10 MW.
One contributor said that based upon company business plans, they will be responsible for 3 MW of WEC generation by 2018 and will have plans to see this expanded to a further 20 to 40 one x MW units over the following years.
Wave energy is in a contraction period at the moment, and it is presently a very difficult market. One contributor said their company may install a device in the next 10 years. At best, it is foreseeable that they could install 3 x 2.5 MW units by 202.
Arrays and initiatives such as WaveHub will progress slowly and not see significant progress until 15–20 years has elapsed.

Table 14 – Trend comments provided only for tidal

There is enough momentum to see some arrays been deployed – 10 to 30 MW. If arrays are successful it is expected that a reasonable size of market will emerge, provided that the supporting infrastructure (e.g. grid connection points) is provided on a 5-year timescale
Tidal energy 30 MW by 2020 is based upon 4 or 5 current array scale projects.
One contributor said that there is a sense that confidence of tidal sector has reduced in the last 12 months and that within their company, demand for tidal services has peaked.
If arrays are successful it is expected that a reasonable size of market will be possible, provided that infrastructure is provided. Market size could be1 – 10 gigawatts [GW]) on a 15-year timeframe.
TEC <40 MW by 2022 are based upon array scale deployment plans. One contributor thinks that present industry 2020 capacity figures are generally over-optimistic.
75 MW TEC by 2020 at typically 1MW units
There needs to be a minimum power rating of 1 MW for TECs to achieve commercial success.
An optimistic view is that there could be larger numbers deployed in 5 to 7 years.
By 2020 up to 3 TEC arrays of between 10 to 20 MW per array will exist.
The first arrays of 3 to 5 units will appear in around 2015; 2017 will see 10 MW arrays; 2020 will see 50 MW arrays.
The TEC 2020 market will see arrays of 5 to 10 units per farm, with arrays of 40 to 100 units in development but not deployed.
One contributor believed that ReUK Industry Statements should be referred to.
For tidal machines the size will be about 1 MW and the deployed number will be several 10s of devices.
For tidal there will be small arrays of machines in 10 years at an approximate 10 MW scale.
2020 will see 20 MW to 50 MW TEC capacity with additional capacity up to 500 MW in planning.
Tidal at 'tipping' point, some convergence is helpful although commercial success is not certain, for example due to very high development costs creating a barrier.
22 m to 30 m rotor diameter will be become typical in future on >1 MW units.

Table 15 – Trend comments provided only for wind

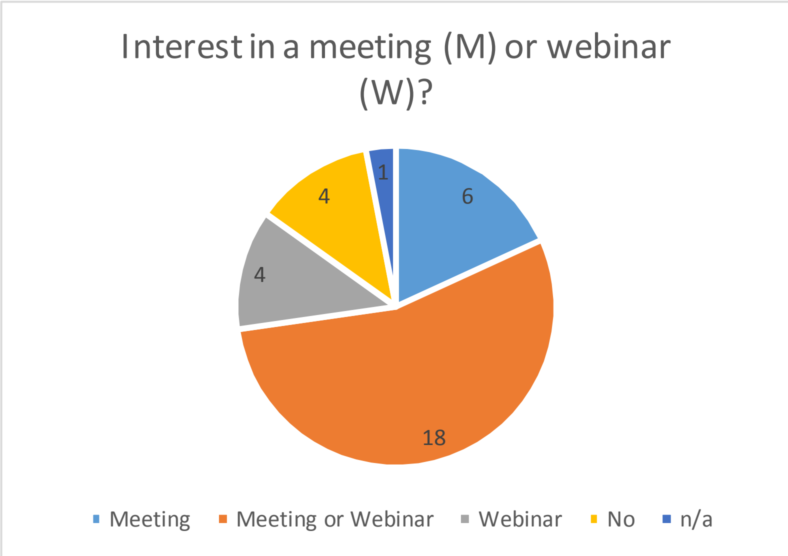
There are trends towards increasing internationalization in offshore wind turbine supply chain.
There is a growing importance of floating offshore wind.
There exists stagnation in the market, with problems and costs related to larger distances and high-voltage direct current.
For some years the power rating will hopefully stay in the 6 MW range. By 2020, this rating should be higher.
Offshore wind will deploy the large Round 3 farms before 2020, but will probably be completed

later than forecast.
The largest that wind turbines will reach will most likely be 10 MW.
The size of the market is very dependent on UK Government policy. Some projects are being held back till after the 2014 Scottish independence vote. The Round 3 projections are probably realistic in terms of maximum overall size of market in UK.
Saturation of the market has not yet been reached in the UK, and therefore the numbers of turbines deployed will increase.
UK OSW Round 3 has consumed all investment appetite of major Utilities; Round 4 and floating wind are significantly post-2020 propositions.
A further 20 GW of offshore wind is certainly possible in the next 10 years. Without this sort of scale there will be little reason for OEMs to undertake the major investments needed to help the market grow.
Future trends will move towards less-sophisticated wind turbines.
Floating wind and 10 MW per unit turbines are post-2020 technology solutions.
Round 3 (offshore wind) initially received enthusiastic responses from the industry. However, timescales have now been extended. Some still say it will start in 2015, but this date could be later. There is no doubt that the market will be big enough (several 10s of GW).
Turbine sizes will get bigger than the 7–8M W sizes seen today. There are no physical limitations, and so larger rotors and increased power will be seen.
The numbers deployed will continue to increase, but perhaps not quite as fast as projected. The deployment is achievable; it may just perhaps be larger and take longer than anticipated.
The 2020 target dates may well become 2030 dates. The recent announcements about nuclear new build may delay investments in offshore wind.
The numbers to be deployed are slipping to later dates, and becoming less predictable.
2014 is acting as a hold point for some projects in terms of timing. 2020 is also a target date, e.g. 100% renewables in Scotland by then.
Wind turbines fixed to the seabed will stay in the 5 to 8 MW size range. Floating turbines may need higher powers to justify the expense of any additional infrastructure.

3.8 Dissemination and workshop event

Of the 33 contributors, there was a significant majority in favour of an event such as a workshop to disseminate the results of the survey and to consider future standards development requirements (see Figure 6). Six were in favour of a physical meeting, 18 were interested in either a physical meeting or a virtual/web-based event and a further 4 interested mainly in a web-based event. This gave a total of 28 who were interested in a meeting or webinar. Five respondents did not want to attend either type of event.

Figure 6 – Respondents' preferences for a meeting or webinar



Of the 33 respondents, 30 agreed that their contact details could be used to send information on the results of the survey and to receive invitations to events related to standards activities. Two respondents did not wish to have their details added to mailing lists and one respondent felt the question was not applicable.

4 Analysis

Building upon the results, Section 3 the following analysis was undertaken.

4.1 Contributor statistics

A range of different types of organizations were contacted across nine industry areas. Fifty contacts were made and 33 completed questionnaires and interviews were completed, giving a response rate of 66%. The breakdown for the number of each type of business area is shown in Figure 1**Error! Reference source not found.**. There was a fairly even spread of business types that were able to contribute to the interviews, indicating that the questionnaire covered the important parts of the overall offshore renewable energy industry supply chain.

The technology area that each of the contributors was involved in was checked. The largest grouping was for organizations that are involved with all three technologies of wind, tidal and wave. It is interesting to note that there are 23 organizations involved with wind energy; 21 organizations involved with tidal; and also 21 involved with wave energy. This information reveals how the three technology areas of wind, wave and tidal are inter-related. However, there are also differences, which allow for specialization in the skills that each of the organizations deploy.

The contributors gave information on their turnover in the offshore renewable energy sector and their number of employees active in the offshore renewable energy sector. This information is presented in Figure 3 and Figure 4. There was an even distribution of organizations across the range of turnovers, except for at the very smallest business scale (with turnover less than £0.5 million) where there was only one organization. Twelve organizations have turnovers greater than £25 million; 7 organizations have turnovers in the £5 million to £25 million range; and 11 organizations are in the £0.5 to £5 million turnover range. The majority, nearly half of the 33 organizations, have between 5 and 50 employees working on offshore renewable energy activities. The next largest number is the 12 organizations with over 251 employees, which are the same 12 organizations with turnovers greater than £25 million. This range of business sizes by both turnover and employee number is useful as it reveals that the information from the survey and questionnaire is representative of a range of views. The information gained is not dominated either by large or small organizations and their particular concerns or points-of-view. With the information on contributor statistics it is possible to state that through the questionnaire, the survey has achieved its purpose of obtaining a representative and fair selection of relevant information on standards use in offshore renewable energy.

4.2 Standards use

The main information gained about the use of standards within offshore renewable energy is that there is a very extensive range of standards that are already used, plus many more standards in related industries that the offshore renewable energy industry does not use – either through lack of awareness, or by choice in that they are not felt to be suitable. In total 335 standards and standard-type documents were found, with a significant overlap between standards identified by BSI and those used by industry.

There were 50 standards found that were both used by industry and found in the BSI listing and these were from the following organizations:

- ASME;
- DNV;
- EMEC;
- EN;
- GL;
- IEC;
- IEEE;
- ISO;
- RenewableUK.

A list of these standards is presented in Table 2. The range of topics covered is significant, as inspection of the titles of the documents reveals. The combination of the industry questionnaire and the BSI review has given a good view of the numerous standards and similar documents both used currently by the industry and available for use. A full listing of the 335 standards is presented in Appendix B. It is interesting to note that there were only a few standards that were consistently selected for use by industry, with only 14 standards having 5 or more users. Many standards had only one industry user, indicating how the offshore renewable energy industry has had to piece together the suite of standards it uses, and that there has only been limited, informal consensus on the most suitable standards to use.

With the large number of possible documents (335 or more), it is interesting to note the comments of several of the contributors, who asked for guidance or 'route maps' for the offshore renewable energy sector and the many documents that could be used. It is suggested that the *Offshore Renewable Energy Standardization Review 2013* report provides a useful overview, along with the detail, of the current situation and can act as a seed' for future route maps, as well as provide a greater understanding of the standards landscape for offshore renewable energy.

4.3 Perception of how well standards support business needs

The 33 contributors rated the standards in terms of how well they supported business needs. The majority of contributors rated most of the standards they used as adequate or better, with 5 standards being singled out and given the highest rating of excellent. In total 139 standards (75%) of the 185 listed by industry were felt to be adequate or better. Nine contributors made comments that standards were less than adequate, or poor. In total 46 standards (25%) of the 185 listed by industry were felt to be less than adequate or poor.

The list of standards of all rankings is given in Appendix B. The standards that were rated highly were three by DNV: DNV-OS-J101, *Design of Offshore Wind Turbine Structures*; DNV-OS-J201, *Offshore Substations for Wind Farms;* and DNV-RP-H103, *Ship Transit Acceleration*. GL-IV-1, *Guideline for the Certification of Wind Turbines* was also rated highly, as was IEC-61400-22, *Wind turbines – Part 22: Conformity testing and certification*.

The 46 standards that were felt to be less than adequate covered a range of different topics including:

- ASME – piping and hydraulics;
- DNV – marine machinery, design of offshore structures, subsea engineering;
- EMEC – various guidelines;
- EN – electromagnetic compatibility and wind turbine protective measures;
- GL – guidelines on certification of offshore turbines and ocean energy convertors;
- IEC – various, such as wind turbine design, lightning protection, marine energy resource assessment;
- ISO – laboratory standards, 19901 series for petroleum and natural gas industries.

This information is extremely useful, as it indicates possible areas and topics for future standards-related activity whereby new standards can be drafted or already-existing standards can be improved/modified/revised. The verbal comments supplied by the contributors along with these rankings were valuable, since the comments often acknowledged that industry was attempting to use an existing standard or document in a new situation. It was perhaps not surprising that the requirements in the standard/document were not always well suited and industry felt that it did not adequately support its needs. This is useful information to support the continued development of better-suited and better-targeted standards, since using an inappropriate document is unsatisfactory for both the user and the potential recipient of any criticism. It should be noted though that 75% of the standards were rated as adequate or better, indicating that when done well, standards are useful to industry. When considering the ranking attributed to the standards used within the contributors' organizations it is worth noting that in the event that a standard is considered to be a poor fit to business requirements, understandably a reluctance to use it will be found. As a result, the questionnaire responses have a natural bias away from identifying very poorly performing standards within this section of the questionnaire.

4.4 Industry problems identified by contributors

Following on from the offshore renewable energy context it was convenient to consider separately the areas of wind, wave and tidal stream.

4.4.1 Issues identified in the wave sector

Wave energy is at a stage of relatively limited technical maturity, resulting in no discernible technology consolidation; many of the issues identified by those working in this offshore renewable energy sector hinge upon this fact. In particular the wave OEMs voiced the view that they are not able to find standards that are well-suited to their technologies and the wave energy environment. They stated that they are faced with the double issue of firstly locating a standard in another industrial area and secondly translating and extrapolating its requirements into their specific applications. The view was expressed that this also led to the dilemma of potentially locating several different standards that when applied to wave energy engineering provide inconsistent solutions and it is then not clear how to reconcile these differences. The process of trying to find 'best-match' standards was noted as being time-consuming and an erratic process.

A number of specific technical issues were highlighted in the lack of standardized procedures about scale-model testing and numerical modelling validation for predicting WEC performance in various sea-conditions. In addition, the problem of an absence of knowledge and experience was a noted barrier to WEC development. The existence of IEC WEC TSs was not felt to be providing sufficient practical engineering guidance at a level of detail capable solving WEC sector problems. The reasons given for this reflect the diversity in the WEC technologies under development. It was expressed that the generality of WEC TSs resulted in an overly vague document.

4.4.2 Issues identified in the tidal sector

The tidal energy sector, like wave energy, is also at a relatively limited stage of maturity. A significant number of the tidal offshore renewable energy area contributors identified the problem of the uncertainty of the tidal environment itself. These issues cover the factors of seabed stability, turbulence and the ability to measure turbulence. This issues stems from the limited maturity of the tidal offshore renewable energy sector and the absence of both theoretical and operational knowledge. There was also an issue of an absence of standardization in conducting tidal flow measurement campaigns and data analysis.

The use of oil and gas sector standards was considered to be less than optimal. A viewpoint given was that these standards are based upon a highly onerous risk culture, which was not directly applicable to TECs. It was pointed out that these differences are linked to manned and unmanned platforms, hydrocarbon explosives and pollution incident implications. The use of the inappropriately high safety factors used in current TEC projects was suggested to increase structural costs by a factor of up to threefold. The cost of installation was noted as being unsustainability high for the longer-term successful development of tidal energy.

4.4.3 Issues identified in the wind sector

The offshore wind industry is at a relatively mature state of development compared with tidal and wave, but is not as advanced as onshore wind. The issues noted by the offshore renewable energy wind industry were either of a very specific, focused technical nature or, at the opposite end of the spectrum, were very broad. The detailed comments made by the contributors are provided in Table 6 and a distillation is provided below.

The broad issues were often related to harmonization across differing standards organizations or between national and international standards. Examples include the difference between the ISO codes widely used in oil and gas and the work and stress basis used for design, compared with the IEC codes that often use a load case basis for design. The difference in grid codes between nations was highlighted as a problem in having to design different turbines for different geographical regions, which increases cost. A widely reported view was on the preference for internationally recognized standards wherever possible, but that this often conflicted with areas that were held to be of national responsibility such as H&S or design of civil structures. This difference between national and international policy was noted in the requirements for certification, which in some countries is a legal requirement whilst in others it is merely a pre-requisite for securing finance.

The more focused technical problem areas included:

- lightning strike and how to provide the increased demands often being placed by customers of turbines;
- the arbitrary nature of the division between grid and turbine certification – the turbine is directly connected to the grid, so why the divide?
- the slowness with which new models and understanding are incorporated into standards;
- the lack of in-depth knowledge of the true nature of the wind resource and the wave loading conditions.

From a commercial perspective it was suggested that there were problems due to the high capital expense associated with installation, along with the fact that the supply chain for much of the offshore wind sector was increasingly constrained.

4.5 Support for the development of new standards

The contributors' opinions and comments about the need to develop new standards geared towards resolving their business issues provided a helpful insight into a number of important factors. On the basis of the responses (see Figure 3.6) it is clear for the sample interviewed that there is significant support for the development of new standards. This is indicated by the replies to the question, 'Could new standards assist with your business problems and issues?', with 51% affirmative 'yes' replies and 30% positive 'probably' replies. However it is worth bearing in mind that this sample could be positively biased towards standards and their development; this is because these contributors represent the 66% of those initially contacted who ultimately were prepared to allocate time to being interviewed. Of the remaining 33% who did not respond to the process of being contacted by email and follow-up phone calls requesting an interview, it is not clear if their absence of input is due to lack of interest or simply other conflicting time demands.

Further insight into the nature of standard development is possible by analysis of the contributors who offered some clarification about their answers. Based upon a review of

Table 7 it was interesting to note that these ten contributors span both the range of all offshore renewable energy areas and all the potential answer options. Several common strands were evident when considering these comments in further detail:

- For all the wind-related comments, the contributors expressed the common sentiment that it is by far preferable to revise the existing standards wherever possible, rather than initiate new wind standards.
- For the wave and tidal comments, the contributors articulated a concern that insufficient knowledge exists within this emerging sector to make the development of new standards desirable. Further to this a secondary issue was noted that particularly within wave energy, there is a lack of technology consolidation, which make standardization very problematic. It was interesting to note that the contributors who raised these points span the complete range of 'yes', 'no' and 'probably' answers. This suggests that although different

contributors share similar concerns, they do not apportion the same views about the value of standards development in resolving them.

4.6 Standards development topics proposed by contributors

In considering the topics that were highlighted as potentially requiring new or improved standards, it was useful to subdivide the needs of the wind as separate from wave and tidal.

4.6.1 Tidal and wave devices

The following topics for future standards development were suggested for tidal and wave:

- Load cases for both wave and tidal devices that are based upon correctly represented environmental conditions (new, specification or guide);
- Guidelines on best practice installation techniques for the range of marine infrastructure being used in the deployment of TECs (new, specification or guide);
- Seabed rock stability and capacity to bear the static and dynamic loads resulting from placing large items of equipment on the seabed. This includes guidance on the measurement and qualification of geotechnical conditions related to the nature of the equipment and environmental loads (new, specification);
- Mooring systems – making use of revised information relevant to these types of device;
- Parameters for modelling turbulence and equipment requirements for its measurement in the marine environment (new, guide);
- Corrosion, abrasion and erosion of material and its degradation resulting from prolonged application in highly energetic tidal stream conditions (revised where available or new, specification).

It was noted though that for wave energy there could be difficulty in developing standards due to the fact that within the industry, there is still a great deal of innovation and difference in the physical form of the WEC devices. These differences in device types makes it difficult to devise standards and documents that can be fully relevant or applied to this wide range of potential device shapes, sizes and forms.

4.6.2 Wind turbines

The following topics for future standards development were suggested for wind:

- Control systems for wind turbines and farms (new, guide);
- Blade repair (new, specification);
- In-service maintenance and repair (all systems) (new, guide);
- Shipping, stowage and clamping of wind turbine components (new, guide or specification);
- Data exchange (improved, specification);
- Lightning protection (improved, specification;
- Development of firmer guidance on the requirements in EIA of offshore renewable energy statuary stakeholders (new, route map or guide).

Within the wind sector there was a strong preference for modifications and improvements of existing standards, rather than new standards.

4.6.3 General topics

There were several other topics suggested of a more general nature. Two prominent contributors expressed opinions for:

- Route mapping – provision of guides for the existing plethora of standards and documents that could be used;
- Harmonization between both national and international codes, and between codes of different standards organizations.

4.7 Industry direction

The contributors' views on the growth trends that will be seen in offshore renewable energy provided useful evidence upon which to base the prioritization of future standards activities. As was apparent even before embarking upon this exercise the relative maturity of the differing areas within offshore renewable energy would be very influential; this was particularly true where the topic of predicted growth was considered.

4.7.1 Wave and tidal growth

Overall the view was reflected that the official growth rates of the wave and tidal sector were over-estimated. Even the most optimistic of the contributors thought that installed wave and tidal power generation would not exceed 100 MWs by 2020. In fact many of the contributors suggested that for wave energy, around 10 MW would be installed by 2020, while for tidal energy the equivalent figure was typically on average around the 30 MW to 40 MW range. Many contributors pointed towards the 3 or 4 tidal array projects that are in planning in considering the sectors potential growth over the next 5-year timeframe. Many of the contributors expressed a note of concern about the future route map and the medium term viability of wave and tidal energy. This concern was expressed especially about wave energy.

4.7.2 Wind growth

Contributors' views about the future growth of offshore wind did not follow the same pattern as those expressed for wave and tidal growth. Instead of predicting the size of the market by attributing a GW installed capacity figure with a certain timeframe, many contributors tended to answer in terms of the anticipated physical power rating size of turbines. The view was expressed that turbines would continue to increase in physical size and progress towards a 10 MW region. The topic of floating offshore wind was noted by a handful of contributors as technology that would not see commercial exploitation until a date beyond the close of this decade. Overall a note of caution was sounded that the growth predictions and targets widely reported in the media several years ago are looking artificially optimistic. Project timelines have been slipping, with one contributor stating that '2020 targets are starting to look like 2030 targets'. The reasons behind this slower-than-anticipated growth in offshore wind are driven by the general economic slowdown post-Financial Crisis, political uncertainty about feed-in-tariffs and Scottish Devolution.

4.8 Interest in dissemination/workshop event

The contributors showed a significant preference in favour of an event such as a workshop to disseminate the results of the survey and to consider future standards development requirements – with 28 interested in a meeting or webinar (see Figure 6). Five respondents did not want to attend either type of event.

Thirty contributors agreed that their contact details could be used to send information on the results of the survey and to receive invitations to events related to standards activities. Two respondents did not wish to have their details added to mailing lists and one respondent felt the question was not applicable.

An event to start the process of dissemination was held for the tidal community at the Tidal UK event in London on 26–27 November 2013 in London. Representatives from BSI attended this event as well as Jamie Grimwade.

The contributors based within the wind industry were generally supportive of an event to understand what information the survey had collected. If there needed to be significant discussion and negotiation then a physical event was generally felt to be of most use – although some contributors noted that time constraints might limit their ability to attend a physical meeting, in which case some form of web-based event would be an acceptable alternative.

5 Conclusions and recommendations

The originally stated requirement from BSI for the required work is reproduced in the following three bullet points:

- The Purpose of the work undertaken in the project was to produce a report on where standards are needed in offshore renewable energy.
- The Objective of the project commissioned by BSI was to perform a strategic review that will inform the direction and actions of BSI as it relates to the future needs of offshore renewable energy.
- The Scope of the project was a gap analysis of standards provision, an indication of the demand for 'missing' standards from the sector and a proposed strategy for meeting the demand. Identification of the opportunities to transfer or to adapt pre-existing standards that have been developed by other branches of the maritime and power generation sectors.

The first requirement has been met by:

- performing a series of structured telephone interviews with organizations and people active in offshore renewable energy, aimed at understanding their use of and need for standards;
- collating and analysing the information collected in the telephone interviews;
- devising a means of presenting the information in figures and tables;
- producing this report.

The second requirement on informing the direction, plus the various requirements in the third item have been met by:

- developing lists of topics and problem areas;
- further analysis and presentation, as shown in Section 4.4 of this report;
- compiling a list of potential topics for further standards work, presented in Section 4.6 of this present report

5.1 Offshore renewable energy-identified issues

The key items outlined in section 4.4 on industry problems identified by contributors are below.

5.1.1 Issues identified in the wave sector

Wave energy is at a stage of relatively limited technical maturity, resulting in no discernible technology consolidation; many of the issues in this offshore renewable energy sector hinge upon this fact. Wave OEMs are unable to find standards that are well-suited to their technologies and the wave energy environment. They are faced with two issues: i) locating standards from another industrial area and ii) translating and extrapolating their requirements into their specific applications. This also led to the dilemma of using several different standards that, when applied to wave energy engineering, provide inconsistent solutions with no guidance on how to reconcile these differences. The process of trying to find standards was noted as being time-consuming and erratic.

Specific technical issues were highlighted regarding the lack of standardized procedures about scale-model testing and numerical modelling validation for predicting WEC performance in various sea conditions. The problem of an absence of knowledge and experience was a noted barrier to WEC development. The existence of IEC WEC TCs was not felt to be providing sufficient practical engineering guidance at a level of detail capable of solving WEC sector problems. The reasons given for this reflect the diversity in the WEC technologies under development. The generality of WEC TSs results in overly vague documents.

5.1.2 Issues identified in the tidal sector

The tidal energy sector is also at a relatively limited stage of maturity. A key problem is the uncertainty of the tidal environment itself. The issues identified in this sector cover the factors of seabed stability, turbulence and the ability to measure turbulence. This issues stems from the limited maturity of the tidal offshore renewable energy sector and the absence of both theoretical and operational knowledge. There is also an issue of an absence of standardization in conducting tidal flow measurement campaigns and data analysis.

The use of oil and gas sector standards was considered to be less than optimal. These standards are based on a highly onerous risk culture, which was not directly applicable to TECs. The use of the inappropriately high safety factors used in current TEC projects was suggested to increase structural costs by a factor of 3x. The cost of installation was noted as being unsustainability high for the longer-term successful development of tidal energy.

5.1.3 Issues identified in the wind sector

The offshore wind industry is at a relatively mature state of development compared with tidal and wave, but is not as advanced as onshore wind. The issues noted by the offshore renewable energy wind industry were either of a very specific, focused technical nature or, at the opposite end of the spectrum, were very broad.

The broad issues were often related to harmonization across differing standards organizations or between national and international standards. Examples include the difference between the ISO codes widely used in oil and gas and the work and stress basis used for design compared with the IEC codes that often use a load case basis for design. The difference in grid codes between nations was highlighted as a problem in having to design different turbines for different geographical regions, which increases cost. A widely reported view was on the preference for internationally recognized standards wherever possible, but that this often conflicted with areas that were held to be of national responsibility such as H&S or design of civil structures. This difference between national and international policy was noted in the requirements for certification, which in some countries is a legal requirement whilst in others it is merely a pre-requisite for securing finance.

The more focused technical problem areas included:

- lightning strike and how to provide the increased demands often being placed by customers of turbines;
- the arbitrary nature of the division between grid and turbine certification – the turbine is directly connected to the grid, so why the divide?
- the slowness with which new models and understanding are incorporated into standards;
- the lack of in-depth knowledge of the true nature of the wind resource and the wave loading conditions.

From a commercial perspective it was suggested that there were problems due to the high capital expense associated with installation, along with the fact that the supply chain for much of the offshore wind sector was looking increasingly constrained.

5.1.4 Key offshore renewable energy recommendations

The recommended topics for further standards work were presented in Section 4.6. They were identified by the gap analysis. Preferences expressed by industry participants are as follows, along with an indication of whether it should be new or revised, and the type of standard that would be most suitable:

5.1.4.1 Tidal and wave devices

- Load cases for both wave and tidal devices that are based upon correctly represented environmental conditions (new, specification or guide);
- Guidelines on best practice installation techniques for the range of marine infrastructure being used in the deployment of TECs (new, specification or guide);
- Seabed rock stability and capacity to bear the static and dynamic loads resulting from placing large items of equipment on the seabed. This includes guidance on the measurement and qualification of geotechnical conditions related to the nature of the equipment and environmental loads (new, specification);
- Parameters for modelling turbulence and equipment requirements for its measurement in the marine environment (new, guide);
- Corrosion, abrasion and erosion of material and its degradation resulting from prolonged application in highly energetic tidal stream conditions (revised where available or new, specification);
- Consistent H&S qualifications and practices across different maritime sectors;
- Route map and indexing exercise for standards that are relevant to wave and tidal applications

It was noted though that for wave energy there could be difficulty in developing standards due to the fact that within the industry, there is still a great deal of innovation and difference in the physical form of the WEC devices. These differences in device types make it difficult to devise standards and documents that can be fully relevant, or applied to this wide range of potential device shapes, sizes and forms.

5.1.4.2 Wind turbines

The following topics for future standards development were suggested for wind:

- Control systems for wind turbines and farms (new, guide);
- Blade repair (new, specification);
- In-service maintenance and repair (all systems) (new, guide);
- Shipping, stowage and clamping of wind turbine components (new, guide or specification);
- Data exchange (improved, specification);
- Lightning protection (improved, specification);
- EIA, offshore renewable energy statutory stakeholder criteria (new, route map or guide).

Within the wind sector there was a strong preference for modifications and improvements of existing standards, rather than new standards.

5.2 Prioritization of recommendations

This study identified a range of topics that the contributors said were eligible for consideration as areas where new standards would assist their business activities. A spread of organizational types and sizes has been engaged in this investigation process and in order to create a concise summary of the options available to BSI, a Boston Square matrix was developed as shown in Table 16. The Boston Square was developed, mindful of the year 2020 that many contributors used as reference point in addressing the questionnaire. The authors of this study gave consideration to both the ease of implementing and the impact of the topics provided by the offshore renewable energy contributors. Because of the subjective nature of this exercise, the assumptions that were considered when attributing an 'ease of implementation' and 'impact' score have been indicated.

Table 16 – Suggested standards topics by impact

Potential Implementation Difficulty	LOW	MED	HIGH
HIGH	Load cases for WECs	Load cases for TECs	
MED	Tidal stream material selection	TEC installation TEC seabed stability TEC turbulence and measurement	OWT control systems for turbines and farms
LOW	OWT sea fastenings OWT data exchange	H&S qualifications and practises harmonisation	OWT lightning strike EIA guidance Route map and indexing existing standards

Potential ORE 2020 Impact

Load cases standardization for WECs was felt to have a low impact due to the development status of wave energy and difficult to implement as the underpinning knowledge and experience upon which to create the standard is lacking. Also, as this area is being developed by IEC TC 114 (PT 62600-2, Design requirements for Marine Energy Convertors (MECs)) Project Team, UK effort into this topic was not recommended.

Load cases standardization for TECs was felt to have a medium impact but would be difficult to implement as the underpinning knowledge and experience upon which to create the standard is limited. As this area is also being developed by IEC TC 114 Project Team (PT) 62600-2 Design requirements for Marine Energy Convertors (MECs)), UK effort into this topic was tentatively recommended as being of medium priority.

A standard about the selection and specifications for materials deployed as part of TECs that are subject to high erosion, abrasion and corrosion associated with high energy tidal environments, was felt to be of low impact and moderately easy to implement. In classifying this topic as low impact, it was assumed that material degradation is a medium- to longer-term phenomenon and although standardization in this area will be useful, the full benefits may not be realized within a 2020 time frame. UK effort in developing this topic was recommended as low priority.

The topic of standards for the installation of TECs was felt to be of medium impact and moderately easy to implement. The scope of this best practice type document would cover recommendations about the use of the range of different marine vessels and infrastructure that can be used when installing TECs. An indication of safety thresholds for different types of vessels could be included within the context of installation station keeping scenarios. The majority of the TECs installed worldwide are clustered within the Falls of Warness at the EMEC test site, therefore it is likely that this standard development activity should be closely linked to EMEC. UK effort into this topic was recommended as being of medium to high priority.

Guidance on the topic of tidal stream turbulence and measurement was felt to be of medium impact and of medium difficulty to implement. In developing this standard it is recommended that the UK builds upon the framework of PT 62600-201, *Tidal Energy Resource Assessment and Characterization* with the objective of extending the definition for the requirements of turbulence mathematical modelling and physical measurement equipment. UK effort into this topic was recommended as being of medium to high priority.

Improvements in standards in offshore renewable energy H&S covering construction and O&M of offshore installations were felt to be of medium impact and ease to achieve. The goal of this would be to ensure a uniform range of different H&S competency and training requirements within the wider maritime sector. This would require a risk-based categorization of different offshore activities and a ranked graduation to training, equipment and support infrastructure. This activity should be undertaken in conjunction with the MCA and RenewableUK. UK effort into this topic is recommended as being of high priority.

Data-sharing protocols relating to offshore wind were felt to be of low impact and readily achievable. The low-impact classification is based upon the assumption that commercial competitiveness will restrict its influence. UK effort directed at topic was not recommended.

Seabed stability standardization for TECs was felt to be medium impact and medium difficulty in terms of implementation. This topic would be based upon developing best practice for the evaluation of the geotechnical load bear capacity of the seabed in immediate proximity to a deployed TEC. The scope of this would be to cover survey requirements, data analysis and load and performance prediction modelling. UK effort into this topic was recommended as being of medium priority.

Standardization in the areas of control for offshore wind turbines and farms was felt to be of high impact and moderately difficult to implement. It is recommended that because of the maturity of the sector and the long-standing establishment of IEC TC 88, the UK should consider a New Work Item Proposal. UK effort into this topic is recommended as being of medium to high priority.

Improved standardization in the area of offshore wind lightning protect of high impact and easily to implement. It is recommended that because of the maturity of the sector and the long standing establishment of IEC TC88, the UK should consider a New Work Item Proposal. As the UK is the world’s leading offshore wind market place, UK effort into this topic is recommended as being of high priority.

Increased standardization in the EIA for offshore renewable energy was felt to be of high impact and easy to implement. It is recommended that in conjunction with the cooperation of EIA statutory bodies an exercise is undertaken to improve the definition of EIA study and reporting requirements. It is felt that this may reduce the cost of EIA and potential compress consenting timescales. UK effort into this topic is recommended as being of high priority.

The development of a standards indexing exercise to provide a route map to guide the development of WECs and TECs was felt to be of high impact and easy to implement. UK effort into this topic is recommended as being of high priority.

Appendix A

Offshore renewable energy standards questionnaire

Introduction

BSI is working in partnership with the Innovate UK, and on behalf of the Offshore Renewable Energy Catapult, to undertake a strategic review exercise to determine how best to serve the offshore renewable energy sector. BSI wishes to support the offshore renewable energy sector with standards that will contribute to development of the sector over the coming years. For this purpose a data-gathering and industry consultation exercise is being conducted, and your kind support in participating in this process is sought.

The information being sought is outlined in Sections 1 to 4 below. Although the intention is to collect most of this information through a telephone interview, some prior preparation may be needed to collate some of the information requested, for example in Section 2 on standards use.

1. Company information

Name and title/position				
Business sector in offshore?	OEM, Supply Chain, Utility, Project Developer, Test Centre, Certification body, Consultant, Financial services, Academic, Other			
Mainly working in wave, tidal and/or wind?				
Size of business in turnover?	<£0.5 million	£0.5 – £5 million	£5 – £25 million	>£25 million
Number of employees?	1 – 4	5 – 50	51 – 250	>251

2. Standards used

2.1 What standards' documents are used in your business when involved in offshore activities? A list would be helpful and can be provided in this table, expanding as necessary. (*See notes below the table for descriptions of the types of documents of interest for this survey.*)		
	Reference number	**Title/name**
A		
B		
C		
etc		

Note: Documents used as 'standards' can be of several different types such as: standards, specifications, guidelines and best practice fuides. The survey is interested in all that are used within the business. Definitions of the various types are provided for guidance below:

Standards – an internationally recognized IEC or ISO document stipulating normative requirements in order to comply with the purposes of the document.

Specifications – a widely recognized industry document containing informative text. Can be used as the basis for a future standard.

Guidelines – documents developed and issued by certification bodies (DNV, GL and others) or another recognized organization. Can also act as the starting point for future international standards.

Best practice – generalized guidance developed by an organization with an industry interest.

Internal – business processes or requirements placed on subcontractors.

2.2 How well do these standards support business needs?						
	Reference number	Ranking 1 to 5, with 1 = poorly, 3 = adequately, 5 = extremely well				
A		**1**	**2**	**3**	**4**	**5**
B		**1**	**2**	**3**	**4**	**5**
C		**1**	**2**	**3**	**4**	**5**
etc		**1**	**2**	**3**	**4**	**5**

2.3 What problems or issues do you encounter in your activities with offshore renewable energy?	
A	
B	
etc	

2.4 Could new standards assist with these problems/issues?	Yes	Probably	No

2.5 If the answer is Yes or Probably, what topics/areas/subjects would be most useful?	
A	
B	
etc	

3. Industry direction

3.1 What trends do you discern within the offshore renewable industry, in terms of potential size of the market? Please consider both the number of deployed units and potential power ratings.	
A	
B	
etc	

3.2 In terms of timescales, when do you feel the offshore renewable industry will reach a particular size or scale, e.g. numbers of deployed units or power rating of equipment?	
A	
B	
etc	

4. Workshop – potential attendance

4.1 A feedback workshop, where the findings of the Standards Questionnaire will be presented and industry is invited to comment, is planned for late November or early December 2013.	
Would you be interested in attending either a meeting (M) or a web-based (W) event?	Yes (M) Yes (W) No
Can your details be added to a mailing list as a potential participant in an event?	Yes No

Appendix B

Full list of standards and related documents from the industry questionnaire and as listed in the BSI due diligence report

Standards rated by industry as either Good (5) or Not adequate (1 or 2).

Key	Listed by BSI or used by Industry	1				
	Identified as Not adequate(rated 1 or 2)	1				
	Identified as Good (rated 5)	1				
Standard or Document Reference No.	**Title**	Rated 1 or 2	Rated 5	BSI listed	Industry use	Industry total
Totals		46	5	45	107	
API RP 2A-WSD	Recommended Practice for Planning, Designing and Constructing Fixed Offshore Platforms - Working Stress Design.	0	0		1	1
API RP 2GEO	Geotechnical and Foundation Design Considerations.	0	0		1	1
API RP 2SK	Design and Analysis of Station-keeping Systems for Floating Structures	0	0		1	1
API RP 6HP	Pipes	0	0		1	1
ASME	Piping	1	0		1	2
ASME PTC 18 : 2011	Hydraulic Turbines and Pump-Turbines	1	0	1	1	2
ASME PTC 29 : 2005	Speed Governing Systems for Hydraulic Turbine Generator Units	1	0	1	1	2
BS EN 1193-1-1	Steel structure design	0	0		1	1
BS 5950	Civils - Concrete / steel structures	0	0		1	1
BS 7000	CDM	1	0		1	2
BS 7608	Fatigue in steel design	0	0		1	1
BS PD8010	?	1	0		1	2
CEFAS	Offshore survey project design	0	0		1	1
CEFAS	IEA guidelines	0	0		1	1
DEF-STAND 00-35	Environmental test methods	0	0		1	1
DNV 30.4	Foundation Design	0	0		0	0
DNV 2.22	Launch and Recovery	0	0		1	1
DNV A 203	Development of new technology - framework	0	0		0	0
DNV CPC25	Environmental data	0	0		1	1
DNV DS101 (or OS-D101?)	Marine machinery	1	0		1	4
DNV HP103	Marine operations	0	0		1	2
DNV OS202 / RPC202?	Offshore structures?	0	0		1	3
DNV-OS-B101		0	0		0	0
DNV-OS-C101	Design of Offshore Steel Structures	1	0		1	3
DNV-OS-C201 : 2012	Structural Design of Offshore Units (WSD Method)	0	0	1	1	1
DNV - C205	Subsea engineering	1	0		1	3
DNV-OS-C401	Fabrication and Testing of Offshore Structures	0	0	1	1	1
DNV OS-C501	Composite Components.	0	0		1	3
DNV OS-C502	Offshore Concrete Structures	0	0		0	0

Key	Listed by BSI or used by Industry	1				
	Identified as Not adequate(rated 1 or 2)	1				
	Identified as Good (rated 5)	1				
Standard or Document Reference No.	**Title**	Rated 1 or 2	Rated 5	BSI listed	Industry use	Industry total
DNV(?) OS-D201	Electrical Installations	0	0		1	1
DNV-OS-E301	Position Mooring	0	0		0	0
DNV-OS-E402 : 2010	Offshore standard for diving systems	0	0	1	0	0
DNV-OS-J101	Design of Offshore Wind Turbine Structures	0	1		1	7
DNV-OS-J102	Wind turbine blades	0	0		1	1
DNV-OS-J103 : 2013	Design of Floating Wind Turbine Structures	0	0	1	0	0
DNV-OS-J201	Offshore Substations for Wind Farms	0	1		1	5
DNV-OSS-312	Certification of Tidal & Wave Energy Convertors	0	0		0	0
DNV-OSS-901	Project Certification of Offshore Wind Farms	0	0		1	4
DNV-RP-B401	Cathodic Protection Design	0	0		0	0
DNV-RP-C201	Buckling Strength of Plated Structures	0	0		0	0
DNV-RP-C202	Buckling Strength of Shells	0	0		0	0
DNV-RP-C203 : 2012	Fatigue Design of Offshore Steel Structures	0	0	1	1	2
DNV-RP-C204	Design against Accidental Loads	0	0		0	0
DNV-RP-C205	Environmental Conditions and Loads	0	0		0	0
DNV-RP-C207	Statistical Representation of Soil Data	0	0		0	0
DNV-RP-F302	Structural code	0	0		1	1
DNV-RP-H103	Ship transit accelerations	0	1		1	6
DNV-RP-J101	Use of Remote Sensing for Wind Energy Assessments - Incorporates Amendment: November 2011	0	0	1	0	0
DNV RP V41	Cathodic protection	0	0		0	0
DNV	Marine ship design aspects	0	0		1	1
DNV	Guidelines for offshore project planning	0	0		0	0
EMEC	Guidelines for Project Development in the Marine Energy Industry	1	0	1	1	3
EMEC	Guideline for marine energy certification schemes	1	0	1	1	3
EMEC	Guidelines for Reliability, Maintainability and Survivability of Marine Energy Conversion Systems	1	0		1	3
EMEC	Guidelines for Grid Connection of Marine Energy Conversion Systems.	1	0		1	3
EMEC	Tank Testing of Wave Energy Conversion Systems	1	0		1	3
EMEC	Guidelines for Manufacturing, Assembly and Testing of Marine Energy Conversion Systems.	1	0		1	3
EN ISO 12100-1	Safety of machinery -- General principles for design -- Risk assessment and risk reduction	0	0		1	1
EN ISO 14121-1	Safety of machinery -- Risk assessment -- Part 1: Principles	0	0		1	1
EN ISO 14121-2	Safety of machinery -- Risk assessment -- Part 2: Practical guidance and examples of methods	0	0		1	1
EN50082-2	EMC: Electromagnetic Compatibility	1	0		1	2
EN 50308 (FprEN 50308 : 2013)	Wind turbines - Protective measures - Requirements for design, operation and maintenance	1	0	1	1	2
EN 50308 : 2005	Wind turbines - Protective measures - Requirements	1	0	1	1	2

Key	Listed by BSI or used by Industry	1				
	Identified as Not adequate(rated 1 or 2)	1				
	Identified as Good (rated 5)	1				
Standard or Document Reference No.	**Title**	Rated 1 or 2	Rated 5	BSI listed	Industry use	Industry total
	for design, operation and maintenance					
EN 547-1:1996+A1:2008	Safety of machinery - Human body measurements - Part 1: Principles for determining the dimensions required for openings for whole body access into machinery	1	0		1	2
EN 614-2:2000+A1:2008	Safety of machinery - Ergonomic design principles - Part 2: Interactions between the design of machinery and work tasks.	0	0		1	1
EquiMar	Protocols / FP7 project	0	0		0	0
Eurocodes, e.g. -3	Various e.g. fabrication in steel and concrete	0	0		1	2
European Directive 94/62/CE	Packaging and packaging waste	0	0		1	1
GL-IV-1	Guideline for the Certification of Wind Turbines, Edition 2010	0	1		1	6
GL-IV-1-12	Wind Energy - Guideline for the Continued Operation of Wind Turbines, Edition 2009	0	0		0	0
GL IV-2-1/13	Wind / Guideline for the Certification of Offshore Wind Turbines	1	0	1	1	4
Gl-IV-4	Guideline for the Certification of Condition Monitoring Systems for Wind Turbines, Edition 2013	0	0		0	0
GL IV-6-3 : 2007	Rules for classification and construction - IV: Industrial services - Part 6: Offshore technology - Chapter 3: Fixed offshore installations	0	0	1	1	1
GL IV-6-4 : 2007	Rules for classification and construction - IV: Industrial services - Part 6: Offshore technology - Chapter 4: Structural Design	0	0	1	1	1
GL IV-6-7 : 2005	Rules and guidelines - IV: Industrial services - Part 6: Offshore installations - Chapter 7: Guidelines for the construction of fixed offshore installations in ice infested waters	0	0	1	1	1
Gl.4.13	Calculation of the loads.pdf	0	0		0	0
GL	'Guideline for the Certification of Ocean Energy Converters, Part1: Ocean Current Turbines'	1	0		1	3
GL-TN	Technical Note for the Certification of Wind Turbines for Tropical Cyclones, Revision	0	0		0	0
GL-TN	Technical Note Certification of Training Programs and Training Systems in the Renewable Energy Industry, Edition 2013	0	0		0	0
GL-TN 065	Technical Note 065 (TN 065) Grid Code Compliance Certification procedure, Revision 7, Edition 2010	0	0		0	0
GL-TN 066	Technical Note 066 (TN 066) Grid Code Compliance (GCC) Test procedure for Low Voltage Ride Through (LVRT), Revision 7, Edition 2010	0	0		0	0
GL-TN 067	Technical Note 067 Certification of Wind Turbines for	0	0		0	0

Key	Listed by BSI or used by Industry	1				
	Identified as Not adequate(rated 1 or 2)	1				
	Identified as Good (rated 5)	1				
Standard or Document Reference No.	**Title**	Rated 1 or 2	Rated 5	BSI listed	Industry use	Industry total
	Extreme Temperatures (here: Cold Climate), Scope of Assessment, Rev 4, Edition 2011					
GL-TN	Technical Note Certification of Fire Protection Systems for Wind Turbines, Certification Procedures, Revision 2, Edition 2009	0	0		0	0
GL-TN	Technical Note Certification of Service Providers in the Wind Energy Industry, Scope of Assessment, Revision 6, Edition 2009	0	0		0	0
GL - Nobel Denton	Offshore lifting regulations and transportation	1	0		1	3
GL - Nobel Denton 007ND	Marine operations	0	0		1	1
IEC61000-5-2	EMC - Cable routings	0	0		0	0
IEC61000-6-2	EMC: Electromagnetic Compatibility	1	0		1	2
IEC61000-6-4	EMC - Electronics in blades?	0	0		0	0
IEC 61400-1 : 2007	Wind turbines - Part 1: Design requirements	1	0	1	1	8
IEC 61400-11 : 2012	Wind turbines - Part 11: Acoustic noise measurement techniques	0	0	1	1	1
IEC 61400-12-1 : 2005	Wind turbines - Part 12-1: Power performance measurements of electricity producing wind turbines	0	0	1	1	1
IEC 61400-12-2 : 2013	Wind turbines - Part 12-2: Power performance of electricity producing wind turbines based on nacelle anemometry	0	0	1	1	2
IEC 61400-2 : 2006	Wind turbines - Part 2: Design requirements for small wind turbines	0	0	1	1	1
IEC 61400-21 : 2008	Wind turbines - Part 21: Measurement and assessment of power quality characteristics of grid connected wind turbines	0	0	1	0	0
IEC 61400-22 : 2010	Wind turbines - Part 22: Conformity testing and certification	0	1	1	1	7
IEC 61400-24 : 2010	Wind turbines - Part 24: Lightning protection	1	0	1	1	3
IEC 61400-25-1	Wind turbines - Part 25-1: Communications for monitoring and control of wind power plants	0	0	1	0	0
IEC 61400-3	Wind turbines - Part 3: Design requirements for offshore wind turbines	0	0	1	1	7
IEC 61400-4	Wind turbines - Part 4: Design requirements for wind turbine gearboxes	0	0	1	1	2
IEC 62305-1	Protection against lightning- Part 1: General principles	1	0		1	2
IEC 62305-2	Protection against lightning- Part 2: Risk management.	1	0		1	2
IEC 62305-3	Protection against lightning Part 3: Physical damage to structures and life hazard	1	0		1	2
IEC 62305-4	Protection against lightning Part 4: Electrical and electronic system within structures	1	0		1	2
IEC/TS 61400-13 :	Wind turbine generator systems - Part 13:	0	0	1	0	0

Key	Listed by BSI or used by Industry	1				
	Identified as Not adequate(rated 1 or 2)	1				
	Identified as Good (rated 5)	1				
Standard or Document Reference No.	**Title**	Rated 1 or 2	Rated 5	BSI listed	Industry use	Industry total
2001	Measurement of mechanical loads					
IEC/TS 61400-14 : 2005	Wind turbines - Part 14: Declaration of apparent sound power level and tonality values	0	0	1	0	0
IEC/TS 61400-23 : 2001	Wind turbine generator systems - Part 23: Full-scale structural testing of rotor blades	0	0	1	1	2
IEC/TS 61400-26-1	Wind turbines - Part 26-1: Time-based availability for wind turbine generating systems	0	0	1	0	0
IEC/TS 62600-1 : 2011	Marine energy - Wave, tidal and other water current converters - Part 1: Terminology	0	0	1	0	0
IEC/TS 62600-2	Guidelines for Design Basis of Marine Energy Conversion Systems	0	0		1	1
IEC/TS 62600-10 : 2013	Marine energy - Wave, tidal and other water current converters - Part 10: Assessment of mooring system for Marine Energy Converters	0	0	1	0	0
IEC/TS 62600-100 : 2012	Marine energy - Wave, tidal and other water current converters - Part 100: Power performance assessment of electricity producing wave energy converters	0	0	1	1	1
IEC/TS 62600-101 : 2011	Marine energy - Wave, tidal and other water current converters - Part 101: Wave energy resource assessment and characterization (IEC 114/70/CD:2011)	1	0	1	1	3
IEC/TS 62600-200 : 2013	Marine energy - Wave, tidal and other water current converters - Part 200: Power performance assessment of electricity producing tidal energy converters	0	0	1	1	2
IEC/TS 62600-201 : 2011	Marine energy - Wave, tidal and other water current converters - Part 201: Tidal energy resource assessment and characterisation	1	0	1	1	4
IMO	IMO Code for the Construction and Equipment of Mobile Offshore Drilling Units (MODU Code).	0	0		1	1
ISO 14001	Environmental management standard	0	0		1	2
ISO 15138 : 2009	Petroleum and natural gas industries - Offshore production installations - Heating, ventilation and air-conditioning.	0	0	1	0	0
ISO 17020	Verification body standard	1	0		1	2
ISO 17025	Testing laboratory standard	1	0		1	2
ISO 19156 : 2011	Geographic information - Observations and measurements	0	0	1	0	0
ISO 19901-1 : 2006	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1 : Metocean design and operating considerations	1	0	1	1	3
ISO 19901-1 : 2013	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 1: Metocean design and operating considerations	1	0	1	1	2
ISO 19901-2	Petroleum and Natural Gas Industries - Seismic design	1	0		1	3

Key	Listed by BSI or used by Industry	1				
	Identified as Not adequate(rated 1 or 2)	1				
	Identified as Good (rated 5)	1				
Standard or Document Reference No.	**Title**	Rated 1 or 2	Rated 5	BSI listed	Industry use	Industry total
	procedures and criteria.					
ISO 19901-3	Petroleum and Natural Gas Industries - Specific requirements for offshore structures - Part 3: Topsides structure	1	0		1	3
ISO 19901-4	Petroleum and Natural Gas Industries - Specific requirements for offshore structures - Part 4: Geotechnical and foundation design considerations	1	0		1	3
ISO 19901-5 : 2003	Petroleum and natural gas industries. Specific requirements for offshore structures. Weight control during engineering and construction	1	0	1	1	2
ISO 19901-8	Petroleum and natural gas industries - Specific requirements for offshore structures - Part 8 : marine soil investigations	1	0	1	1	2
ISO 19902 : 2007	Petroleum and natural gas industries. Fixed steel offshore structures	2	0	1	1	4
ISO 19903	Petroleum and Natural Gas Industries - Fixed concrete offshore structures.	1	0		1	3
ISO 19904-1	Petroleum and Natural Gas Industries - Floating Offshore Structures - Part 1: Monohulls, semi-submersibles and spars.	1	0		1	3
ISO 281	Rolling bearings -- Dynamic load ratings and rating life	0	0		1	1
ISO 76	Rolling bearings -- Static load ratings	0	0		1	1
ISO 81400-4		0	0		0	0
ISO 9001	Standard for Quality Management	0	0		1	1
ISO 9277	Determination of the specific surface area of solids by gas adsorption -- BET method- Neutral Salt Spray without evidence of red rust.	0	0		1	1
Lloyds Register	Marine ship design aspects	0	0		1	1
Lloyds Register	Offshore lifting and transportation	1	0		1	3
Lloyds Register	Lloyd's Register Rules and Regulations for the classification of Floating Offshore Installations at a Fixed Location	0	0		1	2
MIL-PRF-16173E	Corrosion preventive compound, solvent cutback, cold-application. Temporary protection systems	1	0		1	2
NORSOC M120	Marine operations	0	0		1	1
NORSOC N001	Marine operations	0	0		1	1
NORSOC N006	Fatigue	0	0		1	1
NORSOC NEK606	Cables	0	0		1	1
OHSAS 18001	Health & Safety Standard	0	0		1	1
Renewable UK	H&S Guidelines: Onshore & Offshore H&S	1	0	1	1	3
TCE (The Crown Estate)	Guidance on Metocean numerical modelling of offshore wind	0	0		1	1

Summary of the BSI Knowledge Centre literature search

The aim of the research was to conduct a due diligence check for existing standardization activities that may be applicable to this topic.

Desktop research, using BSI's internal standards database PERINORM and the I.H.S. Standards Expert database, was conducted to identify formal standards relating to offshore renewable energy sources. Searches were carried out for international standards (ISO, IEC and others), national standards (from UK, France, US, Germany, Norway, Denmark, Spain) and informal standards from those countries. We also made a brief check on possible legislation affecting offshore renewable energy structures.

ORE and structures in general	Standard or document reference number	Title
International standards		
National standards		
Informal standards		
Wind energy		
International standards		
National standards		
Informal standards		
Legislation/government		
Marine energy		
International standards		
Informal bodies		
Water/hydraulic turbines		
International standards		
National standards		
Ocean/oceanography		
International standards		
National standards		
Informal bodies		
Oil and gas		
International standards		
Informal bodies		

Shipping/navigation	
International standards	
Informal bodies	
Proposed legislation	
Corrosion/coating/paints	
International standards	
National standards	
Informal bodies	
Cabling/cables	
International standards	
National standards	
Informal bodies	
Ladders/railings	
International standards	
National standards	
Nacelle	
International standards	
Lidar	
International standards	
Informal bodies	
Boat landing	
International standards	
Informal bodies	

Web searches were also carried out for relevant organizations that might publish informal standards or guidelines relevant to the topic.

Standards and Innovate UK

Innovate UK – the new name for the Technology Strategy Board) – is the UK's innovation agency. Our aim is simple – to accelerate economic growth by stimulating and supporting business-led innovation. For more information about Innovate UK please see www.innovateuk.org or contact support@innovateuk.org.

Timely, consensus-based use of standards plays a vital role in ensuring that the knowledge created in the UK's research base is commercialized and brought to market as well as playing an important role in driving innovation.

Innovate UK is working with BSI, Research Councils and Catapults to establish new standards earlier in the development of technologies.

We are collaborating in four emerging technology areas to define standards that will accelerate the development of those technologies and provide UK businesses with a competitive "first mover advantage":

Offshore renewable energy	Assisted living
Cell therapy and the subject of this report	Synthetic biology

The four technologies are at different stages of development and face different challenges in their commercialisation. All four technologies are internationally competitive areas, and it is important that the UK creates successful capabilities quickly.

The UK offshore renewable energy sector is rightly recognised as a centre for expertise but, with only a small number of original equipment manufacturers (OEMs), installations thus far have been designed to meet the bespoke needs of these OEMs. If the sector is to act as a platform for the UK to provide global leadership in ORE manufacturing and services, it needs to be more open. This will in turn will boost the security of supply, stimulate further innovation, create UK jobs, and attract further inward investment. Realising this potential is crucial to meeting the UK government's 2020 renewable energy targets and delivering a low-carbon future at the lowest price to consumers.

In 2011, the UK government published the first national Renewable Energy Roadmap which sought to unlock this vast potential, and specifically recognised that one of the barriers to increased deployment of renewable energy is the high cost of market entry. In 2012 the Offshore Wind Cost Reduction Task Force specifically recommended the creation of standards as an important step towards reducing the cost of offshore energy.

Creating the appropriate offshore renewable energy knowledge infrastructure – based on the development of industry-led codification of good practice – will help drive down the costs of market entry and foster an environment of collaboration which can secure the UK's global dominance both in terms of technological innovation and deployment.

Through its energy programme, Innovate UK is working to help UK industry profit from the changes the world will have to make to address the 'trilemma' of energy security, affordability and sustainability. Read more here: www.innovateuk.org/energy. Innovate UK also established the Offshore Renewable Energy Catapult to accelerate innovation in the sector – find out more here: ore.catapult.org.uk.