ANNUAL REPORT

IMPLEMENTING AGREEMENT
ON OCEAN ENERGY SYSTEMS

2013

OCEAN ENERGY SYSTEMS
An IEA Technology Initiative


2013

2013 ANNUAL REPORT

Published by: The Executive Committee of Ocean Energy Systems
Edited by: Ana Brito e Melo and José Luis Villate
Designed by: Formas do Possível (www.formasdopossivel.com)

CONTENTS

CHAIRMAN'S MESSAGE 04

EXECUTIVE SUMMARY 07

01
INTRODUCTION 08
1.1. What is the Ocean Energy Systems? 09
1.2. Benefits 09
1.3. International Vision for OES 10

02
REPORT OF THE EXECUTIVE COMMITTEE 11
2.1. Membership 12
2.2. Executive Committee Meetings 13
2.3. Work Programme & Management 14
2.4. Collaboration with other Initiatives 15

03
COLLABORATIVE PROJECTS 17
3.1. Assessment of Environmental Effects and Monitoring Efforts 18
3.2. Exchange and Assessment of Ocean Energy Device Project Information and Experience 21
3.3. Worldwide Web GIS Database for Ocean Energy 23
3.4. Tool for Assessment of Cost of Energy 24
3.5. Dissemination and Outreach 24

04
CURRENT PERSPECTIVES OF KEY INDUSTRIAL OCEAN ENERGY PLAYERS 27

05
COUNTRY REPORTS 39
Portugal 40
Denmark 44
United Kingdom 46
Japan 59
Ireland 62
Canada 68
United States of America 74
Belgium 83
Germany 85
Norway 87
Mexico 91
Spain 94
Italy 101
New Zealand 108
Sweden 110
Australia 115
South Africa 119
Republic Of Korea 120
China 125
Nigeria 130
Monaco 131

06
STATISTICAL OVERVIEW OF OCEAN ENERGY 133
6.1. Ocean Power in OES countries (2013) 134
6.2. Open Sea Testing Facilities 136
6.3. Electrical Utilities Involved in R&D 138

APPENDICES 140
Appendix 1. About the IEA 141
Appendix 2. About the OES 142
Appendix 3. Contracting Parties to OES 143
Appendix 4. Membership 144
Appendix 5. Executive Committee Meetings 145
Appendix 6. Completed Projects 146
Appendix 7. Terminology for OES 147

CHAIRMAN'S MESSAGE

MR. JOSÉ LUIS VILLATE

TECNALIA
OES CHAIRMAN 2013 – 2014

It is my pleasure to open the 2013 annual report with this first message as chairman of Ocean Energy Systems (OES) following the successful 4-year term of my predecessor John Huckerby, who led an ambitious strategic plan and secured a third 5-year mandate with the International Energy Agency for 2012-2017.

First of all, I would like to welcome two new members: Nigeria and Monaco that joined the OES in 2013, resulting in a total of 21 countries, demonstrating the growing interest in ocean energy worldwide. I trust that the OES family will grow in the coming years with new countries such as Costa Rica, which was invited to join the OES in 2013, and other countries with which we are already working towards their membership.

Although OES growth may involve some management challenges, it also brings a greater wealth of information and opportunities for international collaboration through the exchange of information. This is the main objective of one of our ongoing activities (Annex V). One goal of the new current 5-year mandate is to start up new activities and with this aim the OES has prioritised topics according to the interest of its members. Since priority topics include environmental issues, the OES approved an extension of the task (Annex IV) working on these issues in 2013. Another priority is the cost of energy, and we also approved the start of a specific 1-year activity last year. This activity is channelled towards engaging a large number of international stakeholders to deliver a reliable and credible assessment of Levelised Cost of Energy (LCOE) and to identify paths for cost reduction. It is also worth mentioning that we have started another activity to develop an interactive tool displaying global information on ocean energy, including resources, geophysical information, facilities, infrastructure, etc…

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ALTHOUGH OES GROWTH MAY INVOLVE SOME MANAGEMENT CHALLENGES, IT ALSO BRINGS A GREATER WEALTH OF INFORMATION AND OPPORTUNITIES FOR INTERNATIONAL COLLABORATION THROUGH THE EXCHANGE OF INFORMATION. THIS IS THE MAIN OBJECTIVE OF ONE OF OUR ONGOING ACTIVITIES (ANNEX V).

Another objective of the OES is to spread awareness of ocean energy as the authoritative international voice and to this end we are doing continual outreach, participating in international events and generating and disseminating relevant information through biannual newsletters and periodic website news. Another means of increasing its impact is through collaboration with other international organisations such as INORE (International Network on Offshore Renewable Energies), a very dynamic international network of young researchers in offshore renewable energy. I would also like to highlight that the OES is continuing to collaborate with the ICOE (International Conference on Ocean Energy) whose next edition will be in Halifax, Canada, in the first week of November 2014 (www.icoe2014canada.org). The ICOE is the main global ocean energy event focused on industrial development, so I would like to encourage stakeholders in ocean energy to take part.

Speaking of industrial development, it is also very satisfying for me to present the opinion of six major industrial players in this annual report: Alstom, Andritz, DCNS, Iberdrola, Siemens and Voith. Their answers to a common questionnaire reveal to us their vision and strategy regarding ocean energy. In my opinion, the future of ocean energy depends on a greater involvement of such industrial groups, along with reliable governmental support and continued investment in research projects with a clear focus on cost reduction. Through the country-by-country information included in this annual report, readers will be able to acquire a global understanding of these three key factors in the future of ocean energy.

I do not want to end this message without acknowledging the work of all members of the Executive Committee in achieving the mission and goals of the OES, particularly the collaboration of the two vice-chairs, Michael Reed (U.S.) and Eoin Sweeney (Ireland) and the efforts of Dr. Ana Brito e Melo in her role as OES secretary. She will now take over from me to present the executive summary.

EXECUTIVE SUMMARY

Ocean Energy Systems (OES) is the short name for the international technology initiative on Ocean Energy under the International Energy Agency (IEA), known as the 'Implementing Agreement on Ocean Energy Systems'.

This Annual Report presents an overview of the activities undertaken within the OES in 2013, and their current status. Implementing Agreements operate on a 5-year period called a "term". In 2012 the second term of OES ended. Following an evaluation of this second term the IEA's Committee on Energy Research and Technology (CERT) granted a third mandate for a 5-year term on 29 February 2012 to run until 28 February 2017.

Chapter 1 is an introductory chapter addressing the role and benefits of OES. Chapter 2 provides information about present membership, gives a status overview of the OES activities, international collaboration and sponsorship initiatives in which the Executive Committee (ExCo) was involved during the year. Key accomplishments during 2013 are presented in Chapter 3.

Membership of the OES involves a commitment to national participation in certain collaborative research activities. Some of these research projects generally have duration of a number of years and are led by an *'Operating Agent'* from a member country, responsible for co-ordinating each project and reporting on progress to the ExCo. Under the OES nomenclature these research projects are defined as 'Annexes' to the Implementing Agreement. The ExCo has also introduced some shorter-term projects (approximately 1 year duration) called 'Activities'. During 2013 the following activities and research projects were conducted:

- Second phase of the research project *"Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems"* (3 years project);
- Research project *"The Exchange and Assessment of Ocean Energy Device Project Information and Experience"* (3 years project);
- World Web Gis Database - detailed global information related to ocean energy (implemented in 2013 to be public release in 2014);
- Communication and outreach activities.

As in previous years Chapter 4 presents a contribution by acknowledged industry experts. Six top industrial ocean energy players were invited to respond to the following questions:

- *The involvement of their company in ocean energy*
- *About innovation: how much internally developed in the company, how much contracted to external organizations and how much developed in public funded projects*
- *Expectations about worldwide ocean energy development in the next decades and the long term world value of this industry*
- *Main challenges*
- *How international collaboration could accelerate ocean energy growth along the development pathway and, specifically, the role that OES could play in supporting the development of ocean energy*

Under Chapter 5 each OES member country presents its national programme activities over the last year. The final Chapter 6 is a compilation of statistical information provide by all country representatives.

Dr. Ana Brito e Melo
OES EXECUTIVE SECRETARY

01

INTRODUCTION

1.1

WHAT IS THE OCEAN ENERGY SYSTEMS?

The Ocean Energy Systems Implementing Agreement (OES) is an intergovernmental collaboration between countries, to advance research, development and demonstration of technologies to harness energy from all forms of ocean renewable resources for electricity generation, as well as for other uses, such as desalination, through international co-operation and information exchange.

The OES covers all forms of energy generation, in which seawater forms the motive power, through its physical and chemical properties.

OCEAN ENERGY RESOURCES

Waves, derived from the transfer of the kinetic energy of the wind to the upper surface of the ocean;

Tidal Range (tidal rise and fall), derived from the gravitational forces of the Earth-Moon-Sun system;

Tidal Currents, water flow resulting from the filling and emptying of coastal regions as a result of the tidal rise and fall;

Ocean Currents, derived from wind-driven and thermohaline ocean circulation;

Ocean Thermal Energy Conversion (OTEC), derived from temperature differences between solar energy stored as heat in upper ocean layers and colder seawater, generally below 1,000 m;

Salinity Gradients, derived from salinity differences between fresh and ocean water at river mouths.

1.2

BENEFITS

The OES international co-operation facilitates:

- Securing access to advanced R & D teams in the participating countries
- Developing a harmonized set of measures and testing protocols for the testing of prototypes
- Reducing national costs by collaborating internationally
- Creating valuable international contacts between government, industry and science

The ExCo is continuing to develop a suite of information dissemination tools that will assist the OES in becoming a leading international authority on ocean energy. Ocean energy remains an emerging technology area and will continue to benefit from the existence of the international collaboration mechanism offered under the Implementing Agreement contract.

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OCEAN ENERGY REMAINS AN EMERGING TECHNOLOGY AREA AND WILL CONTINUE TO BENEFIT FROM THE EXISTENCE OF THE INTERNATIONAL COLLABORATION MECHANISM OFFERED UNDER THE IMPLEMENTING AGREEMENT CONTRACT.

1.3

INTERNATIONAL VISION FOR OES

The OES ExCo adopted a new 5-year Strategic Plan in February 2012, which has the vision that OES will become the “Authoritative International Voice for Ocean Energy”. This vision is being realized by documents, such as the “International Vision for Ocean Energy”, published in 2012 and presented in 2013 at several events.

INDUSTRIAL GOAL
By 2050 ocean energy will have grown to 337 GW of installed wave and tidal energy capacity.

SOCIETAL GOAL
By 2050 ocean energy will have created 1.2 million direct jobs and saved nearly 1.0 billion tonnes of CO2 emissions.

The OES Strategic Plan identifies and prioritises four Critical Success Factors for which an action plan for the next 5-year term has been developed:

- High quality information
- A strong communications programme
- An effective organisation
- Shared capability growth

02

REPORT OF THE EXECUTIVE COMMITTEE

2.1

MEMBERSHIP

The Implementing Agreement on Ocean Energy Systems (OES) was initiated by three countries in 2001. As of December 2013, 21 countries are members of the OES: Portugal, Denmark, United Kingdom, Japan, Ireland, Canada, the United States of America, Belgium, Germany, Norway, Mexico, Spain, Italy, New Zealand, Sweden, Australia, Republic of Korea, South Africa, China, Nigeria and Monaco ordered by sequence of joining the Agreement.

Nigeria joined the OES on 20 February 2013 and the signatory entity is the Nigerian Institute for Oceanography and Marine Research (NIOMR).

Monaco joined the OES on 5 June 2013 and the signatory entity is the Government of the Principality of Monaco.

In 2013, the Executive Committee unanimously voted to invite Costa Rica. Communication continued with other countries invited to join the OES: Brazil, Chile, India, France, The Netherlands, Indonesia, Finland, Russia, Singapore and the European Commission. Some efforts have been done to attract other countries with activities or interest on ocean energy, such as Malaysia, Malta and Cuba.

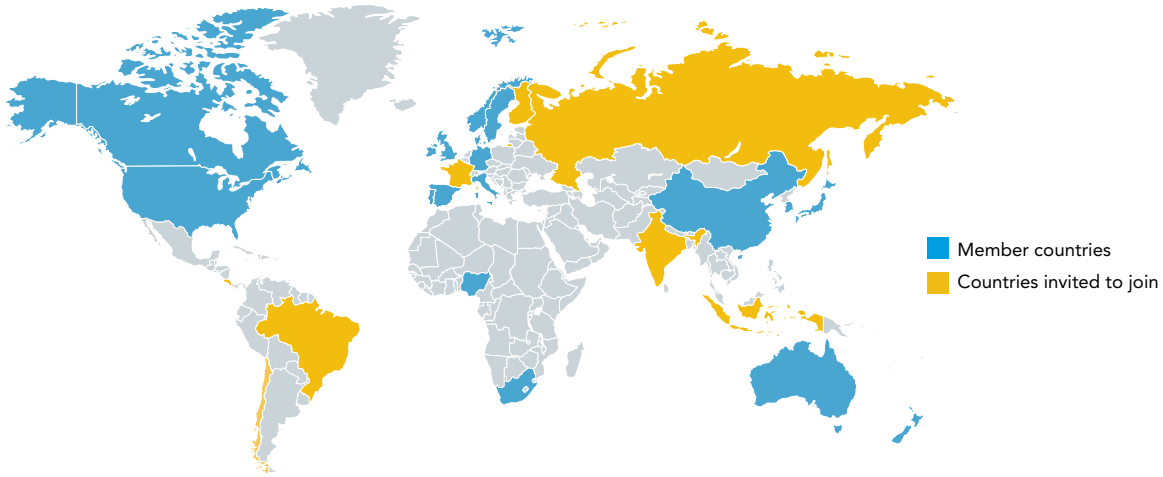


Fig. 1: Members and Invited Countries

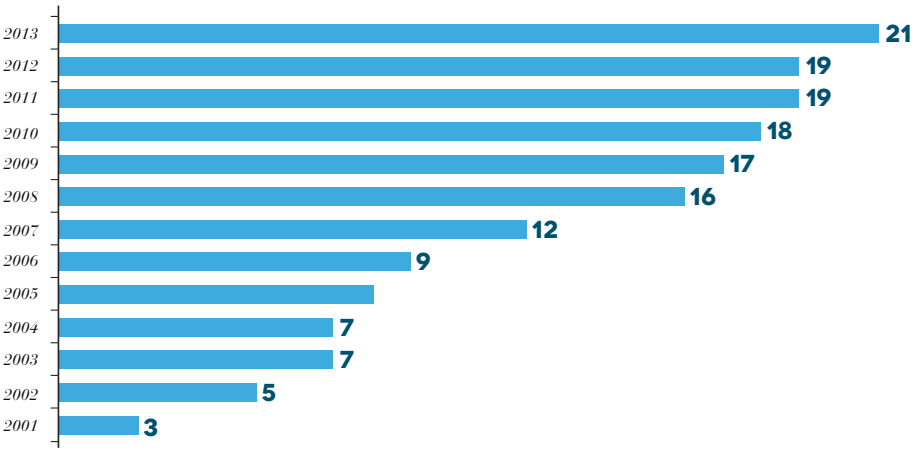


Fig. 2: OES Membership Growth

National governments appoint a Contracting Party to represent it on the ExCo. The Contracting Party can be a government ministry or agency, a research institute or university, an industry association or even a private company. Governments also nominate alternates, who may represent the government at ExCo meetings, if the nominated representative is unavailable. Consequently there is a diversified representation of interests in the ExCo (Fig. 3). The ExCo considers this diversity to be a key strength of the organization and will strive to maintain this balance of representation.

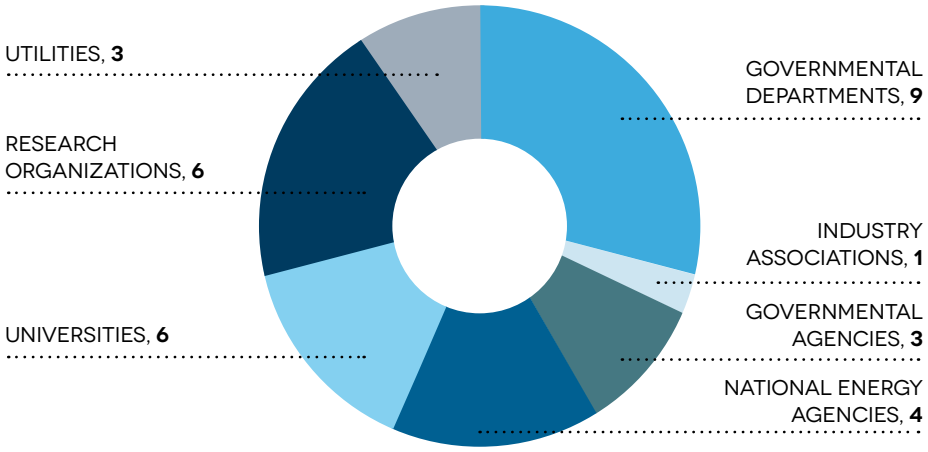


Fig. 3: Diversified representation of interests in the ExCo

2.2

EXECUTIVE COMMITTEE MEETINGS

The Executive Committee (ExCo) is the decision-making body of OES and meets twice a year to discuss its work programme and share information among members. In 2013, ExCo meetings were held in Guangzhou, China (14-15 May 2013) and in Cape Town, South Africa (22-23 October 2013). Where possible, the ExCo tries to offer hosting opportunities to all members and to time and locate its meetings to coincide with major international ocean energy conferences.

24TH EXCO MEETING

14-15 May 2013, Guangzhou, China

This meeting was hosted by the State Oceanic Administration (SOA) and the Delegate member from China, Mr. Dengwen Xia, was the local organiser of the meeting. The meeting was attended by 24 participants from 13 member countries and 3 observer countries (Singapore, The Netherlands and Monaco). A technical tour to a marine energy facility and wave energy device in Guangdong Province (Zhongshan city and Zhuhai city) was organized on the 16 May for the ExCo delegates. The delegates were also invited to attend the 2nd China Marine Renewable Energy Conference that was held at Guangzhou Baiyun International Convention Center, on the 17th May, and to present their national activities.

24th ExCo meeting, 14 – 15 May 2013, Guangzhou, China

25TH EXCO MEETING

22-23 October 2013, Cape Town, South Africa

This meeting was hosted by SANEDI, the South African National Energy Development Institute and the Delegate member from South Africa, Dr. Thembakazi Mali, was the local organiser of the meeting. The meeting was attended by 23 participants from 14 member countries and 2 observer countries (Costa Rica and Indonesia). This meeting was organised in conjunction with a National Seminar on ocean energy organized by SANEDI on 21 October 2013.

A technical tour to the 400 MW Palmiet Pumped Storage Scheme located on the Palmiet River near Cape Town was organized on the 24 October 2013 for the ExCo delegates. This power plant is regarded as a forerunner in environmental engineering, built in a Biosphere Reserve.

25th ExCo meeting, 22 -23 October 2013, Cape Town, South Africa

2.3

WORK PROGRAMME & MANAGEMENT

The collaborative research carried out by the OES ExCo is structured in Annexes (Research Projects) and Activities to the Work Programme. With the exception of Annex I (Dissemination & Communication), which is mandatory, membership of Annexes is voluntary and participation is by both cost-sharing and task-sharing. Shorter projects or "Activities" are usually financed by the Agreement Common Fund, while the "Projects", with typical durations of 2 to 3 years may have specific budget, managed by an Operating Agent (OA), to which only participants in the Project contribute.

Further details on active projects and activities are given in Section 3, and the completed projects are summarised in Appendix 6.

WORK PROGRAMME – ANNEXES	1st TERM	2nd TERM					3rd TERM					
	2002-2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
I. Review, Exchange and Dissemination of Information on Ocean Energy Systems OA: Ana Breito e Melo, WavEC Offshore Renewables - Portugal												
II. Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems OA: Kim Nielsen, Ramboll - Denmark		CONCLUDED										
III. Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grid OA: Gouri Bhuyan, Powertech Labs - Canada				CONCLUDED								
IV. Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems OA: Michael Reed, Department of Energy - USA												
V. The Exchange as Assessment of Ocean Energy Device Project Information and Experience OA: Michael Reed, Department of Energy - USA												

Table 1: OES Research Projects (status: Dec. 2013)

The ExCo is presently developing a number of new proposals for new projects and activities on topics of common interest to participants.
Contracting Parties pay an annual membership fee to the Agreement Common Fund, which covers administrative expenses incurred in connection with the ExCo, including the expenses of the Operating Agent for the Annex I on Dissemination Activities. The present membership subscription fee is € 7,000, which has been held steady for 3 years.
The ExCo elects a Chair and two Vice-Chairs, who serve a 2-year term. Together with the Secretary, who is the only paid member of the ExCo, the Chair and Vice-Chairs form the Cabinet, which manages the day-to-day decision-making to implement the annual work programme and Agreement Common Fund budget approved by the ExCo. The Cabinet also has a leading role in representing the OES at IEA meetings and workshops and making presentations at international conferences.

2.4

COLLABORATION WITH OTHER INITIATIVES

INTERNATIONAL CONFERENCE ON OCEAN ENERGY (ICOE)

The International Conference on Ocean Energy is the global marine energy event focused on the industrial development of renewable marine energy. Held every two years, the goal of the conference and exhibition is to share recent experiences from research and demonstration efforts. It aims to accelerate development by stimulating collaboration networks between companies and research and development centres.
The ExCo has approved the OES would provide a "home" for past and future ICOE conference material. Therefore during 2013 a website to host ICOE conferences has been developed and launched: http://www.icoe-conference.com/
This website is hosted and maintained by the OES and all papers from previous conferences have been uploaded. The OES delegates are also part of the steering committee of the conference. The 2014 ICOE will be held in Halifax, Canada, hosted by Marine Renewables Canada in partnership with The Maritimes Energy Association, Government of Nova Scotia, Trade Centre Limited, and Offshore Energy Research Association. During 2013, OES has been much involved in the organization of the program of this conference, in particular it will organise and chair a session entitled "*Showing the world - update on flagship projects*", and further approved the continuation of the "poster award" support focused on students and young researchers.

INTERNATIONAL NETWORK ON OFFSHORE RENEWABLE ENERGY (INORE)

INORE is a network for postgraduate researchers working with issues related to offshore renewable energy: wave, tidal and offshore wind energy. INORE brings together researchers from around the world to meet, collaborate and share knowledge.
The OES Executive Committee encourages this network and at the last ExCo meeting, the ExCo unanimously agreed to continue providing annual sponsorship to INORE, particularly to develop membership in new regions, including Asia and the Pacific.
One method of supporting international collaboration work is the "International Collaborative Incentive Scholarships", the ICIS scheme, whereby pairs or groups from at least two different countries are awarded a small bursary to fund (usually travel) expenses that will allow a piece of work to be carried out at one of the group member's organisation. Funding these group collaboration projects not only brings together enthusiastic minds, but often results in the publication of a collaborative research paper, sharing the research. In 2013 OES supported the ICIS grants and intends to maintain this support for the next years.

SINGAPORE INTERNATIONAL ENERGY WEEK (SIEW 2013)

The Singapore Energy Market Authority organises the annual SIEW as a platform for the energy community from Asia and the rest of the world to discuss global energy issues, exchange ideas, and facilitate closer cooperation. The theme for SIEW 2013, that was held from 28 October to 1 November, was "New Horizons in Energy".
Ocean energy was a major theme during the Asia Future Energy Forum (AFEF) within SIEW 2013 and the OES International Vision for Ocean Energy has been presented in one of the technical sessions. This Forum was organised by the Southeast Asian Collaboration for Ocean Renewable Energy (SEAcORE).
A roundtable discussion on the role of Government on ocean energy and its impact to industries was further organised to provide a platform for the discussion and exchange of ideas and insights among different stakeholders-government sectors, academia, industry players and civil society-on the role, potential, and development of ocean energy with specific emphasis on the region.
With the support of the OES, SEAcORE was able to utilize funding in order to initiate collaboration for ocean energy in the Southeast Asia region.

OECD PROJECT "THE FUTURE OF THE OCEAN ECONOMY"

"The Future of the Ocean Economy: Exploring the prospects for emerging ocean industries to 2030" by the OECD has the aim to conduct a global forward-looking assessment of the ocean economy to 2030, with special emphasis on the development potential of emerging ocean-based activities. For practical purposes, the project divides the ocean economy into established marine activities and emerging ocean based activities including wave and tidal energy and offshore wind.
The project explores the growth prospects for the ocean economy and its potential for employment creation. Particular attention is devoted to the emerging ocean-based industries: the risks and uncertainties surrounding their future development, the innovations required in science and technology, investment needs, environmental implications, their contribution to green growth, the implications for planning and regulation, and the policy options most suited to boost their long-term prospects while managing the ocean in responsible, sustainable ways.
The OES accepted to collaborate with this study and the Vice-Chairman, Mr. Eoin Sweeney, attended the Stakeholder Meeting organized at the OECD Headquarters on the 30th April 2013 and the first meeting of the Steering Group on the 28th October 2013. The results of these meetings have been reported to all delegates and it has been decided to organize the spring 2014 ExCo meeting in conjunction with a OES/ OECD workshop related wit this study.
More information about the OECD study is available at: http://www.oecd.org/futures/oceaneconomy.htm

EERA OCEAN ENERGY JOINT PROGRAMME

The European Energy Research Alliance (EERA) Ocean Energy Joint Programme is based around six key research themes: Resource, Devices and Technology, Deployment and Operations, Environmental Impact, Socio-economic Impact, Research Infrastructure, Education and Training. OES and EERA-Ocean share common objectives and therefore a first joint EERA-Ocean and OES Annex V workshop "Computational Modelling and Analysis of Wave and Tidal Converters" was organized on the 25th and 26th of November 2013 in Edinburgh. EERA-Ocean member countries are UK, Spain, Ireland, Portugal, Germany, Italy, Norway, France and Denmark.

OCEAN ENERGY (ERA-NET)

The Chairman is Member of the Strategic Advisory Board of the ERA-NET on Ocean Energy called OCEANERA-NET and provided a letter of support recognizing the great importance of this coordinated research to the ocean energy sector. The ERA-NET on Ocean Energy (2013-2017) is funded by the European Commission and provides a framework for transnational joint activities bringing together 16 partners from nine member states intent on gaining the benefits of coordinated research funding.

03

COLLABORATIVE PROJECTS

3.1

ASSESSMENT OF ENVIRONMENTAL EFFECTS AND MONITORING EFFORTS

OPERATING AGENT

Hoyt Battey (USA Delegate), United States Department of Energy (DOE), USA

DURATION

The first phase of *Annex IV - Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems* started in January 2010 and concluded in March 2013. It was renewed for a second three-year phase in May 2013 to run through May 2016.

PARTICIPANTS

	PHASE 1 (2010–2013)	PHASE 2 (2013–2016)
OPERATING AGENT* AND PARTNERS	Department of Energy* (US) Bureau of Ocean Energy Management (US) National Oceanic and Atmospheric Administration (US)	
TECHNICAL CONSULTANTS	Pacific Northwest National Laboratory (US) The Wave Energy Center (Port University of Plymouth (UK) Aquatera, Ltd. (UK)	
MEMBER COUNTRIES	Canada Ireland New Zealand Norway Spain South Republic of Korea	Canada Ireland UK Norway China Spain Portugal
		Republic of Korea Nigeria New Zealand Mexico Japan Australia

Green cells reflect countries that plan to, or have already, confirm(ed) their participation in the renewed phase of Annex IV. Those in yellow reflect countries that have tentative plans to participate in the renewed effort.

OBJECTIVES

A wide range of different ocean energy technologies and devices are currently in development around the world. However, data that do exist on the possible environmental effects of these technologies are dispersed amongst numerous countries, researchers and developers. Over the first phase of the Annex (2010-2013), seven member nations led by the US Department of Energy (in collaboration with the Bureau of Ocean Energy Management, the Federal Energy Regulatory Commission, and the National Oceanic and Atmospheric Administration), partnered to address the recognized need for information on the environmental impacts of marine renewable energy devices, and facilitate efficient government oversight of the industry, to ensure that existing information and data about environmental monitoring (and to the extent possible, practices for environmental mitigation) are more widely accessible to those in the industry; national, state and regional governments; and the public.

The efforts of the Annex IV extension will largely build on the achievements of the first phase; updating and reviewing the functionality and efficiency of Tethys database, expanding the Tethys content to inform and advance the current state of the science, forming collaborative partnerships with similar agencies and entities engaged in environmental research concerning ocean renewable energy, and building and fostering a community of relevant stakeholders (using the Tethys platform) concerned with these issues will all ensure information sharing needed to better understand environmental impacts of marine renewable energy.

ACHIEVEMENTS AND PROGRESS IN 2013

The objectives of the initial phase of the Annex IV effort were met through two broad achievements: (1) the launching of a publically-available, searchable online database called *Tethys* (http://mhk.pnnl.gov), which contains environmental information relevant to the development and use of marine energy devices; and (2) a final report (Copping et al. 2013a) focusing on the state of scientific understanding (as of early 2013) of three broad environmental issue areas relevant to ocean energy technologies around the world: the interaction of marine animals with turbine blades, the effects of acoustic output from tidal and wave devices on marine animals, and the environmental effects of marine energy development on physical systems. The synthesis of these case studies reflects a broad analysis of the current state of understanding regarding environmental impacts of marine energy technologies and remaining information needs.

The Tethys database was developed using the Semantic MediaWiki software that allows all entries to be tagged with multiple fields and key words, including technologies, stressors, receptors, locations, species and others; however the database is currently being transferred to the Drupal platform which will improve the functionality, expansion efforts, and efficiency of the website. Contents of the database were gathered using metadata forms sent to marine energy developers, researchers, academics, regulators, consultants and other knowledgeable parties. One metadata form was created to collect information on environmental monitoring at sites where pilot or commercial ocean energy projects were being deployed, while another form was subsequently created to capture research studies that investigated environmental effects but were not directly associated with a particular marine energy project development site. These methods have continued in the second phase of Annex IV; members of PNNL have actively distributed, gathered new, and updated existing metadata forms. Once identified member nation analysts will aid in data and information aggregation and vetting as part of a greater effort to ensure that the latest information is continually disseminated to regulators, policymakers and the industry at large.

The Tethys database supports access and organization of hundreds of journal articles, technical reports, presentations and research studies on the environmental effects of marine energy developments. Tethys houses both a knowledge base of documents, links and references, along with an interactive map that provides access to all geo-referenced sites and research studies contributed under the Annex IV project. Additional efforts are currently underway to greatly improve the functionality and social platform of the data system, to create an online commons for various stakeholders involved with marine renewable energy. International communication, aided by the Tethys forum, will ensure access to up-to-date information and continued dialogue. This will also help the regulatory stay informed to assist with their decision-making processes. Further understanding of data gaps will also help to frame future research activities.

The Annex IV effort, along with the development and launching of Tethys, were presented at many relevant conferences and venues over the last year; this work resulting from this effort was presented at the Global Marine Renewable Energy Conference (Washington, DC), the European Wave and Tidal Energy Conference (Aalborg, Denmark), and the Workshop on the Instrumentation for Monitoring around Marine Renewable Energy Devices (Seattle, WA).

In addition to the final report, the results of the Annex IV initiative led to a peer-reviewed publication. Copping et al. (2013b), "Tethys: Developing a commons for understanding environmental effects of ocean

renewable energy" was recently published online in the peer-reviewed International Journal of Marine Energy. It is a methods paper that demonstrates the development, existing functionality, and content of Tethys, as well as discusses the future of Annex IV including information updates, improvements, and additional outreach efforts over the next several years. A second manuscript emphasizing the importance of an international assessment of environmental effects of marine renewable energy is currently in review for a special issue of the *Journal of Ocean and Coastal Management*, which we anticipate will be published early 2014.

Annex IV is planning to sponsor the *Environmental Interactions Of Marine Renewable* (EIMR) Energy Technologies conference at Stornoway, Scotland in 2014. Planning for Annex IV activities during the conference has begun. These include Annex IV presentations, the hosting of conference materials on the Tethys website, and a workshop focused on developing effective, hypothesis-based monitoring plans for MHK pilot projects. The Annex IV team is also currently working to build strategic partnerships with existing data systems, including the Crown Estate's Wave and Tidal Knowledge Network and are currently exploring the possibility of a formal collaboration on the two databases.

FUTURE ACTIVITIES

With the industry still at a stage of testing and deploying early commercial devices, the need to have an on- going international dialogue on ocean energy environmental research has been identified as a priority. To ensure that the Ocean Energy Systems (OES) initiative remains a leading provider of accurate information for the ocean energy community, the OES approved a 3-year extension of the Annex IV project. Future activities of the renewed Annex will focus on continuing to build a community of practitioners and experts in the environmental effects of ocean energy, with information gathering and dissemination efforts to provide the most robust body of knowledge regarding the potential impacts marine renewable energy devices may have on marine animals and the surrounding environment.

Specific tasks include the Operating Agent (US Department of Energy) arranging meetings; facilitating the sharing of tasks among Participants; and distributing Annex IV documents. At a minimum, all Annex Participants will be required to identify an "analyst" to aid in the execution of the tasks mentioned above (analysts are expected to contribute about 10 hours of time to the Annex IV project per quarter). **OES member nations are currently being asked to indicate whether they wish to participate in the second round of the Anne IV initiative and if so, to identify their nation's designated analyst immediately.** Annex IV member nations will be asked to contribute €6,000 per annum to facilitate the extension of said tasks, however this participation fee is not required. The Operating Agent and partners will continue to coordinate the following tasks over the next three years among the Annex's Participants:

Year 1 (May 2013 - May 2014): *Update and review of the Tethys database; form strategic partnerships with organizations engaged in the collection and analysis of environmental monitoring information from ocean energy systems; develop an online forum within the Tethys system to facilitate greater information sharing of ocean energy environmental research; host quarterly webinars on latest international research efforts.*

Year 2 (May 2014 – May 2015): *Continue with Year 1 tasks; plan a scientific conference and identify partner organizations; form a working group and identify lead authors to scope a second major report on the state-of-the-science for environmental research.*

Year 3 (May 2015 – May 2016): C*ontinue with Year 1 tasks; hold a scientific conference (similar in scope to the EIMR 2012 conference); complete the state-of-the-science report.*

This extension of Annex IV has been well received and has already gained several new member nations, thus expanding the opportunity for the possible identification of new questions of concern relative to new marine environments and species of interest, new technology designs, and new regulatory regimes.

3.2

EXCHANGE AND ASSESSMENT OF OCEAN ENERGY DEVICE PROJECT INFORMATION AND EXPERIENCE

OPERATING AGENT

Roger Bagbey, Cardinal Engineering on behalf of the Department of Energy (DOE), US

DURATION

Annex V – Exchange and Assessment of Marine Energy Converters Information and Experiences started in January 2012 and is planned to continue through 2015.

PARTICIPANTS

	ANNEX MEMBERS	WORKSHOP II PARTICIPANTS
OPERATING AGENT	Department of Energy (US)	
TECHNICAL CONSULTANTS	National Renewable Energy Laboratory (US)	
MEMBER COUNTRIES	Canada China Denmark Germany Ireland Japan Mexico Nigeria Norway Portugal Republic of Korea Spain United Kingdom United States	Canada China Denmark France* Germany Ireland Japan Norway Portugal Spain United Kingdom United States

* France is not an OES member, but participated in the Workshop by special invitation; the representative will attempt to seek France's OES membership

OBJECTIVES

The objective of Annex V is to accelerate the development and deployment of ocean energy technology through a multi-country exchange of available ocean project information and experience to allow the participants to understand the current state of knowledge in the field, and to develop a consistent method of assessing the performance and cost of marine energy conversion systems. The primary focus of these efforts will be to develop an assessment of the fundamental knowledge in the following 4 Topical Areas of direct interest to the ocean energy community.

1. Methods for estimating and verifying the ocean energy resources and characteristics, including instrumentation types and deployment methods to capture resource data
2. Methods for modeling the interaction of ocean energy devices with the resource and verifying the results
3. Methods for modeling and experimentally verifying energy capture, power system efficiency, and the resulting loads including extreme loads, from the interaction of the device and the resource
4. Methods for estimating and validating the cost and performance for ocean energy device arrays, including component, subsystem, and the electrical cable and supporting installation, operation, and maintenance, to lead to an assessment of the total cost of electricity

The purpose of Workshop I, held October 15 and 16, 2012, was to exchange information and experience on open water testing and site development and operation. That Workshop included participation by about 40 attendees from 12 countries and featured project data and test site operation experience from a cross-section of the industry, including: test site developers and operators; developers of new test sites that were under consideration or being constructed; and converter developers that established and operated their own test sites. A full report of that Workshop, including all presentations can be found on the Ocean Energy Systems website.

ACHIEVEMENTS AND PROGRESS IN 2013

Workshop II of Annex V, held in Edinburgh, Scotland on November 25 and 26, 2013, was attended by about 50 representatives from 12 countries. The Workshop covered the Computational Modeling and Analysis of Marine Energy Converters (MECs), and included projects for wave and tidal energy capture. The specific objectives of the Workshop were as follows:

- A compilation of modeling and analysis methods being employed for MECs. With an understanding of various approaches, including their limitations and the degree to which they have been verified or validated by experiments and demonstrations, both methods developers and device designers can be better informed, thereby avoiding duplication of efforts and repeating past mistakes.
- To identify potential next steps for research, verification and validation testing and facilitate a focused discussion to define research efforts that will create accurate, cost-efficient computational methods that can be generally available to any potential user.
- To identify participants and organizations with an interest in performing the identified research in verification and validation to improve modeling accuracy and cost effectiveness.

The Workshop consisted of 27 presentations and two discussion sessions. One discussion session focused on tidal computational models and the other on wave models. The presentations were evenly split between wave and tidal devices. Presenters were asked to complete a questionnaire to determine their ongoing interest in the exchange of information. Datasheet forms were also circulated to all attendees to capture computational methods currently employed and to identify gaps in methods that need to be filled. This data will be compiled for publication on the OES website, and used to inform additional workshops as well as to address other issues in modeling. The information collected will form a base of computational tools and methods being used, with the ultimate goal of identifying high confidence tools to predict the performance of converters, and to gain the confidence of investors and end users in the ability to assess project cost of electricity (COE).

The discussions of the workshop resulted in a strong consensus of several participants who are interested in some type of benchmarking of computational methods to some baseline model(s) to confirm compatibility and consistency of the methods. A near term phone conversation will be held to discuss details and plans for the next workshop, to be held in the first half of 2014.

FUTURE ACTIVITIES

The database of computational tools and methods resulting from data gathering as part of Workshop II will be compiled and made available within the next few weeks. The Annex will liaise with the IEC TC 114 Ocean Energy committee to ensure that the technical specifications and standards under development guide and inform both the additional efforts undertaken by the Annex, and other proposed activities to develop open source computational tools and associated validations.

During discussions, eight country representatives stated an interest in collaborating on benchmarking and potential associated testing. These were: CA, CN, DK, ES, FR, IE, UK, and US. This concept will be further discussed, and a determination made whether to suggest a further Annex with OES, or to undertake the work under a separate agreement between the interested countries, individuals, and organizations.

It is anticipated that at least three additional Annex V workshops will be held over the next two years. Further information exchange is expected on computational methods, test verification and validation, and methods to perform project performance/cost assessment.

3.3

WORLDWIDE WEB GIS DATABASE FOR OCEAN ENERGY

RESPONSIBLE

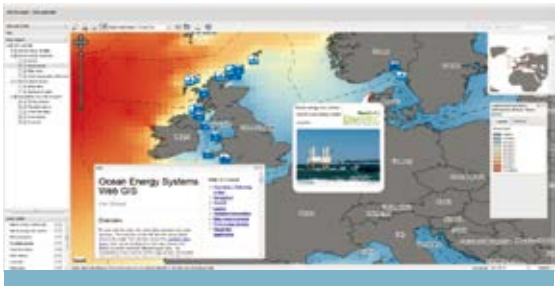
Jochen Bard, Fraunhofer Institute IWES, Kassel, Germany

DURATION

This activity was approved in the 24th ExCo meeting and shall run for 3 years.

OBJECTIVE

The objective is to develop an interactive web-based GIS (Geographical Information System) mapping application and the requirements to implement it on the OES website. The primary purpose of this application is to give interested website visitors access to detailed global information related to ocean energy in an easy to use yet visually striking way. The available information comprise ocean energy facilities, resources, relevant infrastructure and relevant general geopolitical and geographical information, altogether in conjunction with the respective location / extent respectively distribution on a global map. The user of the application is able to display any combination of the provided information with the help of a point-and-click interface which



runs in any common web browser without the need of installing separate software. Through the interface the viewer can zoom and move through the map, select items and display related information and download or print images of the displayed information as desired.

PROGRESS

During 2013 the initial application setup was developed including software implementation and configuration, data collection and data use negotiations, layout and compilation of the displayable layers, and implementation of the data into the server. The tool is expected to be launched on the first quarter of 2014.

3.4

TOOL FOR ASSESSMENT OF COST OF ENERGY

NEW ACTIVITY APPROVED

In the 24th ExCo Meeting the topic "Tool for assessment of cost of energy" has been identified as a priority topic by most Delegates and, therefore, it was agreed to initiate an activity for this topic. In 2013 the terms of reference for this project have been prepared and approved at the 25th ExCo Meeting.

The goal of this project is, within a 12 month project timeframe, to engage a large number of international stakeholders to deliver a reliable and credible Levelised Cost of Energy (LCOE) assessment for wave, tidal, and OTEC technologies, together with identification of the routes to maximise rapid cost reduction through international collaboration and deployment effort.

Immediate benefits that will result from this project include the strengthening of international networks and the increasing of international collaboration, both of which are urgently required.

This project sets out to deliver the assessment of a credible LCOE based on international projects, and the likely future LCOE reduction trajectory of ocean energy projects at a global scale.

Longer term international benefits include enhanced deployment of ocean energy through collaboration of supply chain and development activity across a wider range of stakeholders at an international level. International cooperation and collaboration is recognised as a strategic enabler of accelerated deployment of ocean technology, building upon an understanding of the far reaching implications of ocean energy development, and the diverse range of locations in which ocean energy activity could make a valuable contribution to the energy mix.

Analyses of the LCOE for wave, tidal, and OTEC technology has been carried out at a regional level for a small number of countries, but the impact of international development on LCOE has not been measured.

This project will further the existing state of the art by filling gaps in current knowledge and understanding; and delivering specific international consensus on LCOE – based on the wide consensus from key experts in industry, government and leading research centres across a wide representation of nations.

3.5

DISSEMINATION AND OUTREACH

OPERATING AGENT

Ana Brito e Melo, WavEC Offshore Renewables, Portugal

DURATION

Annex I - Review, Exchange and Dissemination of Information on Ocean Energy Systems is a mandatory Annex of the OES work programme, which has been running since the formation of the OES.

OBJECTIVE

The objective of this task is to collate, review and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of ocean energy systems. Access to this information should facilitate further development and adoption of cost-effective ocean energy systems. In addition, the results of this task aim to facilitate identification of further annexes, as well as continuing to promote information exchange.

PROGRESS IN 2013

During 2013, the following activities have been done:

New publication "Global Status and Critical Developments in Ocean Energy"

The 2008 Annual Report started a tradition of including a series of invited articles, on a specific theme, by acknowledged industry experts. These invited articles examine current issues in the development of ocean energy technologies and provide insights into changing circumstances within ocean energy, e.g., forecasting cost of energy for different technologies. The ExCo decided that, with 5 years' worth of invited articles, it would be valuable to collect these articles together into a single volume as a reference source, which documents the recent developments in ocean energy in OES countries. So the publication **"Global Status and Critical Developments in Ocean Energy"** is intended as an authoritative reference on developments in ocean energy, as they occurred in a year-on-year progression. It includes the following chapters:

- 2008: Global Status and Perspectives of Ocean Energy Technologies
- 2009: Key Technical and Non-technical Challenges for Ocean Energy
- 2010: Key Facilitators for Ocean Energy
- 2011: Marine Spatial Planning and Ocean Energy
- 2012: Development of the International Ocean Energy Industry Performance Improvements and Cost Reductions

Policy Study Review

A policy study has been prepared and will be release in early 2014. It contains a summary of the policies that each country member has adopted to promote and accelerate the uptake of ocean energy.

Website

The OES dedicated website (www.ocean-energy-systems.org) is the primary source of communicating the activities of OES to a wider audience and, through the restricted areas, to ExCo delegates.

Annual Report

A professionally edited and printed Annual Report is produced each year and 1,000 copies are widely distributed. This is intended as the flagship document for OES's activities and a marker for industry development. Members ensure that the Annual Report reaches its target audience in the respective countries. The publication of the Annual Report is accompanied by a worldwide media release.

Promotional Material

Further promotional material includes a display poster and a 6-page leaflet targeting potential new member countries, explaining the role and added value of OES. This leaflet can be delivered to prospective country governments and potential Contracting Parties.

Participation in National Events

Dissemination of OES activities has been an ongoing process, through the presence of OES representatives in well-known conferences related to ocean energy. Such events are the best way to spread awareness about the OES role and activities.

The table below lists the main events in 2013, at which the OES was represented:

EVENT	COUNTRY	DATE
Bilbao Marine Energy Week - Ocean Energy Conference	Bilbao, SPAIN	15 April 2013
6th Global Marine Renewable Energy Conference	Washington, USA	28 April 2013
2nd China Marine Renewable Energy Conference	Guangzhou, CHINA	17 May 2013
EU-OEA Sustainable Energy Week - Conference "Risks & Rewards from Emerging Renewable Technologies: The Ocean Energy Case"	Brussels, BELGIUM	25 June 2013
National Seminar on Ocean Energy	Cape Town SOUTH AFRICA	21 October 2013
Marine Renewables Canada 2013 Annual Conference	Ottawa, CANADA	20 November 2013

04

CURRENT PERSPECTIVES OF KEY INDUSTRIAL OCEAN ENERGY PLAYERS

ALSTOM

Ken Street
BUSINESS DEVELOPMENT MANAGER – OCEAN ENERGY

Alstom 1MW being lifted into water

OES: Please explain, briefly, the involvement of your company in ocean energy
Ken Street: Alstom Ocean Energy are developing a family of tidal turbines (> 1MW) to optimise power generation in the different resource locations around the word. Our 500kW turbine, tested at EMEC, successfully completed its test schedule in November 2012 delivering more than 250MWh into the UK grid. Our 1MW turbine was installed at EMEC in January 2013 and is following a test programme that will conclude at the end of 2014. We have just announced a project in the Sound of Islay (west coast Scotland) with Scottish Power Renewables and Andritz where we jointly install 8 turbines delivering a total of 10MW into the grid. Installation is planned to start in 2016. This is an important step as both companies demonstrate their technology in a pilot array before moving forward to commercial projects. We are also working on pilot arrays in France which is now becoming a second market after the UK.

OES: Innovation is a key issue in developing ocean energy. How much of this innovation is internally developed in your company, how much is contracted to external organizations and how much is developed in public funded projects?
Ken Street: Alstom policy in entering this new market was to investigate the market and identify what we ultimately hope will be a market leading technology requiring industrialisation rather than starting from scratch ourselves. This recognizes that tidal solutions rely not just on sound engineering practice but on a deep understanding of the environment and the tidal resource that we are working in. This knowledge was not already in Alstom and so they needed to find it elsewhere. It is this overwhelming need to understand the working environment that inevitably means we require to contract with organisations that have the necessary skill sets and knowledge such as universities, marine consultancies, offshore contractors, composite blade suppliers, wet mate suppliers etc. We aim to control and grow our IP knowledge in the areas where we believe we have the most to contribute and where the investment is justified in terms of competitive advantage. An estimated 30 - 35% of development cost is outsourced to third parties.
All activities in this sector have a high cost high risk profile and so public funding is very important in enabling progress in line with market requirements however total public funding contribution so far is less that 10% of projected spend.

OES: What are your expectations about worldwide ocean energy development in the next decades and the long term world value of this industry?
Ken Street: There is no doubting that marine energy is at an early stage of development. It requires a certain set of conditions in order to flourish. Ignoring the obvious resource requirement it needs funding in the form of CAPEX grants and a Feed in Tariff to allow it to compete with alternate energy sources. There is also a need for an efficient consenting process and legislative framework that supports its development. The UK is acknowledged as the leader in marine development and this has been achieved

over the last 10 years through a combination of modest public funding, significant private finance and fundamental streamlining of the consenting process backed by positive legislative measures. In the absence of these conditions it is not possible for develop this new technology market. However as costs fall through deployment, innovation and experience in the UK and France and other countries that are able to champion marine the technology gradually becomes viable in other markets where for example the cost of existing electricity is high compared with UK etc.

Deployments prior to 2020 will be modest, limited by a combination of grid restrictions, financial challenges and the resulting technology development progress. Progress is only possible with operating experience. Post 2020 grid restrictions should be less limiting allowing projects in remoter areas of the UK to progress as well as those in France with a significant increase in installed capacity. As we move beyond 2030 hundreds on MWs should be installed and costs will allow projects to develop in the export markets.

It is difficult to be certain of the ultimate market size but a conservative estimate of accessible world tidal resource would be 80GW sales worth £200,000,000,000 and a wave resource of 300GW worth £750,000,000,000 with an annual service market worth £14,250,000,000. It is also credible that as our knowledge increases the size of the resource will increase.

OES: What do you see as the main challenges and how might these be dealt with?

Ken Street: The main challenge is finding the necessary finance to drive the market forwards to the deployment of pilot arrays. There is now recognition in the UK that tidal is ahead of wave in development terms and so this should identify the need to continue R&D support of wave even after tidal arrays start to be delivered. We need to make sure that steps are taken to maintain and increase the number of interested utilities – without customers there can be no market. EON has recently stepped out but with the declared intension of returning should conditions improve. Referring to technology performance and long term market confidence. The last point requires a political solution both at national and European levels. There need to be appropriate incentives for those who are prepared to invest in new technologies aimed at delivering sustainable energy, creating jobs and CO2 reduction. Grid restrictions in the UK are presently a serious constraint and this requires huge investment to overcome. The cost of this work is presently carried by the projects which require the prospective array owners to underwrite the costs which are a huge financial risk when dealing with new technology. Even once the grid is installed there are very high charges for the operator compared with the same installation on the mainland. As the resource (wave and tidal) cannot be transported on a truck an exception needs to be made or further compensation is required.

OES: How do you see that international collaboration could accelerate ocean energy growth along the development pathway and what, specifically, is the role that you would like OES to play in supporting the development of ocean energy and a company like yours?

Ken Street: International collaboration can take many forms. We already have numerous examples in the UK and France of companies working together. This mainly by the OEMs who do not have the same concerns about IP loss that SMEs have. This allows us to be much more open about areas where we can cooperate for the common good. It is widely recognized by the OEMs that right now success is what is required and there is much less concern about who actually archives that first. There are many components and areas where cooperation should be embraced. Connectors, materials, environmental data, offshore operations and procedures are but a few examples.

As deployment costs are high but unavoidable to move the industry forward then projects involving several technologies and several end users are beneficial. They reduce the risks and costs for all at the same time allowing confidence to be increased in the ownership and operation of an array by a greater number of players. This increases the customer base allowing for increased volume.

It makes little sense to repeat the mistakes and not take benefit from the lessons learned from the UK by an insular approach to the market. Strategic agreements between leading countries that result in promotion through shared knowledge can only help grow the industry.

OES can help through the accurate dissemination of sector knowledge (lessons learnt), encouraging international cooperation, and avoiding the industries mistakes of the past of over promising and under delivering. Realism is essential if we are to grow confidence in the marine market which has the power to create jobs, drive investment, provide sustainable power and reduce CO2 emissions.

ANDRITZ HYDRO

Peter Gnos
MARKET MANAGEMENT OCEAN KINETICS

OES: Please explain, briefly, the involvement of your company in ocean energy
Peter Gnos: ANDRITZ HYDRO Hammerfest is one of the worldwide leading developers of tidal turbines. The first prototype, the HS300, was developed in the late 90's and firstly installed in the Norwegian waters the first ever tidal current turbine with permanent connection to a public grid in 2004. This smaller prototype, with an output of 300kW, has delivered over 1.5 GWh to the grid and shown up to 98% availability during prolonged test runs. The turbine passed during his operational lifetime of more than 17,000 hours a full maintenance and validation cycle to prove his "fit for purpose" design base.
Building on the prototype, the seabed-mounted HS1000 is a tried-and-tested design with horizontal axis rotor, pitched blades and yaw feeding a variable speed conventional generator via a gearbox. Automatic control software governing a sensor-driven monitoring system adjusts the leading edge to capture optimum output from a given tidal environment. It is meant for among the most taxing marine currents, designed to handle flows between 1 and well above 4 m/s, in water depths down to 100 meters. ANDRITZ HYDRO Hammerfest successfully installed in December 2011 its full scale, 1MW, tidal turbine destined to validate the technology for the world's first tidal power arrays. The machine has been in operation from more than 1 year, in order to validate performance and operational capabilities. During this first period also continuous autonomous running over a prolonged period has been tested. In January 2013 the turbine has been retrieved for validation, small maintenance and minor repairs and re-installed in August 2013. Since this date, the machine is running in autonomous and continuous operational mode delivering to the national grid, up to date, more than 600MWh. Base on this experience small scale arrays are in development phase on a worldwide base.

OES: Innovation is a key issue in developing ocean energy. How much of this innovation is internally developed in your company, how much is contracted to external organizations and how much is developed in public funded projects?
Peter Gnos: ANDRITZ HYDRO Hammerfest's Research & Development (R&D) activities started in the 1990s, when the HS300 turbine was developed, manufactured and, in 2003, installed in Kvalsund, Northern-Norway. Based on the tested technology, full-scale turbines, with a rated capacity of between 500 kW and 2,000 kW, were designed for the planned commercial applications. The requirement to improve efficiency, reliability while reducing equipment and operational costs, pushes the company to continuously invest in R&D activities in order to achieve the required technical and commercial goals. For these reasons field tests, model test in laboratories, numerical flow simulations, and technology innovations are all combined into an optimized overall development process. Majority of all R&D activities are provided internally, either from ANDITZ HYDRO Hammerfest or from ANDRITZ HYDRO group. Also collaboration with Universities is used to continuously improve our technologies.

OES: What are your expectations about worldwide ocean energy development in the next decades and the long term world value of this industry?
Peter Gnos: To provide an estimation of the market potential of the tidal business is really difficult at this stage. Today the market reached at a "crossing point" in his path. Several major

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FROM A TECHNICAL POINT OF VIEW IT WILL BE CRUCIAL TO DEVELOP A PROPER SUPPLY CHAIN DEDICATED FOR THE SPECIFIC MARKET, CAPABLE TO DELIVER, ON A COST EFFECTIVE BASE, THE REQUIRED INNOVATION ON THE TECHNOLOGY.

technology developers installed, or will shortly install, their full scale tidal devices, delivering with more or less difficulties power to the grid. The natural step further would be know the implementation of first small scale arrays, opening the pathway for bigger and more profitable full scale commercial projects.
Unfortunately what is missing at the moment is on one hand an adequate regulation for approvals, permitting and implementations in some of the countries and on the other hand big utilities capable to finance those projects without the requirement of loans. Today it is clear that the major markets are UK/Scotland, France and Canada considering the supports given by the local Governments in terms of funds and dedicated FIT. Project developers of medium and small scale are willing to develop these new projects but are not sufficiently supported by the banks and their actual risk reluctance.
As soon as the market will be capable to provide at least a two year of full scale array operation the situation might look differently, but until this moment has not come a prediction in terms of volume and numbers is difficult. Some years ago ambitious targets indicated 1,3GW of installed capacity by 2020 (with 150TWh of global potential). Today a realistic forecast indicates 120MW cumulative capacity to be achieved by 2020, implying total revenue of around 650 million USD.

OES: What do you see as the main challenges and how might these be dealt with?
Peter Gnos: From a commercial point of view major challenge will be to provide sufficient confidence to banks and risk adverse big utilities in order to push further the required first projects. From a technical point of view it will be crucial to develop a proper supply chain dedicated for the specific market, capable to deliver, on a cost effective base, the required innovation on the technology. Also marine operation is today a topic under discussion because of the high costs involved. This because today turbine developers have mainly to rely on expensive and unavailable vessels normally used in the “rich” oil and gas sector. New solutions, globally applicable are required and under development at the moment. Another important technical challenge will be the definition and development of suitable technical solutions capable to provide off-shore, submarine hubs to interconnect a series of devices. Today the preferred solution is to export the produced power from each turbine with a single cable connection to the shore. But this cannot be the final future solution when we start to speak about hundreds of devices. Therefore offshore electrical solutions need to be developed, such as:

- Submarine interconnecting hub for devices
- Reliable and cost efficient wet mate connections
- AC or DC power export solutions, depending on the distance to shore

OES: How do you see that international collaboration could accelerate ocean energy growth along the development pathway and what, specifically, is the role that you would like OES to play in supporting the development of ocean energy and a company like yours?
Peter Gnos: An international collaboration is for sure helpful to stimulate the market and provide the required platforms for a sustainable, continuous growth of the technology. As mentioned above the market needs on one side an adequate supply chain capable to provide cost effective technical solutions around the turbine itself and on the other side suitable commercial/financial schemes sufficient to attract investors. The involvement of banks, insurance companies and governments in the market is at the base for a future prosper development of the sector that cannot be further sustained by only technology developers.

DCNS

Fabien Mesclier
DEVELOPMENT MANAGER

OES: Please explain, briefly, the involvement of your company in ocean energy
Fabien Mesclier: DCNS is a world leader in ocean technologies and has the ambition to take part in the emergence of an industrial sector dedicated to renewable ocean energies. In this respect, it is the only industrial company working on 4 technologies:

- Tidal: last year, DCNS took control of Openhydro. The turbine is 16M high and can produce until 2MW of electricity. It has already been tested in open sea and connected to the grid. Commercial partnerships are already signed with clients in France, Ireland, Scotland and Canada.

- Wave: DCNS currently evaluates several wave technologies before deciding which one(s) could be commercialised. For instance a pilot farm composed of Waveroller devices (AW-E / Fortum) is to be installed in Brittany, France by 2016.

- Floating offshore wind: DCNS develops of a MMW prototype in cooperation with a turbine manufacturer. The objective is to install the machine by 2016.

- OTEC: two technical solutions are developed by DCNS: offshore and onshore power plants. In addition of supplying a baseload electricity, OTEC can offer other by-products: desalinisation, cooling, aquaculture. DCNS should be able to propose turn key power plants by the end of 2014. By 2030, OTEC offshore could represent a market of 25 G€ and OTEC Onshore, 9 G€.

OES: Innovation is a key issue in developing ocean energy. How much of this innovation is internally developed in your company, how much is contracted to external organizations and how much is developed in public funded projects?

Fabien Mesclier: DCNS dedicates 8% to 10% of its budget to R&D. The objective is to keep one step ahead by putting a lot of efforts in the development of new products and concepts. DCNS has a dedicated team for each of the 4 technologies within its marine renewable energies Business Unit. The group also has created DCNS Research, whose mission is to innovate in the field of maritime engineering and ocean energy.
However, the budgets needed to develop emerging ocean technologies are important, especially when innovations get closer to full scale prototypes or pilot farms. Eventually, public support is necessary to accelerate the learning curve. The four technologies developed by DCNS have benefited from public funding (EU, national and regional public support).

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THE OCEAN ENERGY SECTOR HAS A HUGE POTENTIAL MARKET. INDEED, EVERY COSTAL AREA CAN BENEFIT FROM WIND, WAVE, TIDAL OR THERMAL ENERGY. FOR INSTANCE, TIDAL ENERGY WHICH IS SEEMED TO HAVE THE SMALLEST POTENTIAL AMONG THE FOUR SOURCES OF ENERGY DCNS IS WORKING ON REPRESENTS 90 GW, WHICH IS THE EQUIVALENT OF AROUND 60 NEW GENERATION POWER PLANTS.

OES: What are your expectations about worldwide ocean energy development in the next decades and the long term world value of this industry?
Fabien Mesclier: The ocean energy sector has a huge potential market. Indeed, every costal area can benefit from wind, wave, tidal or thermal energy. For instance, tidal energy which is seemed to have the smallest potential among the four sources of energy DCNS is working on represents 90 GW, which is the equivalent of around 60 new generation power plants.
In addition, some technologies have proved their ability to produce energy in real sea conditions while new concepts are emerging in various parts of the world: Australia, Japan, South Korea, Canada, the USA, Europe, South America, China, etc.
One can expect that the 2020 decade will see the take-off of the commercial development of ocean energies. By 2030, their LCOE will be competitive with other renewable energy sources. And by 2050, one can expect that up to 100 GW of Ocean Energy projects could be installed.

OES: What do you see as the main challenges and how might these be dealt with?
Fabien Mesclier: Some technological challenges still have to be tackled but most of them will have been solved by the end of the current decade. But other issues remain to be addressed:

- *Cost reduction:* it is essential to be competitive compared to other renewable energies, but also with fossil energies, especially in remote areas. The commercial development will allow realising scale saving, and innovations will also help reducing costs.

- *Reliability and durability:* R&D added to the experience of the prototypes tested in real conditions are needed to improve the reliability and increase the life cycle of a device.

- *Grid connection:* important investments are necessary to connect ocean energy farms to the electrical networks. Public investment will be essential to finance this infrastructure.

- *Public acceptance:* continuous discussions are key to inform local communities and other maritime sectors potentially affected by ocean energy projects

OES: How do you see that international collaboration could accelerate ocean energy growth along the development pathway and what, specifically, is the role that you would like OES to play in supporting the development of ocean energy and a company like yours?
- The importance of international cooperation:
- Transfer of know-how and experience
- Joint development of products, innovations
- New market opportunities

- The role of OES:
- Identification of the most relevant markets: resource assessment, market analysis, cost of energy
- Promotion of ocean energies worldwide
- Encourage new cooperation worldwide

IBERDROLA

Cristina Heredero
HEAD OF TECHNOLOGY, QUALITY AND ENVIRONMENT DEPARTMENT

OES: Please explain, briefly, the involvement of your company in ocean energy

Cristina Heredero: Iberdrola is a reference in marine energy and supports the development of this technology, as in the past did with onshore and offshore wind.

Iberdrola through Scottish Power Renewables branch (SPR), is promoting projects based on ocean energy devices (wave & tidal) in United Kingdom for years.

SPR has obtained the first tidal array consent worldwide with the project Sound of Islay (Scotland) totalling up to 10 MW. This project has been selected to be funded by the NER300 Program of the European Union.

SPR is also promoting other marine projects as Duncansby and Marwick, both in Scotland. Duncansby is a tidal power plant of 95 MW and Marwick is a wave power plant of 49,5 MW.

These sites were secured during Wave & Tidal leasing Round I promoted by The Crown Estate, the company which manages the property portfolio owned by the UK Crown. This leasing round was located in the Pentland Firth and Orkney waters and had a potential capacity of up to 600 MW for wave energy projects and 1000 MW are for tidal energy projects.

In regard with wave energy, Renewables Business Unit of Iberdrola was involved in a project consisted on the installation and testing of a 40 kW Power buoy (from Ocean Power Technologies-OPT) in Santoña in the North of Spain. Also SPR invested in one P2 device from Pelamis Wave Power that is being tested in EMEC in the frame of Orcadian project, in collaboration with EON, which also invested in one P2 device. EON device was manufactured one year before and all the lessons learnt were incorporated to SPR device.

Apart from this Iberdrola through its subsidiaries is also involved in many R&D projects funded by the European Commission and by the Spanish government.

Renewables Business Unit of Iberdrola takes part in the project DTOcean - Optimal Design Tools for Ocean Arrays. Its participation will focus on selection of scenarios for wave energy converter arrays, site identification for specific case study scenarios, requirements and design criteria for ocean energy arrays, validation of the multiobjective tool and some dissemination activities.

Iberdrola Ingeniería has lead the most important Spanish R&D project on ocean energy called Ocean Lider. Running since 2009, OceanLider, has carried out several R&D activities covering resource assessment, technology development of wave, tidal and hybrid systems, electrical transmission, operation, maintenance and safety systems and environmental issues. Renewables Business Unit of Iberdrola has also taken part in this project.

Iberdrola Ingeniería is also coordinating another Spanish R&D project called UHINDAR with the participation of eight leading Basque companies aims at developing a floating wave energy converter (with the OCEANTEC technology) and defining the electric infrastructure and mooring systems for a complete wave energy farm.

Iberdrola Ingeniería is driving a European R&D project focused on efficient wave power partially funded by the European Institute of Innovation and Technology (EIT) through one of its knowledge and innovation communities (KIC InnoEnergy). The company is carrying out this innovative proposal in partnership with the Swedish company CorPower Ocean and the Portuguese marine research centre WavEC. HiWave envisages the demonstration of a new wave power harnessing device and the subsequent design of an offshore farm using this technology.

Finally, Iberdrola Ventures - PERSEO is the Corporate Venture Capital Program of Iberdrola and is focused on investing in technologies and new disruptive businesses that ensure the sustainability of the energy model. One of the main technologic lines of investment is renewable energy and especially marine energy. PERSEO has invested in Oceantec, a Company that was founded with the aim of developing a high performance and cost-competitive wave energy converter. After thorough analysis, the company decided to develop a device based on the Oscillating Water Column (OWC) concept; its prototype has already been tested in a basin (1:25 scale). PERSEO has also invested in ANDRITZ HYDRO Hammerfest (AHH) that is developing its own technology of tidal energy converter. This technology (HS1000 – 1 MW) is being tested in the European Marine Energy Center (EMEC) in Scottish waters through a very thorough testing programme, including and independent power assessment against the international accepted existing standards. Additionally the HS 1000 has obtained DNV prototype certification and is working on obtaining the type certification

OES: Innovation is a key issue in developing ocean energy. How much of this innovation is internally developed in your company, how much is contracted to external organizations and how much is developed in public funded projects?
Cristina Heredero: Iberdrola is very committed with innovation, only in 2012, 145 million euros were spent in R&D area. In particular 20 million euros were spent in renewables R&D projects.
As we have mentioned before Iberdrola has its own corporate venture capital arm, Iberdrola Ventures - PERSEO, which has already invested 40 M€ since its inception, with a significant portion of that dedicated to marine energy technology companies such as AHH and Oceantec.
Additionally Iberdrola has received the support from public funds such us NER 300 from the EU, Crown State, Scottish Government, and Spanish government funding programs.
Iberdrola innovation management model is open and involves the most outstanding professionals, technology centers, university, equipment manufacturers etc. In the field of marine energy we have worked with WAVEC, RES, Garrad Hassan, Frasher Nash, Pelamis, AHH, Alstom and other relevant companies in the sector.

OES: What are your expectations about worldwide ocean energy development in the next decades and the long term world value of this industry?
Cristina Heredero: Tidal energy sector has made significant steps in last years and technology matureness is improving well, nevertheless cost and availability are key factors to be demonstrated in the following years. Wave energy sector is a step behind, because there is not a preferred or winner solution. Nevertheless wave converter devices must be designed with robustness (waves are an aggressive resource), simplicity and economical criterion. If this is achieved wave technology could play a very important role in the medium term as wave energy resources is very abundant compare to tidal energy resources.
In both cases, decided support from public sector is essential.

OES: What do you see as the main challenges and how might these be dealt with?
Cristina Heredero: In the field of wave energy technologies survivability, simplicity and capacity factors increase are key. In both tidal and wave energy technologies costs reduction and operational experience are needed in order to become competitive with the other renewable technologies.

OES: How do you see that international collaboration could accelerate ocean energy growth along the development pathway and what, specifically, is the role that you would like OES to play in supporting the development of ocean energy and a company like yours?
Cristina Heredero: In today´s global world, international collaboration is essential. International agencies such as OES are indispensable to disseminate the knowledge and achievements developed in different countries. OES publications are a reliable source of information for ocean energy sector stakeholders. Additionally is unique voice for the sector for governments and international organizations.

SIEMENS

Achim Woerner
HEAD OF HYDRO & OCEAN SIEMENS AG, ENERGY SECTOR

OES: Please explain, briefly, the involvement of your company in ocean energy
Achim Woerner: Siemens fully acquired Marine Current Turbines in 2012. Siemens designs, engineers and manufactures tidal stream energy devices. Further core activities comprise the development and implementation of tidal power projects.

OES: Innovation is a key issue in developing ocean energy. How much of this innovation is internally developed in your company, how much is contracted to external organizations and how much is developed in public funded projects?
Achim Woerner: Siemens has a highly qualified and experienced team with excellent market, industry, and engineering knowledge. Hence, most of innovations are driven internally, supported by selected external partners & research institutes. Public R&D funding plays an indispensable role in this early stage. Public research & support for tidal resource assessment is the basis for all players in the industry to develop and drive the industry forward.

OES: What are your expectations about worldwide ocean energy development in the next decades and the long term world value of this industry?
Achim Woerner: We estimate globally extractable potential for tidal stream power at ~800TWh per year, resulting in a significant market for OEM and maintenance in a mature state in the 2020s. Only a few MW have been utilized for testing so far, offering an extraordinary growth perspective once the technology has been commercialized. Tidal as renewable & predictable source has long-term the potential to complement the energy generation portfolio.

OES: What do you see as the main challenges and how might these be dealt with?

Achim Woerner: There are three main challenges: Firstly, next generation tidal stream devices have to be proven in small-scale arrays. Funding of required capital by investors and governments is a main challenge to start the commercialization of the technologies.
Secondly, tidal power has to become cost-competitive with other forms of renewable energy within a decade. This can only be achieved by further innovation and volume. Thirdly, grid connections have to be available at most attractive sites. All challenges can only be dealt with if all stakeholders actively push this promising technology.

OES: How do you see that international collaboration could accelerate ocean energy growth along the development pathway and what, specifically, is the role that you would like OES to play in supporting the development of ocean energy and a company like yours?
Achim Woerner: Tidal stream will profit from international standard setting in the ocean energy industry, where OES can play a vital role. Furthermore, sharing of experiences and knowledge from first installation, e.g., in the area of environmental impact studies and resource assessment, can highly accelerate ocean energy growth via international collaboration.

VOITH HYDRO

Prof. Dr.-Ing. Raphael Arlitt
HEAD OF BASIC R&D AND RESOURCE ANALYSES

OES: Please explain, briefly, the involvement of your company in ocean energy
Raphael Arlitt: Voith Hydro Ocean Current Technologies GmbH & Co. KG started its involvement in tidal current energy exploitation in 2005 by an in-house development starting from an innovative concept design via component and subsystem and prototype testing of a scaled device into full scale 1 MW commercial demonstrator testing at the European Marine Energy Centre at Orkney, Scotland, UK.

OES: Innovation is a key issue in developing ocean energy. How much of this innovation is internally developed in your company, how much is contracted to external organizations and how much is developed in public funded projects?
Raphael Arlitt: All concept innovation and key component innovations have been developed internally in Voith Hydro Ocean Current Technologies or sister companies inside the Voith Hydro division or the network of Voith companies. The inventions throughout the innovation process had been further developed in collaboration with research facilities and universities throughout Europe. The university research and development work had received public and industry funds. Final testing of the scaled prototype in South Korea has been funded by the German government while full scale demonstrator testing at the European Marine Energy Centre is being funded by the

MRPF (Marine Renewable Proving Found) of the UK government.

OES: What are your expectations about worldwide ocean energy development in the next decades and the long term world value of this industry?
Raphael Arlitt: Due to world population growth and increased energy consumption per capita there is a demand to convert the electrical energy supply from carbon emitting fossil energy sources into renewable energies. Because of the vast resources, ocean energy has the potential to contribute to a renewable energy mix. In addition, the different characteristics of tidal energy compared to other renewable energy sources contribute to the independence on the fluctuating energy supply of single renewable energy sources as wind and solar.

OES: What do you see as the main challenges and how might these be dealt with?
Raphael Arlitt: The main challenge to utilize ocean energy is to achieve cost competitiveness of this innovative form of energy conversion. Competitive energy transformations (hydropower, wind, solar, etc.) had been developed and optimized over a long period with strong financial investments over decades. Similar support and efforts in the development of a tidal energy industry can lead to industrial sectors covering many areas, like inter-array cabling, offshore operations and need to address further needs to economically deploy and operate these power plants. In ocean energy this ecosystem around the tidal turbine as the centerpiece of the technology has to be developed to achieve cost competitiveness in the least amount of time.

OES: How do you see that international collaboration could accelerate ocean energy growth along the development pathway and what, specifically, is the role that you would like OES to play in supporting the development of ocean energy and a company like yours?
Raphael Arlitt: International collaboration is a necessary fundament of successful development of all technological innovations. International resources need to be utilized to build up an economical successful tidal energy sector with the least amount of time and funding. Here international sourcing for components in the manufacturing process is only one example. OES can support this process by information exchange among technology and project developers and all remaining stakeholders of ocean energy. In particular the information exchange among governments could support the need to synchronize governmental regulation on the consenting and leasing of ocean energy projects and sites. Additionally the collaboration on funding schemes could avoid multiple investments in various countries in similar or related concepts, and therefore increase the effectiveness of investments into the developments.

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INTERNATIONAL COLLABORATION IS A NECESSARY FUNDAMENT OF SUCCESSFUL DEVELOPMENT OF ALL TECHNOLOGICAL INNOVATIONS. INTERNATIONAL RESOURCES NEED TO BE UTILIZED TO BUILD UP AN ECONOMICAL SUCCESSFUL TIDAL ENERGY SECTOR WITH THE LEAST AMOUNT OF TIME AND FUNDING. HERE INTERNATIONAL SOURCING FOR COMPONENTS IN THE MANUFACTURING PROCESS IS ONLY ONE EXAMPLE. OES CAN SUPPORT THIS PROCESS BY INFORMATION EXCHANGE AMONG TECHNOLOGY AND PROJECT DEVELOPERS AND ALL REMAINING STAKEHOLDERS OF OCEAN ENERGY.

05

COUNTRY REPORTS

PORTUGAL

Ana Brito e Melo and Teresa Simas
WAVEC OFFSHORE RENEWABLES

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

A National Strategy for the Ocean (NSO) covering the period from 2013 to 2020 was released by the Portuguese government in March 2013. In this document a strategy is presented for the sustainable development of the economic sectors related with the ocean. This document aims to promote the recovery of the historical Portuguese maritime identity, to take advantage of the economic, geo-strategic and geo-political potential of the maritime territory, to create conditions to attract national and international investment in all sectors of the ocean economy, to reinforce the national scientific and technological skills and to devote Portugal as a global maritime nation with a relevant role in the Integrated Maritime Policy and strategy of the European Union (EU), particularly for the Atlantic area.

Ocean energy is referred in the NSO report as a sector that has been developed in Portugal and for which more incentives should be created regarding the improvement / enlargement of the existing knowledge and engineering skills. The NSO action plan includes the creation of incentives to the installation of new projects in the pilot zones already designated for the activity. This includes the development of the Ocean Plug - Portuguese Pilot Zone designated in 2008, currently managed by REN-ENONDAS. Targets of 80 MW and 250 MW have been estimated for the pre-commercial and commercial phases, respectively, corresponding to Phases 2 and 3 of the facility development to be implemented as the offshore renewable energy sector evolves.

MAIN SUPPORTING INITIATIVES

The available funding mechanisms for ocean energy implementation were included in national and international programs available for general economic activities related with the ocean. These initiatives included:

- The Ocean Knowledge and Economy Cluster (Cluster do Conhecimento e da Economia do Mar[1]; COMPETE program) integrated in the National Strategic Reference Framework (QREN);
- The calls for research and technological projects of the Foundation for Science and Technology[2], the main Portuguese national agency responsible for continuously promoting the advancement of scientific and technological knowledge, including in the ocean energy field;
- The calls for research and development projects as well as concept demonstration projects of the Inovation Support Fund ("Fundo de Apoio à Inovação, FAI[3]);
- The EU 7th Framework program of research and technological development (FP-7) running until the end of 2013.

1 http://www.pofc.qren.pt/areas-do-compete/polos-e-clusters/ecossistema-de-polos-e-clusters/entity/cluster-do-conhecimento-e-da-economia-do-mar?return=%2Fcontentlist.aspx%3Fmenuid%3D95%26page%3D4

2 http://www.fct.pt/

3 http://fai.pt/

NATIONAL SEA TEST FACILITIES

During 2013 the preparation of the Ocean Plug access regulations was initiated as well as the activities to be performed regarding the environmental baseline studies. The Ocean Plug infrastructure is planned to accommodate a grid connected test site for concept demonstration and prototype testing. Plans for the test site development (Phase 1 of the facility development) have been prepared and the infrastructure is planned to inject 12 MW (4x3MW) into the grid.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

A revision of the existing Environmental Impact Assessment legislation was released in October 2013. One relevant innovation of the new law is the creation of a web based "one-stop-shop" facility for the environmental licensing of projects, which will allow the digital delivery of documents during the EIA process. Although the typology of projects for the EIA requirement is clarified under this new law, the application of a case by case approach during the screening process is reinforced to smooth the application of the rigid project dimensions' thresholds and improve the efficiency of the process. According to this new legislation the timeline of the licensing procedures is also clarified.

RELEVANT DOCUMENTS RELEASED

- The National Strategy for the Ocean. Available from http://www.dgpm.mam.gov.pt/Pages/ENM.aspx
- Review of consenting processes for ocean energy in different EU Member States. Available from http://www.sowfia.eu/index.php?id=22
- Consenting procedures review with guidelines for expansion to larger projects and approval process streamlining. SOWFIA report D4.6. Available from http://www.sowfia.eu/index.php?id=22
- An overview of policy and market conditions in Denmark, France, Ireland, Portugal, Spain and the United Kingdom. SI-Ocean project report. Available from http://www.si-ocean.eu/en/

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Instituto Superior Técnico (IST), a school of engineering, part of the Universidade de Lisboa (University of Lisbon), has a recognised tradition on research on wave energy. The wave energy research group has been active in the development of a spar-buoy oscillating water column wave energy converter. Another new concept of a floating wave energy converter (WEC) is under investigation and development.

Tests at a scale 1:16 performed at NAREC, UK

Instituto Superior Técnico provided in 2013, a full one-semester specialization on Ocean Renewable Energy (waves, tidal currents, offshore wind), integrated into the three-semester European Master in Renewable Energy organized by the European Renewable Energy Research Centre (EUREC) Agency and involving 11 European Universities.

The government acknowledged the need to maintain a group on a national laboratory, **Laboratório Nacional de Energia e Geologia**, **IP (LNEG)**, performing research and development on ocean energy. The Ocean Energy group has been working on the development of new concepts for extracting wave energy namely on the simulation of WEC´s with alternative geometries – LNEG project – Development of Offshore Technology. The group has been working on the performance improvement of no-axisymmetric devices with hydraulic and pneumatic power-take-off equipment (self-rectifying air turbines), namely on what concerns the hydrodynamic performance as well as geometry optimization and PTO control. LNEG has been engaged with EU Demowfloat project and to the development of a new Roadmap for Portuguese offshore energy. The continuous improvement of a Geographical Information System (GIS) database developed at LNEG for site selection of wave energy farms and offshore wind farms, continued to provide guidance for installation of wave energy devices in the country.

WavEC Offshore Renewables, is a private non-profit association, currently with 13 associates, devoted to the development and promotion of offshore energy utilization thorough technical and strategic support to companies and public bodies. WavEC team is composed by 23 specialists with a broad range of experience on ocean energy, including both the technical (numerical modeling, wave resource, monitoring, technology) and non-technical (economic models, environmental and licensing, public policies, dissemination) issues.

WavEC is organized in five thematic areas with respective technical/scientific skills:

Technology and monitoring (due diligences and strategic studies, resource assessment, performance monitoring, component development and experimental testing, underwater monitoring)

Numerical modelling (conceptual studies, strategic support, performance studies, techno-economic analysis)

Economy and industry (Techno-economic Analysis, Supply-chain Analysis, Market Research, Socio-economic Impact Assessment)

Environmental issues (acoustic monitoring, development of geographic informations systems, environmental impact studies)

Public policies and dissemination, regarding particularly the development and analysis of strategies and legislative processes for marine renewable energy, including R&D, innovation marketing, supply chain, training and environmental and socio-economic impacts.

On the Island of Pico, Azores, WavEC runs an OWC (Oscillating Water Column; www.pico-owc.net) type wave energy plant. Pico OWC is a unique structure, allowing testing commercially-sized turbines and auxiliary equipments (up to ~700kW). Pico plant is included in the EC large-scale infrastructure project MARiNET (http://www.fp7-marinet.eu/).

Pico OWC

WavEC has been further collaborating with the following technologies: Powerbuoy from the North-American company Ocean Power Technology (OPT), tested in Spain and WaveRoller from the Finish company AW-Energy, tested in Portugal (Peniche). During 2013, WavEC main role in these projects has been the environmental monitoring work and performance assessment.

WavEC has long experience in marine energy technology at R&D level and has been participating on a growing number of European Projects. The table below shows the R&D projects in which WavEC has been involved. In particular, during 2013, the OceaNET Initial Training Network on wave energy and floating offshore wind was initiated. This project, coordinated by WavEC, will run for 4 years with an overall EU budget of 3.4 M€.

FUNDING PROGRAM	PROJECT	2011 2012 2013 2014	WAVEC MAIN ROLE
FP7 – ENERGY	Surge		Environmental and performance monitoring (Waveroller)
FP7 – ENERGY	Waveport		Environmental and performance monitoring (Powerbuoy)
FP7 – ENERGY	Demowfloat		Numerical modelling, environmental monitoring, public outreach (Windfloat)
FP7 – ENERGY	PolyWec		Numerical modelling, environmental monitoring and dissemination
FP7 – ENERGY	DTOcean		Marine logistics and costs modelling (coordinator of these tasks)
FP7 – TRANSPORT	Tropos		Resource evaluation, economics and environmental issues
FP7 – INFRASTRUCTURES	Marinet		Training Program, guidelines and wave energy research
FP7– PEOPLE	Oceanet		Project Coordinators
INTERREG	AtlanticPC		Transnational strategy for marine energies
IEE	SI Ocean		Technology assessment, policy analysis and market development
KIC–INNOENERGY	KIC Prod 1		Development of a multioarametic buoy for environmental monitoring
KIC–INNOENERGY	KIC Prod 4		Maintenance and Deployment Software
KIC–INNOENERGY	HyWave		Benchmarking, hydrodynamic simulations and cost of energy
NATIONAL (FCT)	FWturbinas		Numerical modelling of floating wind offshore turbines
NATIONAL (SIAC)	OTEO		Public policies and technology assessment
DANISH COUNCIL	SDWED		Numerical modelling

Table 1 - Participation of WavEC in R&D projects

INEGI, the Institute of Mechanical Engineering and Industrial Development, founded in 1986, within the Department of Mechanical Engineering and Industrial Management (DEMEGI) of the Faculty of Engineering of the University of Porto is leading the OTEO project - "Offshore Energy Technology Observatory". This project establishes as a strategy the Portuguese and the international knowledge of offshore energy technologies as well as support technologies in order to increase the competitiveness and the entrepreneurship in this sector. WavEC, EnergyIN and Oceano XXI are partners of this project, which was a 2-years project concluded last year. A book entitled "Offshore Renewable Energy - Current Status. Future Perspectives for Portugal", with invited authors, is expect to be released next year.

DENMARK

Kim Nielsen
RAMBOLL

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The partnership for wave energy in Denmark involves the active developers working on different system developments and testing. In 2012, the partnership proposed a long term strategy for development, and in 2013 the partnership has been funded to develop more detailed roadmaps on the development of specific technical challenges facing wave energy, such as mooring systems, flexible cabling, efficient PTO systems and materials.

There is a Danish political support for the development of wave power with about €3million reserved for targeted areas to be defined in the roadmaps. In addition, two major demonstration projects have been in the water through 2013, the WaveStar project and the Floating Power Plant project, both combining wave and wind energy.

MAIN SUPPORTING INITIATIVES

The main funding for wave energy comes through the national research and development programmes through EUDP and Energinet.dk. These programmes support development within all renewable, and, over the last four years, national support directed towards wave energy has been about €2-4 million/year. The strategy developed for wave energy RD&D suggests combining this support with higher feed-in tariffs for wave energy in Denmark to stimulate private investments.

NATIONAL SEA TEST FACILITIES

In 2012, the Danish Wave Energy Centre "DanWEC" received Greenlab funding to establish its infrastructure and facilities at Hanstholm Harbour in the North Sea. The first staff member is employed and DanWEC serves as the secretariat for the partnership on wave energy and as co-ordinator of their Roadmap project.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

WaveStar is exploring possibilities in France and Floating Power Plant in the USA.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Aalborg University is the key research institution in Denmark involved in a number of both National and European projects on wave energy R&D. Aalborg University is the leading partner of the SDWED project, which is a strategic research alliance between major Danish and international stakeholders, funded by the Danish Agency for Science, Technology and Innovation.

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

The partnership of wave energy in Denmark includes the following wave energy developers:

- ResenEnergy, Per Resen
- CrestWing, Henning Pilgaard
- WaveDragon, Erik Friis-Madsen
- WaveStar, Laurent Marquis
- Leancon, Kurt Due Rasmussen
- Weptos, Tommy Larsen
- WavePlane, Erik Skaarup
- Floating Power Plant, Anders Køhler
- WavePiston, Martin von Bülow

OPERATIONAL OCEAN ENERGY PROJECTS

Wavestar has entered into cooperation with large industrial companies in France with the purpose of industrializing WS 1MW wave machine. Cooperation is based on the Wavestar technology; in one project partners come with their knowledge on offshore product industrialization and installation; and in another project with a research approach regarding optimization of energy absorption.

The consortium aims to open markets for wave energy solutions combined with offshore wind parks. The prototype was installed in Hansholm, Denmark, in 2009, and has been in production since 2010. Results achieved with this prototype have confirmed that the machine can harvest energy from wave and convert it into clean energy and that concept is reliable because the machine has been running at full power (365 days, 24 hours/day) throughout 2012 and part of 2013. In September 2013, the machine was moved inside the harbour where it will be rebuilt including extra floats and a new PTO system.

INORE Phd Students visited Wavestar in 2013

Floating Power Plant has been operating in the sea and recently survived the first major storm in 2013 as seen from its webcam below.

Floating Power Plant continued operation and testing in 2013

UNITED KINGDOM

Karen Dennis
DEPARTMENT OF ENERGY & CLIMATE CHANGE

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

Recognised for having some of the best wave and tidal resource in the world, the UK has become a global lead for the development and deployment of wave and tidal energy. The UK Renewable Energy Road Map, first published in 2011, sets out the Government's commitment to wave and tidal stream as technologies which have the potential to play a key contribution to the UK low-carbon ambition post 2020. Since then, yearly updates including a 2013 update published in November, highlights progress made in advancing the sector. The UK Marine Energy Programme Board (MEPB) is the means by which the Government drives this strategy towards meeting the commitments of the Roadmap.

Through the MEPB the UK Government continue to work with industry in tackling the barriers to deployment. By way of the MEPB, the industry has been feeding into the Energy Market Reform (EMR) consultation process, provided evidence to an inter-Governmental group looking at grid and transmission issues in the Scottish islands as well as provided a review of the process of applying for consent with the regulatory bodies. The MEPB is also working on developing the supply chain for a UK marine energy sector.

As part of the strategy for developing a UK marine energy sector, the UK Government has supported the development of two Marine Energy Parks (MEPs); the South West and the Pentland Firth and Orkney Waters Marine Energy Parks. In February 2013, the two parks signed a Memorandum of Understanding (MoU) which signals their commitment to working together to build relationships, address common issues and encourage business and research collaboration. It is envisioned that this close collaboration will provide the means to exchange knowledge and best practice towards developing a UK marine energy industry.

The UK and Scottish Government has been working jointly on efforts to develop a Member State Interest Group for Ocean energy. Most recently, collective lobbying has led to the establishment of a new EU ERA-Net for ocean energy, supported by European Commission funding and led by our Scottish colleagues. We also now see ocean energy included in the EU's new research, development and demonstration funding Programme, Horizon 2020 (this will operate from 2014-20), along with plans for further joint actions between Member States being discussed in the context of the EU's Strategic Energy Technology Plan (SET Plan) Steering Group. This forms part of a continuing development of the SET Plan in which we are playing a proactive role, working closely with the European Commission and other Member States.

In October 2013, the European Ocean Energy Association (EU-OEA) hosted their annual conference in Edinburgh – the first time that the conference was held outside of Brussels. The decision to host the conference in the UK is a recognition of the leading role that the UK, and within it Scotland, has and will continue to play in the commercialisation of Europe's ocean energy industry.

SCOTLAND

Work is underway to review the recommendations and action points contained within the Marine Energy Action Plan, which was published in June 2012. The Action Plan detailed the five key elements around which it would further develop and support the marine renewables industry within Scotland. These are as follows:

- Finance;
- Grid;
- Infrastructure and Supply Chain;
- Planning; and
- Europe.

A new element to reflect the importance of the delivery around Electricity Market Reform (EMR) has also been added to the Action Plan.

The Marine Work Group, led by Scottish Renewables, is currently leading this review and plans to publish the outcome of the review in the first quarter of 2014, pending endorsement from the Minister for Energy, Enterprise and Tourism. The review will also identify on-going recommendations and actions required to ensure that the marine renewables industry continues to make the progression to commercialisation.

Scotland continues to work with colleagues throughout the UK and across Europe through their membership on the British-Irish Council (BIC) and the leadership they provide in taking forward the Marine Energy Workstream and through their membership of the EU Ocean Interest Energy Group in which they support the work to raise the profile and potential of ocean energy within the EU.

WALES

The Welsh Government's Policy Energy Wales: A Low Carbon Transition, published in March 2012, sets out our ambition to create a low carbon economy that delivers jobs, long term wealth and supports our communities. Marine energy has been identified as one of the areas of greatest potential to position Wales at the forefront of key innovation, research and development.

An Energy Programme has been established to drive the ambitions set out in Energy Wales. A delivery plan is expected in the New Year.

Energy policy in Wales sits within the Minister for Natural Resources and Food's portfolio. The Minister recently announced his autumn statement for shaping a more prosperous and resilient future. The statement sets out four key priorities for the Department and our ambitions for meeting the Welsh Government's Programme for Government. The autumn statement notes a Marine and Fisheries Strategic Action Plan will be developed to provide comprehensive and integrated marine governance in Wales.

The Welsh Government is committed to supporting the UK Government in meeting their binding 2020 targets. There are no domestic renewable targets for Wales.

NORTHERN IRELAND

In October 2013, the Department of Enterprise, Trade and Investment (DETI) published the first annual report of the Offshore Renewable Energy Strategic Action Plan 2012-2020. The report shows good progress against a number of key actions to support the development of the 600MW offshore wind and two 100MW tidal projects in Northern Ireland waters announced by The Crown Estate in October 2012. These projects, Tidal Ventures Limited and Fairhead Tidal, are currently working through the survey, research and stakeholder engagement as part of the Environmental Impact Assessment activity for the statutory consents and marine licences. It is expected that these projects will contribute to the Northern Ireland target of 40% renewable electricity consumption by 2020.

In March 2013, DETI consulted on policy proposals for a new Offshore Renewable Energy Bill to include powers in relation to the decommissioning of offshore installations and navigation and safety issues in NI waters. It is hoped that this legislation will be in place during 2015-2016.

MAIN SUPPORT INITIATIVES

The current revenue support for renewables in the UK is the Renewables Obligation (RO) which will be phased out by 2017 and be replaced with a Contract for Difference (CfD). The CfD will be the new support mechanism under the Electricity Market Reform (EMR). Consultation on the EMR Delivery Plan and Strike Prices was held over summer 2013. The final strike prices were published on 4th December. The final Delivery Plan for 2014-2019 will be published by the end of the year.

Initial information on opportunities to access Research and Development funding for marine energy and other renewables continues to be through the Energy Generation and Supply Knowledge Transfer Network (https://connect.innovateuk.org/web/energyktn). Information from the main organisations can be found at the links included below:

- the Research Councils UK Energy Programme provides funding for basic strategic and applied research into a wide range of technology areas: http://www.rcuk.ac.uk/energy.
- the Technology Strategy Board supports medium-size research and development projects using technology-specific research calls: http://www.innovateuk.org/.
- the Energy Technologies Institute is a public-private partnership that invests in developing full-system solutions to long term energy challenges: http://www.eti.co.uk/.
- the Carbon Trust offers a wide range of support for low carbon innovation mainly in the pre-market arena: http://www.carbontrust.co.uk/Pages/Default.aspx.

Four tidal energy projects have been awarded funding towards the deployment of the first tidal array schemes from the UK Government as well as from the European Union (EU). In February 2013, the UK Government announced that, subject to State Aid clearance and financial close, the schemes proposed by Sea Generation Wales Limited off the coast of Anglesey and the first phase of the MeyGen Pentland Firth Inner Sound projects were selected for the £20M Marine Energy Array Demonstrator (MEAD) scheme. This followed the previous announcement made by the EU in December 2012 that the Scottish Renewables' Sound of Islay and the MCT's Kyle Rhea projects were the recipients of a total of €40m from the New Entrant Reserve 300 scheme. The UK and Scottish Governments are working with the award recipients towards financial close and for projects to commence from 2016 onwards.

The Crown Estate is actively supporting development of projects. It has invested over £3m since 2010 to support development in the Pentland Firth and Orkney waters, through an 'enabling actions' programme which tackles key issues affecting the project development process. In September 2013, The Crown Estate completed a report on delivery of the first phases of the projects, which includes a series of recommendations to maximise the capacity installed by 2020.

Furthermore, The Crown Estate is considering investing up to £20m in wave and/or tidal array projects, alongside investments by industry and in parallel with the government grant awards noted above. This initiative began in January 2013 and as of December 2013, The Crown Estate is undertaking due diligence on several candidate projects.

SCOTLAND

In May 2013, the Minister for Energy, Enterprise and Tourism, announced that the Scottish Government's £18m Marine Renewables Commercialisation Fund (MRCF) would be refocused in order to provide a dedicated support mechanism for the wave sector, in line with industry calls. In September 2013, the minister announced that two wave developers – Aquamarine Power and Pelamis Wave Power – would share a £13m slice of the MRCF funds. The fund will be used to accelerate wave energy technologies towards commercial readiness alongside tidal technologies. The remaining £5m will be used to support enabling technologies that are vital to the success of the first wave and tidal arrays.

The Scottish Government has also extended call under the £103m Renewable Energy Investment Fund (REIF) from March 2015 until March 2016. REIF funds will be used to help promote the use of energy from renewable sources by supporting projects that:

- Accelerate the growth of the marine renewable energy sector in Scotland;
- Increase community ownership of renewable energy projects in Scotland; and
- Provide for district heating networks that utilise renewable heat technologies

WALES

The main source for large funding in Wales, both revenue and capital, remains the Convergence & Competitiveness Fund administered by the Welsh European Funding Office (WEFO) on behalf of the Welsh Government. The Welsh Government and WEFO are engaged with the European Commission to consider a structural fund programme post 2013 and how that might support the marine energy sector.
Business Wales also provides business support to people starting, running and growing a business. Their support includes information, advice and guidance.
Wales also has an Economic Growth Fund, which is a non-repayable grant fund. The grant fund aims to develop and bring forward projects that will have an economic impact and benefit for Wales.
Phase 2 of the Wales Economic Growth Fund is open for Expressions of Interest (EoI), until 16 December 2013.

NORTHERN IRELAND

Invest NI, DETI's economic development body, has been working with RegenSW, Scottish Highland and Islands and Renewable UK to develop a UK-wide Supply Chain Model. The Model can be used to provide economic/value analysis, skills requirement analysis, asset register requirements and capability/gap analysis. The model has been tested in consultation with the industry and Renewables UK is working on a computerisation of the model to facilitate industry use. Invest NI has secured the annual Renewables UK Wave and Tidal Conference to be held in Belfast in February 2014 and this event presents the opportunity to launch the Supply Chain Model.

NATIONAL SEA TEST FACILITIES

Plans are underway for the development of a new 20MW marine energy testing facility, the Solent Ocean Energy Centre at St Catherine's Point in the Isle of Wright. Construction is set to begin in 2015. This will be in addition to the three sea testing centres already in the UK to support the deployment of wave and tidal devices. These are:

The European Marine Energy Centre (EMEC)

In 2013 the European Marine Energy Centre (EMEC) celebrated its 10th anniversary, highlighting a decade of marine energy achievements, demonstrating its world-leading status. With 10 years of experience in test site development and operation EMEC holds unique laboratory accreditation in performance assessment to aid investment potential, and continues to seek clients for its expanding specialist facilities.
EMEC is the only accredited wave and tidal test centre for marine renewable energy in the world, suitable for testing 14 full-scale devices simultaneously in some of the harshest weather conditions while producing electricity to the national grid through the company's infrastructure. All monies generated by the sale of electricity are fed back to the developers, increasing the funds for future industry investment.

EMEC's test sites attract developers from all around the globe: to date more devices have been tested at EMEC than any other single site in the world. These developers use the facilities to prove what is achievable in some of the harshest marine environments, whilst in close proximity to sheltered waters and harbours. Accredited by the United Kingdom Accreditation Service (UKAS), EMEC operates to relevant

test laboratory standards, enabling the Centre to provide another unique service - independently verified performance reports.
EMEC has also worked hard to ease the path to market for marine renewable developers by building two scale test sites – the first of their kind anywhere in the world - helping to close the gap between testing in a wave or tidal tank and bringing full scale prototypes to trial in real sea conditions.

The scale test sites allow developers to test smaller scale devices in less challenging conditions than those found at the full-scale test sites, and mitigate the need for big vessels or large plant used in the deployment of full-scale machines (see Figure 1 below).

There are currently 10 full-scale developers testing devices at EMEC. Bluewater Energy Services, Kawasaki Heavy Industries and Atlantis Resources Corporation have contracted EMEC berths for future testing of tidal energy devices currently in development. Nautricity are also currently testing their Cormat turbine at EMEC's scale tidal test site.

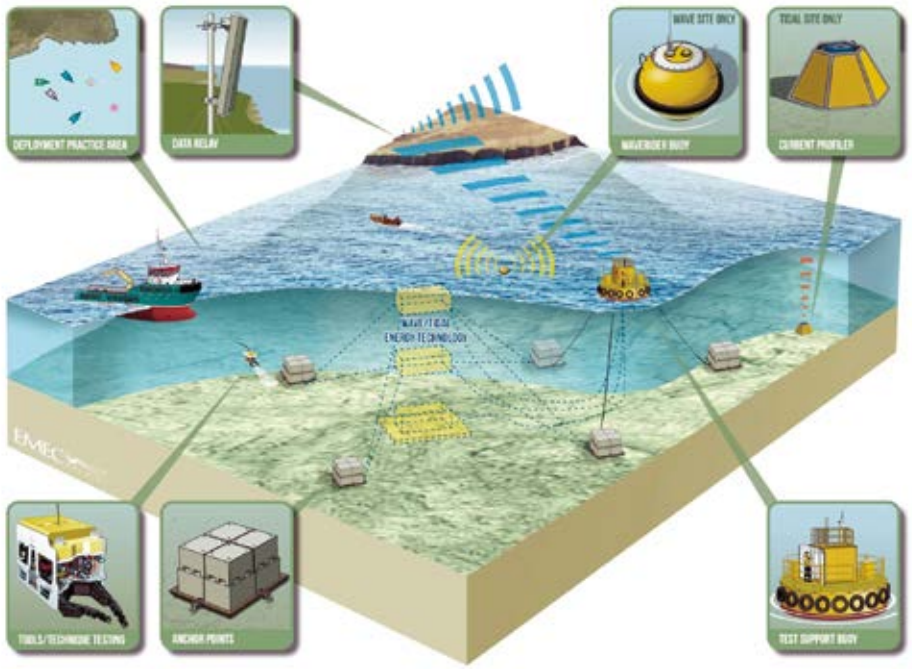

Figure 1 – EMEC scale test facilities

Beyond device testing, EMEC also provides a wide range of consultancy and research services, and is working closely with Marine Scotland to streamline the consenting process. EMEC is at the forefront in the development of international standards for marine energy, and is forging alliances with other countries, exporting its knowledge around the world to stimulate the development of a global marine renewables industry.

WaveHub Test Site

Wave Hub is a pre-installed grid connected site approximately 10 nautical miles (16km) off the north coast of Cornwall for the testing of large scale offshore renewable energy devices. The site has a Section 36 electricity consent and holds a 25 year lease for 8 sq kms of seabed, which is divided into four separate berths, and was originally built to operate at 11kV with a generating capacity of 20MW. Wave Hub is now owned by the UK Government Department of Business, Innovation and Skills (BIS). BIS has established an operating company, Wave Hub Limited, to manage the facility on its behalf and provided grant funding to cover the initial operating period until the site is fully occupied by four device developers.

The priority this year has been to ensure Wave Hub is operationally ready for a deployment and that an effective health and safety management system is in place, operational procedures have been established both on and offshore, the consenting process for developers has been tested, and the operating company has the necessary capacity and capabilities. Additional seabed and metocean surveys have also been undertaken this year to aid device developers. In addition, a review has been undertaken into the state of the industry and the financial viability of wave arrays to ensure that Wave Hub remains fit for purpose. The outcome of this has been a successful upgrade of the onshore substation to enable the Wave Hub electrical system to operate at both 11kV and 33kV, which in turn has increased the generating capacity to 30MW and allowed larger arrays to be deployed at the site. Two developers are in detailed discussions with Wave Hub, each with plans to deploy a 10MW array of their technology from 2015. In early December Seatricity announced plans to develop a 10MW array over the next two years at WaveHub.
Also this year WaveHub have worked with the Energy Technologies Institute (ETI) to diversify Wave Hub so that it can be used as a test site for floating offshore wind demonstrators. Together with Glosten Associates, ETI's selected floating wind developer partner, a consent application has been submitted to the Marine Management Organisation and the Crown Estate has agreed to vary the seabed lease. Plans are in place for the floating wind demonstrator to be deployed at Wave Hub in 2015.

The Falmouth Bay Test (FaBTest) Site

FaBTest has been operating as a non-grid connected commissioning site for marine renewable energy devices since November 2011. The Crown Estate lease and MMO license are held by Falmouth Harbour Commissioners (FHC) and through a memorandum of understanding; the University of Exeter provides a significant contribution to operations and management. The University of Exeter uses the site for on-going work around resource characterization and environmental monitoring, as well as using it to contribute to pioneering research into reliability engineering, which is focused on the nearby South West Moorings Test Facility (SWMTF) and the Dynamic Marine Component (DMaC) rig.
The FaBTest site is pre-consented to accommodate renewable energy devices which fit within a defined 'Rochdale envelope', greatly reducing the risk, cost and time for developers looking to bring a device to scale tests in sea conditions. The near shore location eases real time monitoring communications, access for inspection and repair, along with proximity to dockyard facilities for fabrication and refit. The devices currently pre-consented are wave energy converters (broadly defined by a range of size constraints), guarded underwater turbines and umbilicals/components. Negotiations are progressing to extend the lease and licence to also accommodate floating wind devices.
Since March 2012, the Fred Olsen Bolt Lifesaver has been deployed and will be tested until March 2014.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

The UK Marine and Coastal Access Act 2009 provide the framework for the UK marine licensing regime for activities carried out within the marine environment, such as offshore renewable energy installations. It is implemented by the Marine Management Organisation for England and Wales, Marine Scotland for Scottish waters and the Department of the Environment for Northern Irish waters. Environmental Impact Assessments and, where required, Appropriate Assessments are undertaken for marine energy projects as part of the licensing and consenting process.

SCOTLAND

The Scottish Government has introduced a system of sectoral marine planning to facilitate the development of commercial scale wave and tidal energy projects in sustainable locations. A consultation exercise has recently taken place on the Draft Plans for Wave and Tidal which contain on 8 potential wave and 10 potential tidal options.
In May 2013, Aquamarine Power Ltd received consent for a 40MW wave farm off the north-west coast of Lewis and, in September 2013, MeyGen Ltd received consent for an 86MW tidal energy project in the Inner Sound of the Pentland Firth.

WALES

Natural Resources Wales (NRW) is a new body that was established on 1st April 2013 to ensure that the natural resources of Wales are sustainably maintained, enhanced and used, now and in the future. The new body brought together the work of the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales, as well as some functions of Welsh Government.

NRW assumed responsibility for the administration of marine licensing from the Welsh Government's Marine Consents Unit on 1st April 2013. NRW now process applications for a marine licence under Part 4 of the Marine and Coastal Access Act 2009 on behalf of the Welsh Ministers.

Leasing

To create an addressable market for project developers, which is important to justify continuing government innovation support and private investment in technologies, The Crown Estate has been leasing sites for wave and tidal current projects. To date, over 40 sites have been leased in waters all around the UK. Between 2008 and 2010, The Crown Estate ran the Pentland Firth and Orkney waters leasing round (Scotland), which led to plans for 11 commercial projects; and a further two commercial schemes were let in the Rathlin Island and Torr Head area (Northern Ireland) in 2012. The remainder of the sites are for test and demonstration projects and facilities, including EMEC and Wave Hub (see below). A new test and demonstration leasing process commenced in October 2013 and is planned to conclude in April 2014. The Crown Estate is planning to invite further expressions of interest for wave and tidal current project sites in October 2014. In addition, a market engagement exercise for tidal range sites is planned to commence in December 2013.

RELEVANT DOCUMENTS RELEASED

UK

- Consultation on the draft Electricity Market Reform (EMR) delivery: https://www.gov.uk/government/consultations/consultation-on-the-draft-electricity-market-reform-delivery.
- Proposals for implementing the EMR: https://www.gov.uk/government/consultations/proposals-for-implementation-of-electricity-market-reform.
- EMR Strike prices: https://www.gov.uk/government/publications/increasing-certainty-for-investors-in-renewable-electricity-final-investment-decision-enabling-for-renewables.
- Scottish Islands Renewable Project: Final report: https://www.gov.uk/government/publications/scottish-islands-renewable-project-final-report.
- Additional support for Scottish island renewables: https://www.gov.uk/government/consultations/additional-support-for-scottish-island-renewables.
- Renewables Roadmap Update 2013: https://www.gov.uk/government/publications/uk-renewable-energy-roadmap-second-update.
- Energy and Climate Change (ECC) Select Committee on the Severn: http://www.parliament.uk/business/committees/committees-a-z/commons-select/energy-and-climate-change-committee/inquiries/parliament-2010/a-severn-barrage/terms-of-reference/.
- Section 20, Growth and Infrastructure Act 2013 – Introduces the ability to vary an existing Section 36 consent: http://www.legislation.gov.uk/ukpga/2013/27/contents/enacted
- Information on the Crown Estate work on Wave & Tidal: http://www.thecrownestate.co.uk/energy-infrastructure/wave-and-tidal/.

SCOTLAND

- Marine Energy Action Plan: http://www.scotland.gov.uk/Topics/Business-Industry/Energy/MarineAP.

WALES

- Marine Energy Infrastructure Study and The Economic Impact of the Development of Marine Energy in Wales:http://wales.gov.uk/topics/environmentcountryside/energy/renewable/marine/economic-impact-of- developing-marine-energy/?lang=en.

NORTHERN IRELAND

- DETI March 2013 consultation on policy proposals for a new Offshore Renewable Energy Bill: http://www.detini.gov.uk/consultation_on_policy_proposals_for_an_offshore_renewable_energy_bill.

RESEARCH & DEVELOPMENT

The Low Carbon Innovation Coordination Group (LCICG) brings together the major UK public sector backed organisations that support low carbon technology innovation. The LCICG members between them, including DECC, BIS, Research Councils UK, Technology Strategy Board, Energy Technologies Institute, Scottish Government and Scottish Enterprise, expect to invest in excess of £1billion of public funding in low carbon innovation technologies between 2011-15. The LCICG will develop a shared strategy in early 2014 which defines the agreed priorities for future programme delivery for different technologies including marine.

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Research Councils UK Energy Programme

The Research Councils UK Energy Programme aims to position the UK to meet its energy and environmental targets and policy goals through world-class research and training. The Energy Programme is investing more than £530 million in research and skills in the period 2011-2015 to pioneer a low carbon future. The programme has a current portfolio of over £28 million invested in Wave & Tidal research and training. The research councils intend to maintain this level of support for the foreseeable future.

Work by Supergen Marine consortium continues (Phase 3 funding confirmed for further 5 years). It is conducting world-class fundamental and applied research that assists the marine energy sector to accelerate deployment and provide the highest quality of doctoral training.

The programme is currently working to increase opportunities for international collaboration in fundamental research areas, with a joint research programme with the Chinese Ministry of Science and Technology being launched in early 2014.

2013 will also see the opening of the FloWave All UK Waters wave tank at the University of Edinburgh. The Engineering and Physical Sciences Research Council provided £6 million towards the cost of this world-leading facility which is the first in the world to allow for testing with any relative combination of waves and currents.

Technology Strategy Board (TSB)

The Technology Strategy Board is investing up to £7m in collaborative R&D projects to accelerate the development of innovative infrastructure technologies for the offshore wind, wave and tidal stream industries, to help reduce the cost of electricity generation. The Engineering and Physical Sciences Research Council (EPSRC) is providing up to a further £500k to fund academic partners in projects focused on high voltage direct current (HVDC) technologies. The Infrastructure for *Offshore Renewables* funding competition opened in December 2013.

The competition is designed to help develop supply chains for offshore renewables. A particular feature of this funding call is that it aims to encourage companies from outside the sector to get involved and bring their own specific insights and expertise to bear in this area.

Reducing the cost of energy generation is a key challenge for the offshore renewable industries, and opportunities exist across the respective supply chains for innovative and cost-cutting technologies.
The competition covers three themes related to balance of plant infrastructure and projects can relate to any aspect of the lifecycle of a wind, wave or tidal stream farm within these themes, which are; electrical infrastructure, including HVDC technologies, support structures and sensors and monitoring.
The successful projects will be decided in April 2014.

The Technology Strategy Board also continued with dissemination of its 2012 *Marine Energy: Supporting Array Technologies (MESAT)* programme with an event held in November to update the industry on the progress of the projects. Technology Strategy Board invested £6.5m in 7 projects aiming to develop technologies to support wave and tidal arrays under its MESAT programme. Presentations from this event are available at https://connect.innovateuk.org/web/marine-energy-supporting-array-technologies.

Energy Technologies Institute (ETI)

The Energy Technologies Institute (ETI) is a public-private partnership between global energy and engineering companies – BP, Caterpillar, EDF, E.ON, Rolls-Royce and Shell – and the UK Government. Public sector representation is through the Department for Business, Innovation and Skills, with funding channelled through the Technology Strategy Board and the Engineering and Physical Sciences Research Council. The Department of Energy and Climate Change are observers on the Board. The ETI, makes targeted commercial investments in projects covering heat, power, transport, and their supporting infrastructure across nine programme areas – offshore wind, marine energy, distributed energy, buildings, energy storage and distribution, carbon capture and storage, transport, bioenergy and smart systems and heat.

The ETI launched the Tidal Energy Converter (TEC) System Demonstrator project in May 2012 to identify an optimised route for cost effective deployment of tidal stream technologies at commercial scale in UK waters. The project led by Atlantis Resources Corporation with Lockheed Martin as systems integrator and Black & Veatch acting as project manager adopted a systems engineering and through-life approach and successfully developed an outline design of an optimised tidal stream array which if developed would be commercially viable in 2020. The project completed in November 2013 delivering a proposal for a 6MW array demonstrator on the MeyGen site that will prove a significant proportion of the innovation necessary to meet the 2020 commercialisation target. The ETI is now reviewing the project outputs and considering the way forward.

The ETI's ReDAPT (Reliable Data Acquisition Platform for Tidal) has successfully installed and is testing 1MW Alstom horizontal axis tidal turbine at EMEC. The turbine has reached the full nominal power of 1MW after a series of gradual increases in power and has generated over 138MWh of electricity to the grid. Testing and collection of operational data will continue until the end of 2014.

Other ETI marine projects include:

- The PerAWAT (Performance Assessment of Wave and Tidal Array Systems) project has validated numerical models to predict the hydrodynamic performance of wave & tidal energy converters operating in arrays and hence reduce design uncertainty. Using data and findings from this project member DNV GL were able to release the commercial wave device design tool – WaveDyn in 2012 and will release array design tools Tidal Farmer and Wave farmer in 2014.
- The Tidal Resource Modelling project which has developed a hydrodynamic model of the entire tidal resource around the UK is now available to the public under the commercial name SMART Tide and is accessible through a web interface via a Fee-For-Service managed by HR Wallingford.
- In February, ETI also launched a £1.4m project with Pelamis Wave Power to boost the cost effectiveness of large scale wave energy arrays in the UK waters. This will build on the tests currently taking place at EMEC in the Orkneys and push Pelamis' design forward to commercial readiness – increasing the output of their devices while reducing their cost of energy.

The Offshore Renewable Energy Catapult

The Offshore Renewable Energy (ORE) Catapult became operational in 2013. It was established by the UK Technology Strategy Board to accelerate the development of innovative technology that will lead to cost reductions in the offshore wind, wave and tidal sectors. It is one of seven Catapult centres that have been set up to bridge the gap between research and commercialisation in the UK. By analysing and prioritising industry issues and by active involvement in current research developments, the ORE Catapult will initiate programmes to accelerate the development of innovative engineering solutions. In the marine sector, ORE Catapult has worked with the Carbon Trust to establish the Marine Farm Accelerator (MFA). The MFA is built around a steering group of wave and tidal project developers who are actively working on first arrays. Six work streams have now been identified covering Energy Yield, O&M, Site Characterisation, Electrical Systems, Installation and Insurance. These work streams will lead to a programme of targeted R&D projects in 2014. In addition to the MFA, ORE Catapult is developing projects in the areas of standards, reliability and resource modeling.

The National Renewable Centre

The National Renewable Energy Centre, Narec, has invested a total of £150 million in integrated research and testing facilities for the offshore renewable energy and marine industries. The facilities which includes a wave tank, still water dock and simulated seabed has enabled Narec to play an instrumental role in the testing and trialling of novel cutting devices for rock trenching equipment, submerged testing of ROVs and subsea foundation performance tests. Other projects have included the development of power take-off systems for marine renewable devices, cable joint integrity tests, salt corrosion analysis and materials and coatings selection.

Narec is a project partner in MaRINET (Marine Renewables Infrastructure Network for Emerging Energy Technologies), a €9 million EU funded FP7 project, allowing researchers and developers access to specialist marine renewable energy testing centres across Europe to create a network of expertise in the marine renewable energy sector with experience at all scales of offshore technology research and development.

Narec is also managing a number of ERDF innovation projects and is working with manufacturing and engineering companies to take forward specific technology development projects in key areas of the offshore renewables supply chain such as a cable trencher designed specifically for the offshore renewables industry as well as the design and development of smart cable technology.

Earlier this year, tidal energy developer Current2Current Ltd (C2C) contracted Narec to carry out testing investigations on their Tidal Energy Converter (TEC) prototype as well as to undertake commissioning testing of their prototype power take-off (PTO) system and in June 2013, Siemens-owned MCT arrived on

site to test the prototype power train for their SeaGen-S 2MW device. The six month test programme using our 3MW drive train test facility for the testing of tidal turbine nacelles, will help prove the performance of next generation tidal turbines.

SCOTLAND

Scotland continues to provide significant support for the development and deployment of wave and tidal energy projects in the Scottish isles. The six companies which received support through the £14.8m WATERS programme are making good progress towards the completion of their projects during the course of 2014.

WALES

The Welsh Government continues to support institutions like the Low Carbon Research Institute (LCRI) and SEACAMS (Sustainable Expansion of the Applied Coastal and Marine Sectors) to develop expertise and technologies to meet growing demands for marine renewables.

Low Carbon Research Institute – Marine Energy Research Group

The Low Carbon Research Institute (LCRI) was set up in 2008 to unite and promote energy research in Wales to help deliver a low carbon future. The multidisciplinary LCRI aims to support the energy sector, UK and globally, to develop low carbon generation, storage, distribution and end use technologies and practices, and to provide policy analysis and advice. The organisation of the research work has been specifically designed to answer environmental and engineering concerns, and supply stakeholders with the information required to reduce risk and instil confidence in the industry.

The work of the LCRI is funded by the European Regional Development Fund.

LCRI Marine is a collaboration of all the leading academic marine institutions in Wales. The project aims to enable, support and help build a sustainable marine energy sector in Wales. It provides the independent and world-class research essential to move the marine renewable energy industry forward.

LCRI Marine is actively working together to optimise the performance of marine renewable energy devices and assess the impact of these devices on the environment. The following study areas give an insight of the important research work that LCRI Marine is undertaking in order to help build a sustainable marine energy sector in Wales:

- Site selection
- Marine hydro-environmental Modelling
- Hydrographic surveying
- Minimising impact
- Underwater noise
- Echosounder identification
- Marine turbulence and tidal turbines
- Modelling coastal hydrology
- Turbine performance array modelling

Sustainable Expansion of the Applied Coastal and Marine Sectors

Bangor University's Sustainable Expansion of the Applied Coastal and Marine Sectors (SEACAMS) project received funding in 2010 from the European Regional Development Fund through the Welsh Assembly Government. SEACAMS promotes the integration of research and business opportunities in the marine sector.

SEACAMS aims to integrate research and business opportunities in the marine sector in Wales and they work in partnership with Bangor, Swansea and Aberystwyth Universities.

SEACAMS objective is to help expand the coastal and marine sector in Wales. The projects undertaken to date include:

- Mapping the underwater environment
- Fly-through video and seascapes
- Wrecks: exploration and siting
- Movies of coastal currents for your business
- Marine renewable energy: site feasibility
- How to solve a problem like siltation in a marina
- The hydrodynamic resource of north wales
- Swansea marina salinity
- Water quality assessment: Swansea docks
- Using the sea to heat a country house
- Developing scientific content for Gower national trust
- Bioblocks for coastal sea defence
- Determining the ecological value of seagrass (zostera marina) meadows at Porthdinllaen for tourism development and stakeholder management
- Development of engineering design for underwater sledge
- Reverse engineering design of remote water sampler

NORTHERN IRELAND

A Centre for Advanced Sustainable Energy (CASE) has been set up in Queen's University Belfast (QUB) to facilitate business led research into sustainable Energy Technologies including wave and tidal technologies. The centre is working with Northern Ireland and international companies in a number of projects including tidal testing techniques e.g. it is working with Fairhead Tidal Energy, in relation to its 100MW tidal project off the North Coast in NI waters. CASE and Invest NI Triple "T" project on 1/10 scale small scale array testing is on-going in Strangford Lough. The project was set up to rather data on the interactions between tidal devices at the QUB tidal test site. The test equipment allows various arrangements of turbines to be set up and power outputs measured and the analysis of this data will provide information essential to full scale device deployment.

A Centre for Advanced Engineering and Composites has been set up attached to Bombardier Aerospace continues to facilitate business led research into, amongst other advanced engineering, the development of composites which will include manufacture of components for renewable technologies.

Supported by Invest NI, McLoughlin & Harvey Offshore has recently completed Phase 1 of an R&D project on subsea drilled foundation installation methods for the wave and tidal sectors. This work aims to reduce the time and cost required to install tidal turbines by adapting already available marine plant. Phase 2 work will continue in 2014.

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

Major industry players continue to show interest in the development of the sector in the UK. In September, Lockheed Martin announced they will be working with Atlantis Resource Corporation (ARC) to design, develop and engineer a 1.5MW tidal turbine which will be used in the MeyGen project. ARC later announced in November that it has wholly acquired MeyGen Limited. ARC will be working jointly with Andritz Hydro Hammerfest which will be providing the turbines for the first phase of MeyGen funded through MEAD.

This is in addition to Alstom, Siemens and DCNS which have all previously acquired Tidal Generation Limited (TGL), Marine Current Turbines (MCT) and Open Hydro respectively.

Operational projects in the UK during 2013 are still single test devices. The SeaGen tidal device which has been deployed at Strangford Loch since 2008 has generated over 9.2GWh up to November 2013. Single devices deployed for testing around the UK are:

WAVE SITE DEVELOPER	DEVICE	RATED CAPACITY	LOCATION
Aquamarine Power Ltd	Oyster 800	800kW	EMEC
Pelamis Wave Power	P2-001	750kW	EMEC
ScottishPower Renewables	P2-002	750kW	EMEC
Seatricity	Oceanus	800kW	EMEC
Wello Oy	Penguin	500kW	EMEC
Fred Olsen	BOLT Lifesaver	250kW	FaBTest
TIDAL SITE DEVELOPER	**DEVICE**	**RATED CAPACITY**	**LOCATION**
TGL (a wholly owned Alstom Company)	DeepGen	1MW	EMEC
ANDRITZ HYDRO Hammerfest	HS1000	1MW	EMEC
OpenHydro	Open Centre Turbine	0.25MW	EMEC
Scotrenewables Tidal Power Ltd	SR250	0.25MW	EMEC
Voith	Hy-Tide	1MW	EMEC

PLANNED DEPLOYMENTS

The four projects referenced under main Supportive Initiatives have plans for deployment by 2016. Tidal Energy Limited also has plans to deploy their DeltaStream project off Ramsey Sound, Pembrokeshire around 2014 having received an additional £1.6m of EU funding towards the project. They have also secured in principle an agreement for a seabed lease from The Crown Estate for a 10MW pre-commercial tidal array off St Davids, Pembrokeshire.

Two consortium groups also have active plans for tidal ranges projects in the UK. The Hafren Power consortium is working on plans for a barrage of around 6464 MW across the Severn estuary. Tidal Lagoon Limited is leading a consortium with plans for a 240 MW lagoon scheme in Swansea Bay.

JAPAN

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Aiming to promote a comprehensive and systematic implementation of the policies related to the ocean, the Japanese Government endorsed the "Ocean Basic Law" in July 2007. Based on this "Ocean Basic Law", later the cabinet issued the so called "Basic Plan on Ocean Policy" in March 2008.
In 2013, a new "Basic Plan on Ocean Policy" for the coming five years was formulated. In this plan, ocean renewable energy is described as follows.

PROMOTION OF OCEAN RENEWABLE ENERGY UTILIZATION

PROMOTION OF OCEAN RENEWABLE ENERGY TECHNOLOGY DEVELOPMENT WITH A VIEW TO REALIZING COMMERCIALIZATION.

- Development of ocean energy "demonstration fields" and promotion of cooperation among the related industries and the private sector in order to achieve cost reduction in power generation using the ocean energy and secure the safety and security of the sea, and stimulate international competitiveness that will lead to regional economic revitalization.
- Facilitating the practical use of the demonstration fields through effective coordination.
- Verifying the safety and security measures by a third party and overcoming the technical difficulties before experimentation in actual sea areas.

PROMOTION OF PRACTICAL APPLICATION AND COMMERCIALIZATION OF OCEAN RENEWABLE ENERGY

- Adoption of measures that regulate the preservation of the marine environment, development and use of the sea, and secure marine safety and other matters while recognizing the important role of local governments.
- Development of legislation that regulates the use of available sea areas.

- For the promotion of ocean renewable energy utilization, it is important to deepen knowledge on the ocean information, reflect the results on measures for realizing sustainable use of the ocean and constantly update the "press report on Meteorology and Oceanography" so that users can peruse information readily.
- In places where other marine utilizations are constructed, it is important to establish coordination with the existing area administrator and prevent interference with the original utilization application.
- In addition to development of systems that ensure the safety of power generation equipment and offshore structures, it is important for Japan to lead international competitiveness in the marine industry, and establish the technology standards.
- Regarding the demonstration projects of offshore wind power generation, it is necessary to conduct environmental impact assessment studies. Moreover, for other ocean renewable energy power generation technologies, environmental impact assessment will be conducted if the need arises in the future.
- In order to meet the challenges related to the ocean-specific high cost infrastructure development such as the backyards, barge, etc., it is necessary to ensure safe and efficient installation and maintenance operations.

INFRASTRUCTURE DEVELOPMENT FOR MARINE RENEWABLE ENERGY SPREAD

- Perform comprehensive discussion on the measures that are expected to lead to spread ocean renewable energy, including the ways to achieve the policy goals.
- Accurate evaluation of ocean renewable energy cost will become possible after the practical implementation of the respective technologies.
- Increasing public awareness of the importance of ocean renewable energy in Japan through public activities.

OFFSHORE WIND POWER GENERATION

Promotion of technological development

- Aiming to establish the bottom-mounted technology for offshore wind power generation systems and offshore wind condition observation system in Japan, 2MW experimental facilities will be constructed off Kitakyushu city and Choushi city by the end of 2014. Environmental impact assessment studies will also be carried out for these projects.
- Research for the development of drive train, long blade and remote monitoring system for large scale power generation system are also being conducted.
- A small scale (100 kW) offshore floating wind power generation system that takes into account the characteristics of the weather and sea conditions of Japan was constructed off Kabashima Island, Nagasaki Prefecture in 2012. The Project was followed by a 2 MW unit constructed in 2013 at the same place; the two projects aim to promote research in real sea conditions that lead to the establishment of technology by the year 2015.
- In order to realize the floating offshore wind farm, the world's largest wind farm is currently under construction off Fukushima Prefecture. In addition, safety, reliability and the economic aspects of the project will be evaluated by the end of the year 2015.

- Development of environmental impact assessment methods and maintenance techniques that coexist with fishing industry and the ship navigation safety.

Development of safety standards

In order to ensure the safety of the floating offshore wind power generation facility, technical issues related to the security of the various parts of the system are being investigated, including the floating body, protection against capsizing, sinking, etc. In addition, technical studies for risk reduction during deployment of large-scale facility are also being performed.

From the results of these studies, it was possible to formulate safety guidelines by the end of the year 2013, and lead the establishing of international standards in the International Electrotechnical Commission (IEC).

Infrastructure development

- For the widespread of offshore wind power generation technology, researches aiming to resolve difficulties associated with the construction and maintenance works at large scale wind power generation, and developing of the large-sized barge used for the system deployment should be pursued.

Advanced initiatives

- Take the initiative and introduce wind power generation system into coastal areas in order and achieve sustainable development.
- Achievement of reduction in the cost of energy and emissions in the fishing ports and securing emergency power generation from renewable energy resource.

OTHER FORMS OF OCEAN ENERGY POWER GENERATION

- In order to realize practical systems that utilize the various forms of ocean energy (wave, tidal, current, thermal energy, etc.) for power generation and capable of achieving generation cost less than 40 JPY/kWh, it is important to pursue research on innovative technology development and carry out empirical studies to promote the relevant technology from various perspectives.
- For the widespread of ocean energy, it is important to apply measures to ensure safety of the power generation facilities, including the floating or submerged body, also to ensure that the power generation facility comes in harmony with the original purpose or function of the port.
- According to the "Basic Policy for the Great East Japan Earthquake and Tsunami Reconstruction Efforts", development for the establishment of innovative power generation system of high efficiency, high reliability and low cost is to be established under existing natural conditions in the Northeast coast.

IRELAND

Eoin Sweeney
SUSTAINABLE ENERGY AUTHORITY OF IRELAND

INTRODUCTION

The Ocean Energy Strategy was initiated in 2006, aimed at developing the wave and tidal sector. Since then, there has been ongoing work to create a supportive policy framework, develop infrastructure, support industry development and build research capacity to create a favourable developmental environment. To this end, the Ocean Energy Development Unit (OEDU) was set up in the Sustainable Energy Authority of Ireland (SEAI) in 2008 to take the sector forward, through a comprehensive suite of activities.

As in 2011 and 2012, in 2013 the global funding issues, together with the much slower than expected rate of development and deployment of ocean energy technologies, has meant a much slower than anticipated rate of development in the ocean energy sector in Ireland.

OCEAN ENERGY POLICY

STRATEGY AND NATIONAL TARGETS

Ireland's Offshore Renewable Energy Development Plan (OREDP) is in the final stages of development by the Department of Communications, Energy & Natural Resources and is due for launch imminently. The OREDP will set out how policy is in development in this sector and take account of all of the factors that are likely to affect policy as it develops and outline how key Stakeholder will assist Offshore renewable policy development in the coming years.

The draft Plan notes Ireland's involvement in many initiatives and its openness, at a strategic level, to considering the possibilities and opportunities offered by offshore renewable energy. The draft Plan considers the development of offshore wind, wave and tidal energy in the period to 2030.

Ireland has been set a binding renewable energy target under Directive 2009/28/EC and has published a National Renewable Energy Action Plan (NREAP) setting out how the target for 2020 is to be achieved. In the NREAP, Ireland states in its modeled electricity scenario that it expects 555MW of offshore wind to be contributing to its 2020 target as well as 75MW of wave and tidal generated power.

The Renewable Energy Directive provides co-operation mechanisms for Member States to trade renewable energy in the period to 2020, if they are able to exceed their national target. The government is involved in bilateral discussions with neighbouring countries on the use of these mechanisms for the export of renewably generated electricity. A study on the cost benefits of Ireland engaging in the co-operation mechanisms under the Directive was completed in 2012.

In 2013 the Irish Government set national research priorities and Research into Marine Renewable Energy is one of 13 national priorities.

An Ocean Energy Roadmap, formulated by SEAI, was published in 2010. It is designed to initiate a debate about the pathway to 2050 for ocean energy in Ireland. The key features of the Roadmap are:

- The Strategic Environmental Assessment reports that, potentially, 29GW of ocean energy capacity can be installed without likely significant adverse effects on the environment.
- Employment opportunities of up to 70,000.
- Cumulative economic benefit up to €12 billion by 2030 and up to €120 billion by 2050 from factors such as electricity generated, emissions reductions, security of supply, regional development & knowledge created.
- National energy security is significantly enhanced.

There will be ongoing testing of the assumptions and projections in updating this Roadmap in 2014.

SUPPORT INITIATIVES AND MARKET STIMULATION INCENTIVES

In 2009, the government announced a Refit tariff of €220 MW, for wave and tidal energy. This has not yet been activated and the Department of Communications Energy and Natural Resources will consider the matter again under the development of the final OREDP.

MAIN PUBLIC FUNDING MECHANISMS

The principle funding mechanism for the ocean energy sector is the Prototype Development fund, administered by the Sustainable energy Authority of Ireland (SEAI). This supports industry-led projects for the following types of activities:

- Projects to develop and test wave and tidal energy capture devices and systems;
- Independent monitoring of projects/technologies;
- R&D aimed at the integration of ocean energy into the electricity market and the national electricity grid (and network);
- Data monitoring, forecasting, communications and control of OE systems;
- Specific industry-led research projects which will be carried out by research centres.
- Other significant funding for university/industry research projects and for the commercialisation of successful early-stage companies is provided by Enterprise Ireland, the indigenous industry support agency.

RELEVANT LEGISLATION AND REGULATION

Offshore marine renewable energy projects currently fall within the jurisdiction of the Foreshore Acts 1933 to 2009. The Foreshore Acts apply to the seabed and shore below the line of high water of ordinary or medium tides and outwards to the 12 nautical miles limit of the territorial seas (22.22 kilometres). Jurisdiction beyond this limit is determined by the UN Convention on the Law of the Sea.

Since 2010, the Department of Environment, Community and Local Government (DECLG) has been working on the streamlining and modernising of the consent process for foreshore developments, with particular emphasis on renewable energy projects. It is intended that the reforms will deliver a plan-led policy framework for the approval of activities and developments in the marine environment, a single consent process for project approval as well as greater certainty of timeframes. Mandatory pre-application consultations, transparent assessment of environmental impacts and full public participation are also planned. A new legislative Bill is now expected in 2013 or early 2014.

DECLG is also working with other relevant Departments and agencies on the development of a marine spatial planning framework, providing for the strategic development of the foreshore while managing competing, and often conflicting, sectoral demands. In 2012 extensive new Special Areas of Conservation were announced which will have implications for the development of marine renewable energy projects.

RELEVANT DOCUMENTS RELEASED

A full list of publications relevant to the OE sector is available at http://www.seai.ie/Renewables/Ocean_Energy/Ocean_Energy_Information_Research/Ocean_Energy_Publications/.

A study was also commissioned on the options for offshore grid on the west coast of Ireland. This was completed in 2013.

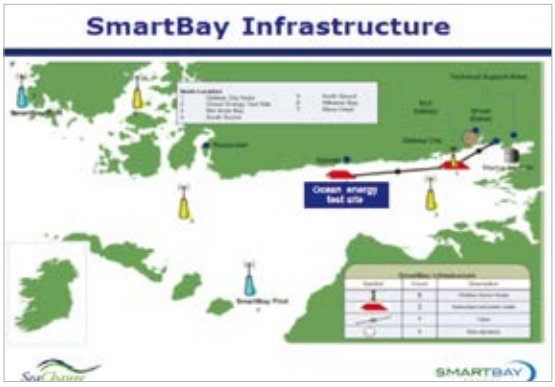
RESEARCH & DEVELOPMENT

GOVERNMENT FUNDED R&D

SEAI is continuing work on the establishment of a full scale grid connected wave energy test facility off County Mayo. It will be connected to the national electricity grid and will provide facilities for the testing of full scale devices in development by Irish and multi-national companies and will be able to accommodate up to 3 devices at any one time. A grid offer is in place, a formal lease application has been made and is currently awaited. It is planned to commence construction of the sub-station in 2014.

SEAI, in partnership with the Marine Institute, continued to operate the wave energy 1/4scale test site in Galway Bay. Work commenced, aimed at enhancing the facility by providing power and bandwidth to the site, in conjunction with the SmartBay initiative. This work will continue into 2014.

The SmartBay Pilot Project in Galway Bay is designed to be a research, test and demonstration platform, and innovation test bed, for new ocean technologies developed by research institutes and companies in the fields of communications, informatics, instrumentation and sensors. During 2013 an operating company – SmartBay Ltd – continued to develop and manage the research infrastructure in Galway Bay.



The Hydraulics and Maritime Research Centre (HMCR) in University College Cork is the principal ocean energy research facility in Ireland, with special interest in ocean energy research and coastal engineering. Major enhancement of the facility as the National Ocean Test Facility is now in the design phase, as a key part of the Irish Maritime and Energy Research Cluster (IMERC), with financial support from the Higher Education Authority, industry and the OEDU. Construction will commence in 2013. Key areas of research expertise include:

- Ocean Energy Resource assessment
- Wave Energy Physical Device model testing
- Field Testing and measurements - Wave, Tidal, Coastal
- Computational Fluid dynamics – Wave & Tidal
- Numerical modelling, Wave, Tidal & Coastal processes
- Analytical Modelling , Wave, Tidal & Coastal processes
- Electrical, Power Electronics and Control Systems

- Instrumentation and Data acquisition
- PTO – Turbomachines & Hydraulics
- Economic Modelling
- Environment and Marine Law

HMRC has now been renamed the Beaufort Institute, a constituent part of the Irish Maritime and Energy Research The Cluster. UCC was awarded some €19m, in 2013, by Science Foundation Ireland for a multi-year research programme. The programme – Marine Renewable Energy Ireland (MAREI) – covers all aspects of MRE and is supported by a range of industry partners.

The University of Limerick has been actively pursuing the development of air turbines for use with oscillating water column devices. It also has a Robotics group with special interest in applications in the marine renewables area.

The Electricity Research Centre in University College Dublin has had significant involvement in the integration and the study of management issues for intermittent renewable generators such as wind power systems operating on the national grid. Their interests include modelling of dynamic response of electrical generators and tidal energy systems.

The Department of Electronic Engineering in the National University of Ireland, Maynooth has a dedicated Wave Energy Group group working in the areas of:

- Hydrodynamic modelling
- PTO modelling
- Impact of wave directionality on WECs
- Device optimisation
- Control system design for WECs
- Resource assessment and forecasting
- Projects funded by Enterprise Ireland include SeaGrid, a study on grid integration software and services of ocean energy and NAVITAS, a study on Economic Assessment of Ocean energy systems, farms and projects.

INDUSTRY FUNDED R&D

All of the research and demonstration activities conducted in Ireland involve an element of match-funding from industry.

SEAI and Enterprise Ireland are funding Ocean Energy device developers at various stages and are also funding development of new components and supply chain elements that will ultimately assist all of the industry. Examples of projects funded in the period 2010-2012 include:

- *Benson Engineering - Device and sea water component pump*
- *Limerick Wave - Power take off*
- *Carnegie Wave - Site assessment*
- *Open Hydro - Technology enhancement*
- *Jospa - Device development*
- *Waveberg - device development*
- *Key Engineering Services - systems devlopment*
- *Cyan Wave - device development*
- *Wave Energy Ireland - combined device development*
- *Wavebob - technology enhancement*
- *Ocean Energy Ltd - device development*
- *Bluepower Energy - power take off*

- *Technology from ideas - supply chain and components*
- *Seapower - device and components*
- *Houston engineering - power take off*
- *IBM Inc - Acoustic monitoring of WECs*

PARTICIPATION IN COLLABORATIVE INTERNATIONAL PROJECTS

UCC co-ordinates the MaRINET (Marine Renewables Infrastructure Network for Energy Technologies) project. MARINET is a new network of research centres which aims to accelerate the development of marine renewable energy (wave, tidal & offshore-wind) by bringing together world-class testing facilities to offer EU-funded testing and to coordinate focussed R&D. Many European marine renewable energy test centres have formed this network in order to work together to offer their unique capabilities and services in a coordinated way. The European Commission has supported this initiative by way of funding through the FP7 programme. This enables MARINET partners to offer periods of access to their facilities at no cost to users. Access is open to all potential users who wish to avail of these facilities – research groups, companies, SMEs etc.

The aim of MARINET is to facilitate testing and to coordinate and advance marine renewables R&D at all scales - from small models and laboratory tests through to prototype scales and open sea tests. Through this EC funding, MARINET offers periods of access, at no cost to users, to test facilities which are located outside the country where those users work. Users can avail of this access to test and develop their devices and concepts. This enables users to access facilities which are not available in their home country and may be too expensive to access normally, or are simply inaccessible under national renewables support funding as the desired facilities are located outside the state providing that funding. Users can avail of a range of infrastructures to test devices at any scale or to conduct tests on power take-off systems, grid integration, moorings and environmental data – thereby accelerating the development of the offshore renewable energy sector.

As well as offering test facility access, MARINET will also implement common standards for testing, conduct research to improve testing capabilities and provide training at various facilities in the network in order to enhance expertise in the industry.

Access is available to 42 facilities from 28 network partners spread across 11 EU countries and 1 International Cooperation Partner Country (Brazil). MARINET brings together a network of personnel in the offshore marine renewable energy sector with expertise at all scales of marine technology research and development. The initiative runs for four years until 2015, with at least four calls for access applications. In total, over 700 weeks of access is available to an estimated 300 projects and 800 external users. For further information see www.fp7-marinet.eu

SOWFIA - Streamlining Ocean Wave Farms Impact Assessment – Multi-disciplinary multi-partner EU EACI IEE project with objective to develop and improve tools and methods for environmental and social impact assessment of wave farms (UCC Partner).

IEC TC114 - Ireland has a mirror committee and contributes experts to TC114 development of standards and guidelines in ocean energy.

IEA OES - Ireland contributes directly to IEA in terms of EXCO but has also been a key contributor to many of the collaborative annexes.

International Smart Ocean Graduate Education Initiative - Ireland has a graduate programme co-funded by members of the SmartOcean group which has a mix of Irish and International entities. First round of PhDs starting.

Lean Wind - The HMRC is also the co-ordinator of the Lean Wind project, designed to reduce costs of offshore wind technology and operations.

Ireland, through HMRC, also participates in the European research network, EERA, and is participating in the preparation of an ERA-Net proposal, to deepen collaboration between European countries in OE.

KEY STATISTICAL INFORMATION - LEVEL OF PUBLIC AND PRIVATE INVESTMENT ON R&D

- Public expenditure on R&D in 2013 is estimated to be €2.5m
- Private investment on R&D in 2013 is estimated to be €4m

TECHNOLOGY DEMONSTRATION

OPERATIONAL OCEAN ENERGY PROJECTS

Nine projects were funded by SEAI under the Prototype Fund, however no new operational projects were undertaken in open waters in 2013.

NEW DEVELOPMENTS

UCC Beaufort and IMERC

As mentioned in section 3.1 DCENR, IDA, PRTLI, SEAI-OEDU, UCC and Bord Gais are funding a new building to house the National Ocean Test Facility. This is a €16.5m cornerstone and flagship facility housed within the Irish Maritime and Energy Research Cluster (IMERC). IMERC is a joint venture between UCC, Cork Institute of Technology and the Irish Naval Service.

Westwave 5 MW Demonstration Project

The WestWave project aims to develop the first wave energy project in Ireland by 2015 by generating 5MW of electricity from the plentiful wave energy resource off the west coast of Ireland. WestWave is a collaborative project being led by ESB International (ESBI). ESBI has been engaged with a number of WEC developers and in 2014 will select their preferred technology or seek to have the project delayed until 2015.

ESB, with support from the Sustainable Authority of Ireland (SEAI), is building upon previous supply chain analyses of marine energy to focus specifically upon the requirements of the WestWave Project. Within this supply chain study the project team has assessed, along with four leading technology developers, the requirements to deliver the WestWave project within the timeframe required. The project is currently undergoing feasibility assessment processes involving the European Investment Bank, the Department of communications, Energy and Natural Resources and ESB.

Lease awards Northern Ireland

Two companies were awarded rights to develop the tidal renewable energy resource in Northern Ireland. These are:

- Tidal Ventures Limited for the 100 MW tidal opportunity at Torr Head:a joint venture between OpenHydro Group, a designer and manufacturer of tidal turbines, and Bord Gáis Energy one of Ireland's leading energy providers.
- DP Marine Energy Limited with DEME Blue Energy for their 100 MW tidal stream energy project off Fair Head: this project is a consortium comprising Cork based DP Marine Energy Limited and the Belgian marine engineering company DEME Blue Energy.

CANADA

Monika Knowles & Jon Brady
NATURAL RESOURCES CANADA

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

Canada's Marine Renewable Energy Technology Roadmap establishes targets whereby the Canadian sector contributes to projects totaling 75 MW by 2016, 250 MW by 2020 and 2 GW by 2030 for installed in-stream tidal, river-current and wave energy generation.

Nova Scotia's Marine Renewable Energy Strategy outlines the Province's plan to promote innovation and research, establish a regulatory system and encourage the development of market-competitive technologies and an industrial sector. It sets targets to develop marine renewable energy legislation by 2013, the installation of 5 to 60 MW of grid-connected in-stream tidal electricity generation by 2015 and 300 MW of in-stream tidal electricity generation grid connected by 2030.

MAIN SUPPORT INITIATIVES

Support Initiatives & Market Stimulation

Over the last six years, Marine Renewables Canada estimates that there has been at least $85 million in federal and provincial support to marine energy development projects.

At the provincial level, the Nova Scotia Utility and Review Board (UARB) has released its decision for developmental tidal Feed-in-Tariff (FIT) rates. Developers may choose between 1 of 2 FIT 'paths': Developmental or Testing. The two paths are designed to respond to the diverse nature of industry plans, turbine designs, and build out to multiple device projects, accommodating in a more accurate manner than a single path would the variety among tidal energy projects. The Testing Path allows for initial deployment of a single device for a 3-year period at a particular rate, followed by further deployments at another rate for a 15 year period. The Developmental Path allows for the deployment of multiple devices for a period of 15 year. Both FIT rate paths are 'declining block', thus the rates decline in accordance to the megawatt hour (MWh) output of the project, which reflects project efficiencies and economies of scale.

TEST PATH – PHASE 1		TEST PATH – PHASE 2		TEST PATH – PHASE 3	
≤ 3,330 MWh	> 3,330 MWh	≤ 16,560MWh	>16,560MWh	≤ 16,560MWh	>16,560 MWh
$575	$455	$495	$375	$530	$420

The Government of Nova Scotia also has the Community Feed-in-Tariff (COMFIT) program, which was launched in September 2011. Under the COMFIT programNova Scotia allows local community groups to connect small-scale in-stream tidal devices, under 500 kW, to the electrical grid at the distribution level at a feed-in tariff price of 65.2 cents/kWh over a 20-year contract.

Main public funding mechanism

To date, Canada's main public funding programs supporting national research, development, and demonstrations are from federal programs administered through the Office of Energy Research and Development, such as the Clean Energy Fund (CEF), the Program for Energy Research and Development (PERD) and the ecoENERGY Innovation Initiative (ecoEII). Through these programs Canada has committed approximately $37 million to marine renewable energy RD&D since 2010. In addition, Sustainable Development Technology Canada (SDTC), an arm's length foundation created by the Government of Canada, has committed approximately $13 million to develop and demonstrate projects that include in-stream tidal, river-current and wave energy technologies.

The National Research Council Industrial Research Assistance Programme has supported many early technology assessment and physical and numerical modelling trials. Most projects have benefitted from the refundable tax credit for Scientific Research and Experimental Development. Many projects have also received support from provincial economic development agencies.

Nova Scotia has directly invested in the FORCE development initiative and, through the Offshore Energy Research Association of Nova Scotia (OERA), supported a number of strategic research projects in marine energy, estimated to be approximately $8 million. In addition, provincial economic development agencies and funds, in Nova Scotia, Quebec, Ontario and British Columbia, have provided at least $10 million to support projects.

Relevant Legislation and Regulation

At the federal level, on November 6, 2013 Canada's Minister of the Environment finalized amendments to the *Regulations Designating Physical Activities* under the *Canadian Environmental Assessment Act, 2012 (CEAA 2012).* The amended *Regulations Designating Physical Activities* identifies the projects that constitute a "designated project" which may require a federal environmental assessment (EA) under the CEAA 2012. As part of the amended regulations, in-stream tidal projects were differentiated from tidal barrage projects and their capacity threshold for triggering Ministerial consideration for a federal environmental assessment was increased from 5 MW to 50 MW. The EA threshold for tidal barrages remains at 5 MW.

These amendments operationalize the spirit of the new CEAA 2012 that seeks to reduce assessment duplicity between federal and provincial governments and focus federal assessments on those major projects with the greatest potential for significant adverse environmental impacts to matters of federal jurisdiction. Environmental assessments for projects that fall outside this scope will be solely conducted by provincial governments, including in-stream tidal projects under 50 MW.

CEAA 2012 allows the Minister of the Environment to order an assessment for any non "designated project", including offshore wind and wave projects, where there may be adverse environmental effects related to federal jurisdiction.

Regardless of where a marine renewable energy project is planned for development in Canada or whether or not it triggers a federal environmental assessment a number of federal regulatory approvals are required from several federal departments in the areas of fisheries, navigation and certain environmental issues. This federal regulatory role stems from the federal government's jurisdiction and responsibility over these areas.

At the provincial level, in Nova Scotia's 2012 Marine Renewable Energy Strategy the provincial government established a Regulatory Plan emphasizing environmental protection, stakeholder engagement and a licensing system for demonstration and commercial projects. By December 2013, the Nova Scotia Government was finalizing an amendment to the Nova Scotia Renewable Electricity Regulations, under the Electricity Act, which will establish a provincial in-stream tidal application approval process for projects to

go through to qualify for the Development FIT Program. As part of these regulatory amendments, eligible areas for tidal energy developments will be restricted to areas that have had a Strategic Environmental Assessment conducted for marine renewable energy.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

Canada has robust laws governing the oceans that can be used for licencing renewable energy projects in the federal offshore. However, similar to many countries around the world there is no specific legal framework designed for the licencing of renewable energy activity in the federal offshore. Under the Marine Renewable Energy Enabling Measures program, the Department of Natural Resources Canada is taking a lead role towards the development of a policy framework for licensing and administrating renewable energy activities in the federal offshore on behalf of the Government of Canada.

As referenced above, the amendments to the *Regulations Designating Physical Activities*, under the new CEAA 2012, identify a new capacity threshold of 50 MW to trigger a federal environmental assessment for in-stream tidal energy projects. In accordance with the new CEAA 2012, the Canadian Environmental Assessment Agency must render a final decision on a standard environmental assessment within 365 days from the commencement of the assessment.

In Nova Scotia, following the provincial government's finalization of the amendment to the Nova Scotia Renewable Electricity Regulations, an application approval process to qualify for the Development FIT Program will be established. Under the anticipated new approval process, the Minister of Energy may issue a final Development FIT approval after an applicant demonstrates that it has received all necessary approvals from the relevant provincial and federal regulators. The final Development FIT approval will outline the FIT rate the project will receive for the power it produces and will also include conditions the applicant is expected to meet through the lifecycle of the project. A project cannot proceed towards construction and development without the FIT approval from the Minister of Energy. Once an applicant receives the Development Tidal FIT approval from the Minister, it may proceed to entering into a Power Purchase Agreement with the provincial utility, Nova Scotia Power Inc., into order to receive its designated FIT rate and term.

RELEVANT DOCUMENTS RELEASED

- Nova Scotia Marine Renewable Energy Strategy
- International Overview of Marine Renewable Energy Regulatory Frameworks
- Pathways of Effects for Offshore Renewable Energy in Canada
- A Framework for Environmental Risk Assessment and Decision-Making for Tidal Energy Development in Canada
- Marine Renewable Energy Technology Roadmap – released late in 2011

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Government Funded R&D

In September 2012, Natural Resources Canada's Office of Energy Research and Development (OERD) committed an additional $5 million under the Clean Energy Fund program to FORCE in order to assist in supporting costs related to the development of a subsea cable-connected instrumentation platform,

which will host monitoring equipment for site characterization and environmental monitoring. The total instrumentation platform project value is $10 million, with $ 5 million in additional funding is coming from Encana, Ocean Networks Canada and the FORCE berth holders.

In 2013, Natural Resources Canada committed $6.1 million to research, development & deployment activities in marine renewable energy, including wave, in-stream tidal, and river current energy.

FORCE, the Nova Scotia Offshore Energy Research Association (OERA) and the Fundy Energy Research Network (FERN) in Nova Scotia continue to conduct and support research activities to help advance the Canadian Marine energy industry. FORCE began design and operational work on the Fundy Advanced Sensor Technology (FAST) platform – a recoverable seabed mounted platform designed to advance the understanding of the FORCE side and the instrumentation required to measure it.

Marine energy research is being conducted at the universities of Victoria, Manitoba, Acadia, Dalhousie and the College of the North Atlantic. Marine energy research activities at these universities have been growing with around 15 graduate students, and the first at a doctoral level, and focused research grants, as estimated by Marine Renewables Canada, of approximately $5 million in place.

Natural Resources Canada's internal CanmetENERGY Marine Energy Technology team is supporting and conducting technology-focused research. The CanmetENERGY Marine Energy Technology Team is currently engaged in marine energy research to support the development of international standards, technology advancement, resource characterization, and monitoring equipment.

The Department of Fisheries and Oceans (DFO) in collaboration with the Nova Scotia Department of Energy is continuing to explore the development of national guidance regarding the development of in-stream tidal energy projects in Canadian waters.

Participation in Collaborative International Projects

In September 2011, Canada and the United Kingdom endorsed the Canada-United Kingdom Joint Declaration to ensure a stronger partnership for the 21st century. As part of the Joint Declaration both governments declared an intention to mutually encourage the development of marine renewable energy technologies from pilot-scale devices to grid-connected power generation stations. Since this time, the tenets of the UK-Canada Joint Declaration were further articulated in the Canada–UK Innovation Statement, which committed the UK and Canada to "collaboration on technology development and knowledge sharing between both countries to accelerate the development, demonstration and deployment of technologies and process to support the marine energy sector…". There have been four missions between Scottish and English government officials and Canada, as well as a marine renewable energy trade-mission, with government and industry representatives, under the auspices of the Joint Declaration. These missions explored strategic partnership opportunities and further strengthened commercialization efforts between Canada and the UK.

In February 2009, the Clean Energy Dialogue was established between Canada and the United States to enhance joint collaboration on the development of clean energy science and technologies to reduce greenhouse gases and combat climate change. In June 2012, the release of the Clean Energy Dialogue Action Plan II identified offshore renewable energy as one of the policy priorities under the Electricity Grid Working Group. As part of this initiative, Canada's Department of Natural Resources and the U.S. Department of Energy collaborated in the commissioning of a report on the marine renewable energy regulatory regimes of the following six European countries: Denmark, Germany, Ireland, the Netherlands, Portugal and the United Kingdom. The focus of this report, entitled "International Overview of Marine Renewable Energy Regulatory Frameworks", is to provide a governance and regulatory overview of each country and lessons learnt by industry and government in the administration of offshore renewable energy activities.

The Fundy Ocean Research Centre for Energy (FORCE) and the European Marine Energy Centre (EMEC) joined in a strategic relationship in 2011 with the signing of a Memorandum of Understanding. In 2012, both FORCE and EMEC continued collaborative activities in scientific and technical areas of mutual interest.

The 5th International Conference on Ocean Energy (ICOE) will be held in Halifax, Nova Scotia in November 2014. Marine Renewables Canada, the Canadian association for marine energy, is the lead national host for ICOE 2014 and is working with core local partners to organize and deliver the event. The event is anticipated to attract 700-900 attendees and will highlight the role that Canada will play both domestically and internationally as the sector matures with particular focus on world-leading activities in Nova Scotia.

TECHNOLOGY DEMONSTRATION

OPERATIONAL OCEAN ENERGY PROJECTS

The technology developer, Renewable Energy Research (RER), reports that the 250 kW TREK turbine has been in operation since August 17th 2010 in the Saint-Lawrence River near Montreal, Quebec. As of December 2013, RER reports that it has been operating for a total of 28,800 hours, with zero failure. RER is planning to install more turbines starting in 2013.

Clean Current is operating a 1.5m river turbine at the Canadian Hydrokinetic Turbine Test Centre in Manitoba since September 2013.

The 20 MW Annapolis Royal tidal barrage power plant was commissioned in 1984 and continues to operate today. It is owned and operated by Nova Scotia Power (a subsidiary of the utility company EMERA). Annapolis Royal is the only commercial tidal power plant in North America.

PLANNED DEPLOYMENTS

The 500 kW (2 x 250 kW) Canoe Pass project in British Columbia is planning to deploy the New Energy EnCurrent generators in 2014. The project will be in a causeway of a narrow channel between Quadra and Maud Islands in British Columbia.

In November 2013, Renewable Energy Research (RER) and Boeing announced a multiyear agreement with the government of Quebec, to provide 40 hydrokinetic turbines that will generate about 9 MW of clean renewable power in the St. Lawrence River near downtown Montreal, Quebec.

FORCE has completed construction of the 138 kV transmission line and the substation and electrical infrastructure. FORCE has also completed phase 1 of the subsea cable lay trials. The FORCE visitors centre received about 4,300 visitors as of December 2013. In December 2013, FORCE successfully installed a data cable designed to connect to the Fundy Advanced Sensor Technology (FAST) recoverable underwater research platform – the first subsea cable ever installed in the Minas Passage. This data cable will allow continuous, real-time data transmission from the platform to shore via the FAST platform, and provides valuable information on cable behavior and experience in cable deployment in the Minas Passage in advance of planned subsea power cable deployment in 2014.

Fundy Tidal Inc., a community-based project developer, was awarded COMFIT approvals for 5 of their projects: Digby Gut (1.5 MW); Petit Passage (500 kW) and Grand Passage (500 kW) which are near the mouth of the Bay of Fundy, and near Cape Breton; Grand Narrows / Barra Strait (100 kW) and; Great Bras D'Or Channel (500 kW). Currently, Fundy Tidal Inc. is undertaking resource assessment analyses, site characterization and screening-level environmental assessment work. In-stream tidal current energy converters for these projects will be chosen through a request for proposal (RFP) process.

Clean Current and Fundy Tidal Inc. have entered into an agreement to test and demonstrate a 3.5m diameter Clean Current turbine in Grand Passage, Nova Scotia. This project is part of a larger Tidal Power System (TPS), which will include energy storage and system controls, to enable a balancing of power with community load. The project is expected to last a minimum of 12 months, with a target commissioning date in the late 2014 / early 2015.

Clean Current will deploy an array of river turbines in 2014. Several sites are being considered and final decision will be made in 2014.

Idénergie is a new company that is developing very-small scale river-current energy converters. They have conducted initial trials with their machine in Quebec. In 2013, Idénergie focused on the development of a new turbine, and fine tuning key components within the turbine. Idénergie is expecting to complete final testing and demonstration of their turbine by the beginning of 2014, so that the technology is ready for sales by the summer of 2014.

Verdant Power is moving forward with its Ontario project initially planned for the St. Lawrence River near Cornwall, Ontario. The company has advanced its technology, resource assessment capabilities, continues to develop cost-efficient river deployment and anchoring foundation, and is further evaluating locations in Ontario for development.

UNITED STATES OF AMERICA

Michael Reed
U.S. DEPARTMENT OF ENERGY (DOE)

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The mission of the Department of Energy's (DOE) Water Power Program (WPP) is to research, test, evaluate, develop and demonstrate innovative technologies capable of generating renewable, environmentally responsible and cost-effective electricity from water resources. Pursuant to that mission, the Program is currently undertaking the necessary analysis to assess the opportunities associated with tapping ocean energy resources. The completion of significant advanced assessments of U.S. wave and tidal energy resources has resulted in a programmatic decision to focus technology development efforts largely on the abundant national wave energy resource. Based on these analyses, the Program has established a national marine and hydrokinetic (MHK) cost reduction goal of twelve to fifteen cents per kilowatt hour by 2030. To accomplish this goal the WPP has a strategic focus on the following four major thrust areas:

- 1. Technology Advancement and Demonstration
- 2. Testing Infrastructure and Instrumentation Development
- 3. Resource Characterization
- 4. Market Barrier Identification and Removal

The 2013 DOE MHK portfolio consisted of 87 projects and represented a total Program investment of $33.8 million. Most of the MHK funding (69%) was directed toward major thrust areas one and two.

MAIN SUPPORT INITIATIVES

During 2013, the DOE invested $16 million to address key technical and market barriers to the deployment of wave and tidal technologies in the United States. Together, these projects will increase the power production and reliability of wave and tidal devices and help gather valuable data on how deployed devices interact with the surrounding environment. The Department made investments in eight projects to help U.S. companies build durable, efficient wave and tidal devices that reduce overall costs and maximize the amount of energy captured. Additionally, the Department invested in nine projects that will gather and analyze environmental data from wave and tidal projects as well as potential development zones. Finally, the DOE completed design reviews of MHK wave and tidal current technologies that were demonstrated in open water, allowing the Program to validate cost and performance data and guide future MHK technology cost reduction and reliability improvement opportunities.

The DOE also awarded five Phase I awards of up to $150,000 to companies developing MHK technologies through the Small Business Innovation Research (SBIR) and Small Business Technology Transfer (STTR) program. The SBIR/STTR program is a U.S. Government program in which federal agencies set aside a small fraction of their funding for competitions only open to small businesses. These programs help emerging

MHK technologies advance along the DOE Technology Readiness Level (TRL) chain. Small businesses that win awards in these programs keep the rights to any technology developed and are encouraged to commercialize the technology.

Furthermore, several key pieces of legislation that will benefit the advancement of the marine renewable energy industry are currently under consideration in the United States. The Marine and Hydrokinetic Renewable Energy Act of 2013 (S.1419) was proposed in August of 2013 and is currently pending debate and vote in committee. This bill would promote research, development, and demonstration of MHK renewable energy technologies. The proposed Prioritizing Energy Efficient Renewables Act of 2013 (H.R.2539), would permanently extend the Renewable Energy Production Tax Credit for wind, geothermal, hydro and marine power and would eliminate the tax credit for intangible drilling costs, the domestic manufacturing tax credit for oil and gas, as well as the percentage depletion credit for oil and gas wells. This bill is currently referred to the House Committee on Ways and Means.

The Climate Protection Act of 2013 (S.332) would enable the Environmental Protection Agency to establish a 'Sustainable Technologies Finance Program' that would alleviate cost burdens for ocean, tidal or hydropower energy projects through loans, credit instruments, loan guarantees. As of February, 2013 this bill has been referred to the Committee on Environment and Public Works. The Advancing Offshore Wind Production Act (H.R.1398) aims to streamline the permitting process in the siting and development of offshore wind energy by setting a 30 day timeline for the Secretary of the Interior to act on permits for all weather testing and monitoring projects in the US Outer Continental Shelf. This bill includes a provision that would extend this timeline to applications for tidal and ocean current energy projects. Finally, the Renewable Electricity Standard Act of 2013 (S.1595) and the American Renewable Energy and Efficiency Act (S.1627), both pending, would each create a renewable electricity standard that would apply to all renewable energy sources.

NATIONAL SEA TEST FACILITIES

The DOE announced up to $1.5 million in funding for the Northwest National Marine Renewable Energy Center (NNMREC) and the California Wave Energy Test Center (CalWave) to design open water testing facilities to accelerate the development and deployment of wave energy systems. NNMREC, in conjunction with other research and testing activities at Oregon State University (OSU), will develop their Pacific Marine Energy Center South Energy Test Site (PMEC-SETS), a grid-connected test facility, to evaluate utility scale wave energy converter (WEC) device performance, environmental interactions, and survivability. CalWave will investigate and characterize two wave energy sites five miles off of the coast of California (Santa Barbara County and Humboldt Bay) that have an annual average power density greater than or equal to 30 kilowatts per meter and have a depth of 50 meters.

The Naval Facilities Engineering Command (NAVFAC) operates an intermediate-scale Wave Energy Test Site (WETS) facility located at Marine Corps Base Hawaii, Kaneohe Bay, Hawaii. The existing facility consists of infrastructure to support offshore testing of a point absorber or oscillating water column device with up to a three-point mooring configuration. In addition, the facility includes a subsea power cable from an onshore data collection facility to a mooring assembly located at a 30 meter (98 ft.) depth test site, 1.2 kilometers (3,900 ft.) offshore. WETS is working to provide two new berths for a total of three grid-connected berths in water depths ranging from 30 to 80 meter for WEC devices in the 100 to 1000 kilowatt range.

The DOE also continues to support the following National Marine Renewable Energy Centers. These centers will provide the necessary domestic expertise and infrastructure needed to facilitate comprehensive, standardized testing of MHK devices and to produce certified environmental performance data, ultimately providing the necessary level of confidence to enable the private financing of commercial generation plants.

Northwest National Marine Renewable Energy Center – Wave and Tidal Test Facility

In 2013, NNMREC branded their marine energy converter testing facilities as the Pacific Marine Energy Center or PMEC. Just as the European Marine Energy Center has a variety of sites based on scale and technology, PMEC will encompass the range of test facilities available to the marine energy industry.
NNMREC supports two test sites, the South Energy Test Site (SETS) and the North Energy Test Site (NETS). SETS is under development and will serve as the utility-scale wave energy test facility for the U.S. Researchers at OSU are conducting site characterization and a cable routing study is in process. SETS is expected to be available for device testing in 2016. NMREC deployed the Ocean Sentinel mobile ocean test buoy for the second season in the operational NETS. While no WEC tested this summer, researchers gained important insights into loading on mooring and anchoring systems. In October, NNMREC completed 4.5 years of continuous data collection at a tidal energy site in Puget Sound, Washington. The long-term time series of current velocity, underwater noise, water quality, and marine mammal echolocations are available for use by other research organizations and industry.
Researchers at both OSU and the University of Washington have been collaborating on the design and simulation of advanced mooring systems for wave and current converters. Collaborative efforts are also advancing the development of an adaptable, cabled package suitable for deploying high bandwidth instrumentation needed for environmental monitoring of wave and current converters.

Southeast National Marine Renewable Energy Center (SNMREC) - Ocean Current Test Facility

SNMREC is working to advance research on open-ocean current systems by building the capability, infrastructure, and strategic partnerships necessary to support technology developers on the path to commercialization. During 2013, SNMREC continued work on regulatory activities supporting infrastructure development. A significant milestone was realized with the long awaited completion of an environmental assessment of the proposed research lease area and issuance of a Finding of No Significant Impact[4]. Plans for the ocean current test facility include installation of non-grid-connected offshore test berths to evaluate commercial device components and sub-systems.

Hawaii National Marine Renewable Energy Center (HINMREC) – Wave and OTEC Test Facility

HINMREC's mission is to facilitate the development and commercialization of WEC devices and to assist the private sector in moving ocean thermal energy conversion (OTEC) systems beyond proof-of-concept to pre-commercialization. OTEC activities are currently focusing on system and component engineering, sustainable resource modeling and environmental impact studies. HINMREC is also collaborating on the Navy's WETS facility to assess the power performance of WEC devices tested at the site and determine their acoustic and electromagnetic field signatures.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

The Annex IV effort has been very successful in accomplishing the goals set out at its initiation; namely to facilitate efficient government oversight of the development of ocean energy systems by compiling and disseminating information on the potential environmental effects of these technologies and on methods used to monitor for effects. However, with the industry still at a stage of testing and deploying early commercial devices, the need to have an on-going international dialogue on ocean energy environmental research has been identified as a priority. To ensure that the Ocean Energy Systems (OES) initiative remains a leading provider of accurate information for the ocean energy community, the OES unanimously approved a three year extension of the Annex IV collaborative effort through May, 2016. The extended Annex will focus on information gathering, dissemination and discussion; future plans for the effort include: updating and improving the functionality and utilization of a knowledge management database; forming strategic partnerships with organizations engaged in the collection and analysis of environmental monitoring

4 http://www.boem.gov/Florida-Revised-EA-FONSI-August2013/

information from ocean energy systems; hosting informative webinars; hosting a scientific conference and completing a state-of-the-science report that evaluates all data to-date focusing on environmental impacts of marine renewable energy development.

In an effort to further understand potential environmental effects from the deployment and operation of MHK energy devices, DOE, in collaboration with the Bureau of Ocean Energy Management and the National Oceanographic Partnership Program, awarded $2.4 million dollars for nine new research projects to collect data and information. These projects will address key environmental data gaps associated with potential effects of wave and tidal energy devices. The awarded projects will address many high priority market barrier issues, which include characterizing device generated noise and its subsequent effects on marine megafauna; understanding static and dynamic interactions that fish have with tidal turbines, as well as using and developing models to predict strike occurrence; and assessing the potential effects that electromagnetic fields associated with power from MHK devices may have on marine species. Each of these projects will involve either direct monitoring for environmental effects around deployed MHK devices, or synthesize existing data and known stressor-receptor relationships from appropriate surrogate technologies to better ascertain potential impacts to be expected from deployed MHK devices.

In June, DOE partnered with Pacific Northwest National Laboratory (PNNL) and the NNMREC to host the *Instrumentation for Monitoring around Marine Renewable Energy Devices* workshop. More than 30 experts from around the world gathered to better understand the instrumentation needed to monitor environmental effects of marine renewable energy devices. Various monitoring modalities were discussed, including optical and acoustic cameras, as well as passive and active acoustic monitoring methodologies. A final workshop report will be released early in 2014.

RELEVANT DOCUMENTS RELEASED

Several publications related to MHK technology development were released in 2013. First, the DOE continued the Reference Model Project (RMP), a comprehensive review of existing technology archetypes, with integrated modules for design, manufacture, deployment, and operations and maintenance, as well as a baseline LCOE analysis for each archetype. The objective of the RMP is to create a well-documented methodology for the design and economic analysis of marine energy conversion (MEC) technologies to harness tidal, river, and ocean energy and advance the technology and knowledge base towards commercial viability. In addition, the effort provides four MEC reference resource sites modeled after actual tidal, river, ocean current, and wave energy sites that industry and the research and development community can use to develop their MEC technologies. The modeled sites can also be leveraged to develop LCOE estimates to compare to the LCOE baselines established during the project. Reference models were developed for the following MHK technologies:

- 1. Dual Rotor Axial Flow Tidal Turbine
- 2. Vertical Axis Dual-Rotor Cross Flow River Turbine
- 3. Wave Point Absorber
- 4. Ocean Current Turbine
- 5. Attenuator (under development)
- 6. Oscillating Water Column (under development)

Supporting documentation[5] including analysis and validation test data that will feed into a report on the first four reference models is now publically available. The report on the first four reference models is scheduled to be released in January of 2014.

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5 http://energy.sandia.gov/rmp

Additionally, in partnership with Sandia National Laboratories (SNL), the National Renewable Energy Laboratory (NREL), and PNNL, the DOE developed four MHK Cost Reduction Pathway White Papers to characterize critical cost drivers and identify opportunities to reduce these costs through specific improvements. These white papers pull from multiple sources of information including the RMP, one-on-one webinars with MHK technology developers, and a literature review. The webinars enabled an information exchange on specific areas for cost reductions. The literature survey included national and international research and development to understand the current issues, solutions, and research pathways. The Cost Reduction Pathway White Papers are now publically available and open to industry comments via a public forum[6]. The specific MHK technologies studied are:

- 1. Attenuators
- 2. Axial flow turbines
- 3. Oscillating water columns
- 4. Point absorbers

To normalize competing claims of LCOE, DOE has also developed, for its own use, a standardized cost and performance data reporting process to facilitate uniform calculation of LCOE[7] from MHK device developers. This standardization framework is only the first version in what is anticipated to be an iterative process that involves industry and the broader DOE stakeholder community.

The LCOE reporting process references a generalized Cost Breakdown Structure (CBS)[8] for MHK projects. This CBS is a hierarchical structure designed to facilitate the collection and organization of lifecycle costs of any type of MHK project, including WECs and current energy converters. At a high level, the categories in the CBS will be applicable to all projects; at a detailed level, however, the CBS includes many cost categories that will pertain to one project but not others. This version of the CBS is a working draft under development by DOE and NREL.

There were a number of advances in environmental research and information sharing in 2013. In January, the comprehensive final report of the International Energy Agency (IEA) OES Annex IV collaborative effort was released[9]. Content from the final report was presented at several conferences over the last year, including the Global Marine Renewable Energy Conference and the European Wave and Tidal Energy Conference. Other publications stemming from this work are currently under review with the J*ournal of Ocean and Coastal Management* and the *International Journal of Marine Energy*. Finally, building upon the DOE-funded research that the Electric Power Research Institute (EPRI) conducted over the last several years, a comprehensive research report[10] was released in June that summarizes several experiments evaluating fish injury and survival rates after passing through several hydrokinetic turbine designs. Results of these studies indicate that fish are largely able to avoid turbines, resulting in very low mortality. With the assistance of the Oak Ridge National Laboratory (ORNL) and Alden Laboratory, EPRI is continuing this work by assessing fish behavior, injury and mortality around a FreeFlow hydrokinetic turbine in light and dark conditions within a test flume.

In February, PNNL, publicly released a large portion of the knowledge management system *Tethys*[11], featuring many of the materials and metadata forms collected during the information gathering during the Annex IV effort. In addition to providing broad access to information on environmental effects of marine energy and offshore wind developments, *Tethys* can act as a commons for bringing together researchers, device and project developers, regulators, and stakeholders, to explore shared interests. The reports

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6 http://en.openei.org/community/node/775
7 http://en.openei.org/community/document/mhk-lcoe-reporting-guidance-draft
8 http://en.openei.org/community/document/mhk-cost-breakdown-structure-draft
9 http://mhk.pnnl.gov/wiki/images/4/42/Final_Annex_IV_Report_2013.pdf
10 http://mhk.pnnl.gov/wiki/images/f/f6/Jacobson_et_al_2012.pdf
11 http://mhk.pnnl.gov/wiki

mentioned here, as well as other DOE environmental studies reports will help to inform regulators as means to help streamline siting and permitting processes associated with ocean energy development; these documents can be accessed through *Tethys*.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

The U.S. DOE is a key research and development (R&D) institution that is committed to developing and deploying a portfolio of innovative technologies for clean generation. The Program is therefore leading efforts to prove functionality; evaluate technical and economic viability; and generate cost, performance, and reliability data for a variety of devices.

During 2013 the DOE awarded approximately $13.5 million to eight projects to help U.S. companies build durable, efficient wave and tidal devices that reduce overall costs and maximize the amount of energy captured. The projects will develop new drivetrain, generator and structural components as well as develop software that predicts ocean conditions and adjusts device settings accordingly to optimize power production. These projects will focus on improving the cost competitiveness of systems already in development, with the goal of advancing the technology performance of these systems. More importantly, these projects work to develop component technologies that are applicable to a number of MHK systems. This will assist in establishing the beginning of an MHK supply chain.

The U.S. DOE also partners with several national laboratories (NREL, ORNL, PNNL and SNL) to support R&D in MHK technologies.

National Renewable Energy Laboratory

NREL's water power technologies research supports WWP's efforts to research, test, evaluate, develop and demonstrate deployment of innovative water power technologies. NREL supports development of market-relevant scientific and technical knowledge, research and testing, and addressing environmental impacts. Specifically, NREL supports the WPP through:

- Wave and tidal computation modeling and analysis
- Industry project development, needs assessments and data management
- Testing instrumentation, standards, and certification
- Tidal and current resource characterization
- Training, education and outreach

NREL also works with DOE, other national laboratories and industry to develop strategic long-term visions and roadmaps for water power in the United States.

Oak Ridge National Laboratory

ORNL is involved in a number of research and development activities supporting DOE's WPP mission. These activities and products help developers advance MHK technologies to commercialization and help all stakeholders understand and resolve environmental issues. ORNL is researching environmental effects of MHK technologies. ORNL scientists are conducting laboratory, mesocosm, and field experiments of the potential impacts of MHK installation and operation, including:

- Effects of electromagnetic fields on fish behavior
- Effects of noise on fish behavior
- Toxicity of MHK device coatings and lubricants
- Alteration of habitats for aquatic organisms

Pacific Northwest National Laboratory

PNNL supports the WPP through research, engineering, information aggregation and disseminations, resource characterization and forecasting, market analysis, planning, and coordination to overcome technology, market, environmental, and social barriers for wind and water power. PNNL's specific efforts include:

- Tidal and current modeling development and validation
- MHK technology advancement through advanced materials and manufacturing reliability
- Wave resource characterization
- Monitoring tools and mitigation technologies and methodologies
- Education outreach and information sharing

Sandia National Laboratories

SNL, through a partnership with several national laboratories and academic institutions, is leading efforts in technology development, market acceleration, and the reference model developments. Specifically, SNL contributes to MHK technology in the following areas:

- Advanced non-linear controls, code development, array optimization, and extreme events simulation
- Design and testing of tidal turbines as well as requirements for development for deep tank testing
- Wave environment characterization and measurements in tidal flows

One key R&D effort on which the national laboratories collaborate is the development of an open source WEC simulation code called WEC-Sim. As demonstrated through wind industry experience, WEC developers, who are typically start-ups with devices in the prototype phase, can accelerate development, analysis, and certification of system designs using a verified and validated suite of numerical modeling tools. Accordingly, to assist the nascent ocean energy industry, NREL and SNL are developing an open-source WEC simulation tool that will be capable of modeling the dynamic response and power performance of WEC devices in operational wave climates. Development of the open-source WEC-Sim modeling tool will reduce the cost burden that commercial modeling tools place on WEC researchers, and will encourage the development of new and innovative design concepts. WEC-Sim will be verified and validated through code to code and experimental wave tank data comparisons. A beta version of WEC-Sim will be released online in FY14.

A newly launched online coding competition will produce one of the code modules for WEC-Sim: Open Wave Analysis and Response Program (OpenWARP): Predicting Hydrodynamic Forces for Renewable Ocean Energy[12].

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

Columbia Power Technologies (CPT)

CPT is developing a point absorber wave power system. The StingRAY wave power system is meant to be deployed in water depths over 60 meter and arrayed in "farms" much like wind turbines. The wave farms are usually located at least one to two miles from shore; away from the coastline and the sensitive habitats contained there.

The StingRAY captures energy from each passing wave and produces electricity on-board the device.

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12 http://www.topcoder.com/doe

The electricity generation process includes a series of steps starting with the transfer of captured energy from the forward and aft floats to two rotary, low-speed, high-torque electric generators on board the StingRAY. The generated power is then conditioned to stable, electric-grid-compatible output. In a wave farm, this electricity is centrally collected in an offshore "sub-station" for transmission ashore and connection to the grid.

Dehlsen Associates

Dehlsen is developing two ocean energy devices. One, the Aquantis, is an ocean current technology designed to harness energy from the continuous and powerful Gulf Stream current to provide, base-load electric power generation from a heretofore, untapped, major regional source of renewable energy. Aquantis deployment is initially aimed at the southeastern US coastline where the Gulf Stream is in close proximity to major load centers.

The second ocean energy device being developed by Dehlsen is the Centipod. The Centipod is a multiple pod, wave energy converter. This technology has undergone open water testing and is looking to conduct further open water testing.

Northwest Energy Innovations

NWEI is a Portland, Oregon, based firm specializing in ocean renewable energy development. Their Wave Energy Technology – New Zealand (WET-NZ) device uses its wetted surfaces to transfer wave forces to the structure, operating in heave motion similarly to other point absorber technologies, as well as capturing surge and pitch energy through the horizontal motion of the reactive hull and the active float.

NWEI received a DOE award during 2013 to deploy their device at the Navy's WETS facility in Hawaii. The objective of the project is to redeploy the WET-NZ Oregon Device to conduct open-ocean, grid connected testing for a period of up to twelve months to optimize energy capture and validate the LCOE model. Deployment is currently scheduled for March of 2014.

Ocean Power Technologies (OPT)

OPT is developing a WEC that uses the rising and falling of waves to produce power. The device moves up and down with the waves and the resultant mechanical stroking is converted via a power take-off (PTO) to drive an electrical generator. OPT's PowerBuoy system transmits the generated wave power to shore via an underwater power cable.

Sensors on the PowerBuoy continuously monitor the performance of the various subsystems and surrounding ocean environment. Data is transmitted to shore in real time. In the event of very large oncoming waves, the system automatically locks up and ceases power production. When the wave heights return to normal, the system unlocks and recommences energy conversion and transmission of the electrical power ashore.

Ocean Renewable Power Company (ORPC)

In 2012, ORPC delivered the first power to the grid from their federally-licensed Cobscook Bay Tidal Energy Project. ORPC deployed a cross-flow horizontal axis turbine, the TidGen. The passing tidal currents rotate the foils of the device which drive a permanent magnet generator. The electricity produced by the generator is transmitted to shore through an underwater transmission line. The TidGen is designed for use at shallow to medium-depth tidal sites.

ORPC is also developing a RivGen Power System and the OCGen Power System. The RivGen is designed for use at river and estuary sites, especially those on isolated grids that depend on diesel for electrical generation. The OCGen Power System consists of moored, stacked generating units, designed for use in deep tidal and offshore ocean current sites.

Oscilla Power

Oscilla is developing a wave energy harvester that consists of a large, simple buoy tethered to the ocean floor by mooring lines that are made up no-moving-parts. The device uses a reverse magnetostriction power take-off. Oscilla has conducted open water tests of their device and plan to conduct more testing in FY14.

Public Utility District N°. 1 of Snohomish County (SnoPUD)

SnoPUD is working with OpenHydro, an Irish technology company, to design, build and install two, grid connected, marine turbines at a tidal energy pilot plant in Admiralty Inlet, west of Whidbey Island. The OpenHydro turbines are designed to be deployed directly on the seabed. Installations will be silent and invisible from the surface. They will be located at a depth that will present no navigational hazard.

Resolute Marine Energy (RME)

RME is developing a surge WEC. RME is currently looking to complete development and commercialization of a wave-driven seawater desalination system that operates completely "off-grid" and fills a huge gap in the market for seawater desalination systems. In addition, RME is also in the early stages of identifying opportunities to cost-effectively supply electricity to near-shore communities that currently rely upon diesel generators.

Verdant Power

Verdant Power is developing an axial flow tidal turbine designed to produce power from river currents. On January 23, 2012, the Federal Energy Regulatory Commission (FERC) issued a pilot commercial license for the RITE Project – the first-ever commercial license for tidal power in the United States. Under the license, Verdant Power plans to develop a 1 MW pilot project in the East Channel of the East River comprised of up to 30 commercial class turbines, which would be installed in a staged approach. The pilot license issued to Verdant Power is for ten years.

Vortex Hydro

Vortex Hydro Energy has exclusive license to commercialize a University of Michigan patented, hydrokinetic power generating device, the Vortex Induced Vibration Aquatic Clean Energy (VIVACE) converter, which harnesses hydrokinetic energy of river and ocean currents. This converter is unlike water turbines as it does not use propellers. VIVACE uses the physical phenomenon of vortex induced vibration in which water current flows around cylinders inducing transverse motion. The energy contained in the movement of the cylinder is then converted to electricity.

BELGIUM

Dennis Renson & Julien De Rouck
GHENT UNIVERSITY

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

Belgium has to increase its share of renewable energy production to 13% of the total consumption by 2020. This share has been growing steadily in the last year; 0.4 % in 2000, 6.1 in 2010 and 8% by the end of 2011. Main incentives aim at wind energy (onshore and offshore), biomass, biogas and solar energy. The offshore wind energy concessions in the Belgian North Sea will have the biggest impact on renewables, leading up to a total of ± 2200 MW of offshore wind power by 2018.

MAIN SUPPORT INITIATIVES

A green energy certificate market is implemented to support renewable energy production with Tradable Green Certificates (TGC). For each renewable technology, a stakeholder analysis is put forward to determine the level of support. A generic business case is constructed with input of the developer, the technology supplier, investors, banks…This exercise will determine the cost of the renewable electricity and the matching value of the TGC in €/MWh. The business case is frequently updated in order to align the new TGC support with the technology evolution.

NATIONAL SEA TEST FACILITIES

A test facility was implemented at approximately 1 km from the Harbour of Ostend. The test facility has easy access for deployment and maintenance from the Harbour of Ostend. Wave riders register the available wave climate, an antenna and camera onshore ensure the data connection and visualisations. Navigation buoys protect the test zone from unwanted marine traffic. There is no grid connection installed (yet).

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

The Belgian maritime spatial plan foresees an area for the 'exploitation for offshore wind, wave and tidal energy'. This area has been divided into 7 zones for which the Government has given concessions for alternative energy project development. The last concession (±55 km from the coast) was granted in July 2012 to the temporary trading company Mermaid. This Mermaid concession zone aims at the installation of 450MW wind and 20 MW wave energy (rated power). This hybrid park has a water depth of 35-40m and an average wave climate of 6.5 kW/m.

RELEVANT DOCUMENTS RELEASED

The BOREAS final report that describes the assessment of the wave and tidal energy potential in the Belgian North Sea is available online (www.belspo.be).

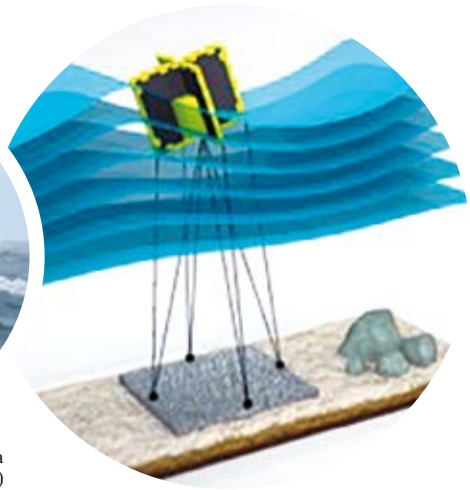
RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

The FlanSea project aims at designing and developing a wave energy converter for low to moderate wave energy in the Belgian part of the North Sea (and other moderate wave zones). The project partners are DEME blue energy, Cloostermans, Harbour of Ostend, Electrawinds, Spiromatic, Contec and 4 research groups from the University of Ghent. The project has been partly funded by IWT (Flemish Agency for Innovation by Science and Technology).
The FlanSea device of 4.4m diameter, 5m height and 25 tonnes weight was commissioned outside the Harbour of Ostend in July 2013. Results should be available by mid-2014. The plans and intentions for FlanSea II are currently under construction.

Laminaria has developed a multidirectional surge device. The tank tests have recently ended. The developer is now filing for proper IWT funding to start sea trials.

FlanSea device at sea
(Flanders Electricity from the sea, www.flansea.eu)



Laminaria shallow water multidirectional surge device

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

The Gen4Wave platform was founded in 2012 and is a blue energy stakeholders' organisation. This platform is used for optimizing the use of maritime expertise and (wave and tidal) test facilities between the industry, universities and government.
Mermaid has received the concession for their plans to build a combined wind and wave energy park in the 7th and most northern part of the Domain Concession Zone. THC Mermaid is a partnership that consists of 65% of Otary RS and 35% of Electrabel (GDF SUEZ). Otary is a collaboration of Aspiravi, Electrawinds, Nuhma, Power@Sea, Rent-A-Port, Socofe and SRIW Environment.
The idea is to use synergies of offshore wind and wave energy as a way of overcoming certain obstacles for implementing a wave and wind energy park. The presence of the wave energy devices between the wind turbines can imply crucial cost reductions for the offshore wind farm. A first high level study of possible wave energy devices that are appropriate for the Mermaid site is completed.
In the tidal sector, the Belgian company DBE (Deme Blue Energy) has an agreement (together with DP marine Energy) for lease from the Crown Estate for 2 big tidal turbine projects with only 60 km distance in between: 30 MW in Islay (8 km off the tip of the Rhinns) and 100 MW in Fair Head (www.deme.be).

GERMANY

Jochen Bard
FRAUNHOFER IWES

OCEAN ENERGY POLICY

The revised 2012 version of the Renewable Energy Sources Act, adopted in 2011 and in force since 1 January 2012, is designed to facilitate a sustainable development of energy supply in Germany, to reduce the costs of energy supply to the national economy, to conserve fossil fuels and to promote the further development of technologies for the generation of electricity from renewable energy sources.

The purpose of this Act is to facilitate a sustainable development of energy supply, particularly for the sake of protecting the climate and the environment, to reduce the costs of energy supply to the national economy, also by incorporating external long-term effects, to conserve fossil fuels and to promote the further development of technologies for the generation of electricity from renewable energy sources.

To achieve this purpose the Act aims to increase the share of renewable energy sources in electricity supply to at least 35 % by 2020 and 50 % by no later than 2030; 65 % by 2040 and 80 % by no later than 2050 and to integrate these quantities of electricity in the electricity supply system.

The following definition has been adopted: "renewable energy sources" shall mean hydropower, including wave power, tidal power, salt gradient and flow energy, wind energy, solar radiation, geothermal energy, energy from biomass, including biogas, biomethane, landfill gas and sewage treatment gas, as well as the biodegradable fraction of municipal waste and industrial waste (Source: Act on granting priority to renewable energy sources, 1 April 2012).

The tariff paid for electricity generated from hydropower which includes the above mentioned ocean energy sources amounts to 12.7 cents per kilowatt hour for the first 500 kilowatts of the rated average annual capacity; 8.3 cents per kilowatt hour for the rated average annual capacity between 500 kilowatts and 2 megawatts etc. and finally goes down to 3.4 cent for a capacity over 50 MW. The current feed in tariff system includes a decrease of the tariff for hydropower by 1% per year, starting in 2013.

In 2013 the Ministry for the Environment was still in charge of funding research on renewable energies including wave and tidal technologies. Details of the currently funded projects can be found in the 2012 country report. In addition, the Ministry of Economics and Technology runs the research programme "Next generation maritime technologies" which is valid for a period from 2011-2015 and covers shipbuilding, navigation and maritime technologies. Marine energy technologies are explicitly mentioned under the strategic objectives for maritime technologies due to the significant future opportunities these offer. Consequently R&D projects with regard to ocean energy technologies are in principle eligible under this programme.

RESEARCH & DEVELOPMENT

PUBLIC AND PRIVATE R&D

In the public sector, around 15 R&D institutes and universities are involved into developing wave, tidal current and osmotic power mainly in the framework of European research projects. The National funding in the framework of the national energy research programme for renewable energies was approximately € 160 million in 2011. This programme is open to ocean energy research. Up to now, six technology projects related to the development of components and concepts for tidal turbines and wave energy components have been funded by the federal Environment Ministry (BMU) with a total amount of around € 7 million. For details please see the 2012 country report for Germany.

Marine Current Turbines Ltd (MCT) now wholly owned by Siemens, forming part of the Hydro & Ocean Business has pioneered the development of tidal stream generation technology for over 20 years. Since the installation of the 1.2 MW SeaGen S device in Strangford Lough in 2008, the system has been subject to 3 years of testing and analysis. There are great expectation about the realisation of the first two farm projects namely, the 8-MW-project Kyle Rhea in Scotland and the 10-MW farm at the Anglesey Skerries in Wales. These sites have been leased by The Crown Estate. MCT has an agreement in place to supply SeaGen devices for the Minas Basin Pulp & Power site at FORCE in the Bay of Fundy. In November 2013 UNITe a French SME specialised in renewable energy production established in 1985 and Siemens have signed a memorandum of understanding to provide a joint response to the French Government call for expressions of interest to install pilot tidal energy plants off the French coast at Cotentin and Finistère zones. (Source: MCT)

Voith Hydro Ocean Current Technologies - a former joined venture between Voith Hydro and Innogy Venture Capital - has installed a 1MW commercial size demonstrator due to be tested at EMEC. Preparatory works commenced in summer 2011 with a 23m monopile installed in the seabed at EMEC's tidal test site at the Fall of Warness off the northern island of Eday. The 1MW horizontal axis turbine – HyTide – which is 13m in diameter and weighs 200 tons was successfully installed in 2013 (Source: EMEC). In 2012 GDF SUEZ had announced that they had selected Voith's HyTide technology for a tidal power project at Raz Blanchard in Lower Normandy with a plan to install up to 100 turbines at this site. In 2013 an industrial partnership agreement involving further partners had been signed to develop the pilot site at Raz Blanchard in 2016 which is expected to have a capacity between 3 and 12 MW (Source: GDF Suez).

Schottel GmbH has delivered two of their STG 50 turbines to Sustainable Marine Energy for a 100 kW community scale demonstrator based on their PLAT-O platform to be tested off the Ilse of Wight. Canadian Black Rock Tidal Power Inc. has announced plans to use the STG50 for a 2.5 MW installation using the Tidal Stream Triton support structure.

A start-up company is currently developing a novel wave energy device. The NEMOS system consists of an elongated floating body which is braced by three cables to the ocean floor. Excited by the movement of waves, it transmits mechanical energy to the generator by means of a cable. The generator itself is positioned at the tower of a wind turbine above sea water level. New to this development are the trajectory of the floating body and the control strategy. The overall system efficiency is expected to outperform conventional wave energy concepts with vertical movement only. With a change in the wave direction the orientation of the body also changes by a self-employed system. (Source: www.nemos.org).

Other German suppliers such as Bosch Rexroth, Schaeffler, Contitech, Thyssen Krupp, Hunger Hydraulik and Hydac deliver components and parts for a number of ocean energy devices – for wave as well as tidal turbine technologies mainly in Europe. Certification companies such as the DNV Gl-Group and consultants are contributing to the technology and project development in the sector. This international collaboration demonstrates the technology export opportunities which exist in ocean energy for the German industry.

TECHNOLOGY DEMONSTRATION

In addition to the projects mentioned above major German utilities are active in the OE sector with test installations and prototypes around Europe. There is no ocean energy installation realised in Germany yet and no plans for installations have been published in 2013.

NORWAY

Harald Rikheim
RESEARCH COUNCIL OF NORWAY

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

Norway has no special policy for ocean energy, but ocean energy is included in more general renewable energy policies and programmes.

MAIN SUPPORT INITIATIVES

In 2011 Norway and Sweden signed an agreement for a joint green certificate market. One certificate per MWh will, from 2012, be given to all new renewable energy generation in 15 years, independent of technology.

The price per certificate is driven by the market with a common target of 26.4 TWh by the end of 2020. The total compensation (el-spot + certificate) for the renewable producers are in the long term believed to be approximately €70-80/MWh.

A total income of €70-80/MWh is almost certainly not enough for wave and tidal projects in the next decade. Instead, the governmental support programmes for research and development are intended to drive the development.

The Norwegian Energy Agency, Enova, offers capital grants for full-scale demonstration projects of ocean renewable production. While up to 50% of eligible costs can be covered, Enova's funding measured in absolute figures is limited. In addition, Enova has a programme that supports demonstration of new energy technology.

In 2010, Innovation Norway launched a programme supporting prototypes within "Environmental friendly technology". Ocean energy is included in this definition. Projects are supported with up to 45% of eligible costs.

The Research Council of Norway has an energy research programme called ENERGIX. This programme supports R&D within all renewable energy technologies.

For 2013, these three institutions had a combined budget of approximately €110 million.

NATIONAL SEA TEST FACILITIES

The research cluster in Trondheim, comprising NTNU and SINTEF/MARINTEK, is active in ocean energy research. Some of the activities are technology screening and verification, control systems, mooring, marine structures, safety, optimal design of devices, and load modelling. MARINTEK's model tank is also used to test ocean energy devices. SINTEF/NTNU is a member of the EU MARINET research network.

Runde Environmental Centre (REC) is located on the island Runde, off the Norwegian west coast. REC is a research station with activities within marine biology, oceanography and ocean energy.

REC has developed leading in-house competence on environmental monitoring, and offers ROV survey, field sampling and laboratory facilities to investigate environmental impacts of the tested devices.

Stadt Towing Tank (STT) was founded in 2007 to deliver test and research services to the marine industry. The main market for STT has been ship designers in the maritime cluster of north-western Norway, but projects related to renewable energy have also been tested. Among the renewable energy projects has been working with wave energy converters, windmill installation concepts, windmill foundation solutions and windmill service vessels.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

The Ocean Energy Bill, which regulates offshore renewable energy production entered into force on 1 July 2010. According to this new legislation licences to build offshore wind, wave and tidal farms in certain far-shore geographical areas cannot be given without a prior governmental process where suitable areas are identified. This legal framework is very much inspired by similar legislation in the Norwegian petroleum sector.

As a follow up on the Ocean Energy Bill, a group of relevant governmental bodies has identified 15 areas that could be suitable for large-scale offshore wind power. More detailed "strategic consequence assessments" was finalized in late 2012.

Meanwhile, the Norwegian Water Resources and Energy Directorate (NVE), the licensing body has continued to prioritize small scale demonstration projects located near shore according to the existing Energy Bill. The licensing process is efficient and pragmatic since the demonstration projects are small in physical installations and operation time.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

The research cluster in Trondheim, comprising NTNU and SINTEF/MARINTEK, is active in ocean energy research. Some of the activities are technology screening and verification, control systems, mooring, marine structures, safety, optimal design of devices, and load modelling. MARINTEK's model tank is also used to test ocean energy devices. SINTEF/NTNU is a member of the EU MARINET research network.

TECHNOLOGY DEMONSTRATION

OPERATIONAL OCEAN ENERGY PROJECTS

Andritz Hydro Hammerfest

The company was founded in Norway in 1997 by the local utility company Hammerfest Energy and is currently owned by Andritz Hydro, Iberdrola and Hammerfest Energi. Andritz Hydro Hammerfest is among the leading tidal energy technology developers in the world and is now taking the step into commercial delivery. The Company has unrivalled commercial operation experience and has received Carbon Trust funding for the tidal turbine development. In December 2012, Andritz Hydro Hammerfest was awarded €207 million from NER300 for the proposed Sound of Islay project.

Fred.Olsen

The company Fred. Olsen has continued to test their wave energy buoy "BOLT" in Norwegian waters. The point absorber unit, which has a 45 kW installed capacity, is located on the southeast coast of Norway, close to the town of Risør. The system is not grid connected, but has produced many MWhs of electricity to an onboard load bank. Sea trials have continued in 2013.
In a direct continuation of the work with "BOLT", Fred. Olsen has been awarded grant support from the UK Technology Strategy Board. This, in turn, led to the design, manufacturing and deployment of a full scale

device at the "FABTest" test site off Falmouth in southwest England. The unit, which has three power take -off units with a total of 240 kW installed capacity, was christened "Lifesaver" and deployed in March 2012. Sea trials with electricity production will continue for a full year before the unit is deployed elsewhere.

Statkraft's Osmotic Power Prototype

The principle of osmotic power is utilizing the entropy of mixing water with different salt gradients. An osmotic power plant extracts power from salinity gradients by guiding water with low salt gradient and water with higher salt concentration into separate chambers, divided by a membrane. The salt molecules pull the water with low salt gradient through the membrane due to osmotic forces, creating a pressure on the side with higher salt concentration that can drive a turbine.
Statkraft opened the world's first osmotic power plant in 2009 in Norway. The operation of the plant proves that power from salinity gradients can supply a stable base load of renewable energy, with a minimal ecological footprint. The next big milestone is the decision to build a 2 MW pilot plant. Investment decision is planned for 2014. Furthermore, the goal is to build a full scale demonstration plant within 2020.

PLANNED DEPLOYMENTS

STRAUM

STRAUM is a Norwegian technology developer and supplier of wave, tidal and offshore wind power systems. STRAUM's business idea is to develop, design and deliver a unique range of marine renewable power plants together with strategic partners. The STRAUM technologies are all "in-front" and backed by strong IP portfolios, and include the following power plant systems: Hydra Tidal™- tidal & ocean current power plants, OWC Power™- wave power plant and WindSea Floater™/WindSea Jacket™ - floating and fixed offshore wind power plants.
The Hydra Tidal™ floating ocean energy system is one of a very few full scale tidal energy plants built and deployed in the world. STRAUM is planning to re-deploy the Morild II tidal prototype that at the moment is at a shipyard for repair and maintenance. The business idea of OWC Power is to develop and commercialize a wave power concept based on the Oscillating Water Column (OWC) principle. For this technology STRAUM is currently performing a small scale testing programme both for the wave chamber and the air turbine.
For further information on STRAUM, please visit www.straumgroup.com

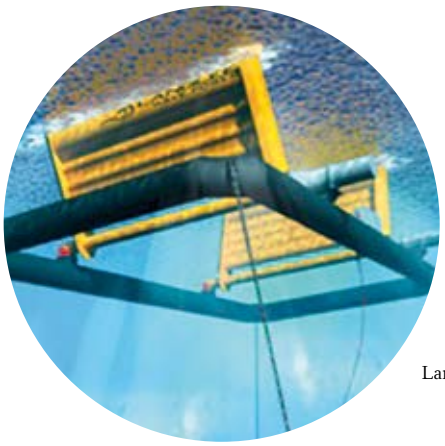
Havkraft AS

Havkraft is a Norwegian technology company specialized in onshore, nearshore and offshore installations for the utilization of wave energy for wave damping and power production, with both low-tech and high-tech solutions for all markets. The company's shareholders are founder and inventor Geir Arne Solheim and Fjord Invest. Havkraft cooperates amongst others with Dr. Ing. Karl Christian Strømsem. Tests conducted in 2012 show that the H-WEC (Havkraft Wave Energy Converter) is a perfect wave energy converter, with the potential to capture the complete energy field and to utilize all the natural frequencies in the waves. This high efficiency combined with a simple construction - with no movable parts in contact with the sea - in an improved and patented OWC device with low OPEX and CAPEX. A large scale test programme was started in 2012 with support from Innovation Norway and co-investors.

Langlee Wave Power

The wave energy converter, named Langlee Robusto, is a semi-submerged, floating steel structure anchored to the seabed with four chains. The wave energy is captured by large water wings that swing back and forth with the waves, converting the energy into electricity by generators with minimum loss. The electricity is connected to the onshore grid by a subsea cable.
The Langlee Robusto is competitive to traditional wind power in terms of cost, operating hours and area utilization. Additionally, the Langlee Robusto is not visible from shore, it does not take up land space and it has no environmental impact. The steel structure is designed for fabrication by local shipyards, thereby reducing cost and generating local jobs.

The strategy of Langlee is to use standard offshore technology to ensure maximum safety and minimum cost. No special materials or custom made components. The structure is made from standard steel pipes painted with Jotun's anti-corrosion/anti-fouling system. The generator system is using technology developed for heave compensated cranes and electric cables and connectors have been used in offshore ROVs for decades. Langlee is planning to install a full scale prototype in 2014.



Langlee Artistic Impression

Flumill

The company Flumill has obtained a licence from NVE for deploying up to 5 MW tidal energy production in Rystraumen in Troms in the northern part of Norway. A grid connection arrangement has entered into force with Troms Kraft.

Flumill is planning to build and install a full scale grid connected demonstration system in Rystraumen in 2014. Enova has granted support of NOK 57,3 million to the project. The demonstration system will have a rated capacity of about 2 MW.

Deep River

Deep River has developed a tidal, current and river plant. The company plans to install a demonstration system in a Norwegian tidal stream in 2013. The company is currently seeking investors.

Tidal Sails

Tidal Sails is developing and constructing energy plants generating electricity from ocean currents and tidal streams. Aluminium sail profiles attached to wires sail with the current at an angle, capturing energy and converting it into clean electricity. Linearly moving sails have great extraction efficiency, thus dramatically reducing the cost of the electricity generation. Tidal Sail's technology may be used in different settings and is protected by several patents worldwide.

Tidal Sails has a small scale demonstrator operating in a stream outside Haugesund, Norway. This has a nominal capacity of 28KW, and provides an excellent basis for scaling up systems to the range of several MW. The hydrodynamic forces work exactly the same in any scale.

In 2012, the company delivered an application for a demonstration project of 3MW in Kvalsundet near Hammerfest, in Norway. Yearly production is estimated to be 8 GWh.

Ocean Energy

Ocean Energy AS has designed a worldwide patented wave energy plant. The technology is based on the Swedish wave company Seabased AB, but Ocean Energy has developed and patented a "Storm Buoy". The storm buoy can be submerged and withstand extreme waves. The solution is developed in cooperation with the leading environments at universities in Norway (NTNU) as well as the "Maritime Cluster" at Ulsteinvik, Sunnmøre in western Norway (www.ocean-energy.no).

The project is supported by Innovation Norway and Ocean Energy plans a demonstration at Runde in 2013.

MEXICO

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ENERGÍAS ALTERNAS ESTUDIOS Y PROYECTOS SA DE CV

OCEAN ENERGY POLICY

In the last decades, Mexico has continued with structural changes in the energy sector. These changes have led to the creation of new legal frameworks and research and innovation centers to promote development of renewable and clean energy technologies in the country. These actions show the commitment and aggressive position of the Mexican Government towards renewable energy technologies.

In 2013, the Secretary of Energy (SENER) announced the competition for funding the creation of three innovation centers for geothermal, wind and solar energy technologies. The funds for these centers will come from the "Fondo sectorial de sustentabilidad energética SENER-CONACYT" and the "Fondo para la Tecnología Limpia". These funds are backed up by 0.13% of the value of crude oil and natural gas extracted by the state-owned company PEMEX, and international institutions such as the World Bank (WB) and the Inter-American Development Bank (BID). There has not been any announcement yet regarding a centre for innovation for marine energy technologies. However there have been talks inside SENER about this topic.

Mexico does not have a specific policy or regulation towards ocean energy systems. However, there are some regulations and policies for renewable energy technologies that do take into account ocean energy technologies. The Law of Public Electricity Service (LPSEE), published in 1992, allows the participation of the private sector in the generation of electricity. The Law on the Use of Renewable Energy and Energy Transition Financing (LAERFTE), published in 2008 with the intent to establish a specific and more favorable framework for renewable energy technologies, defines ocean energy as one of the technologies that could be granted permission of deployment from the Energy Regulation Commission (CRE).

NATIONAL STRATEGY AND TARGETS

There is not a specific strategy or roadmap for the development of ocean energy technologies in the country. Nonetheless, national energy targets could have a positive effect in their development.
The National Energy Strategy 2013-2027 establishes the target of increasing the share of non-fossil fuel technologies in the electricity generation portfolio to 35% by 2024. This plan illustrates the need for diversifying the electricity portfolio. According to the National Energy Strategy 2013-2027 under current legislation and technology comparison, based only on the cost per unit of energy, the electricity energy mix by 2027 would be formed by 72% gas, 12 % other fossil fuels and 16% non-fossil fuel technologies. This is very far from the target established one year earlier.

The National Energy Strategy 2013-2027 asserts that in order to reach the 35% of non-fossil fuel in the electricity generation target, the technology comparison should be made by taking into account the cost per unit of energy as well as the cost of the environmental externalities of each technology. This would elevate the total cost of fossil fuel technologies, thereby supporting the development of renewable energy technologies. In addition, the 2013-2027 strategy expresses the need for increasing distributed generation, to limit the stress on the transmission system. This also benefits renewable energy technologies due to the fact that resources tend to be distributed along the territory rather than concentrated on a single spot. The creation of a centre for innovation for ocean energy technologies would greatly encourage academia, research institutes and the private sector to flourish the sector.

MAIN SUPPORT INITIATIVES

There are different funds established to promote the diversification of primary energy sources in the country such as:

- "Fondo sectorial de sustentabilidad energética SENER-CONACYT" – This fund encompasses 0.13% of the crude oil and natural gas extracted by PEMEX to the development of renewable and clean technologies as well as promoting technologies for energy efficiency.
- "Fondo para la Tecnología Limpia" - This fund is backed up by the WB and the BID. The aim of the fund is to promote clean energy technologies.
- "Fondo para la transición energética y el aprovechamiento sustentable de la energía" – This fund aims to promote the diversification of the energy portfolio, the development of renewable energy technologies, energy efficiency.
- International financing programme for renewable energy projects – This programme is supported by the Global Environmental Facility (GEF) through the International Bank for Reconstruction and Development (IBRD). The objective of the programme is to reduce the environmental impact and promote the usage of natural resources by small and medium enterprises (SMEs).

In addition, there are some fiscal incentives aimed to promote investment such as:

- Accelerated depreciation – This incentive allows for the 100% of depreciation for assets involved in the generation of energy from renewable sources during the first year.
- Tariff 0 – This incentive exempts from import or export taxes the trade of assets involved in the research or development of clean energy technologies.

There are other programmes that support renewable energy sources such as:

- The Rural Electrification Project from Renewable Energy Sources – The aim of this project is to promote electrification projects at socially excluded regions and without connection to the grid.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

The main research and development institutions in the country are the electrical energy public-owned company CFE, the National Autonomous University (UNAM), and the National Polytechnic Institute (IPN). The following table summarizes some of the ongoing and future projects from these institutions.

PROJECT NAME	INSTITUTION	DESCRIPTION
Hydrogenerator QK	UNAM	Design and development of a floating device to extract energy from moving water
SIBEO	UNAM	Design and development of a device that pumps water from the open sea to an enclosed reservoir through the resonance of the waves
Oceanographic review off the coast of Mexico	UNAM	Assessment of the potential of thermal gradient projects for the air conditioning of hotels at Mexican coasts.
Observations and predictions of ocean variables off the Gulf of Mexico	IPN - CICATA	Monitoring and assessment of changes in the sea level at the Southeast coasts of the Gulf of Mexico. The project could predict the energy potential at those sites.
Mapping the wind, wave and tidal resource off the coasts of Mexico	CFE	The aims of the project are three: i) to develop a database containing the time series measurement of wind, waves and currents at three specific locations, ii) to develop an online tool to predict ocean variables such as wind, waves, currents, sea level, and temperature and iii) to create a platform by which the actual and predicted variables of the sea could be consulted.
Development of devices to harness waves and currents	CFE	Carry out oceanographic studies, including mathematical models, geophysics and soil mechanics to evaluate the energy potential of wave and ocean currents.
Getting Through Osmosis Ocean Energy	UNAM	Evaluation of different types of membranes and devices for harvesting energy from salinity gradient and osmosis.

TECHNOLOGY DEMONSTRATION

The ocean energy technology in Mexico is at the beginning. Therefore, there are no current demonstrations or planned deployments. In 2012, CFE started the bidding competition for a 3MW wave energy power plant that would be located at Rosarito, Baja California. The plant that would have been the first of its kind in Latin America had demonstration purposes. Unfortunately, the contract has been rescinded early this year.

SPAIN

José Luis Villate [1]
TECNALIA

INTRODUCTION

The Spanish Renewable Energy Plan 2011-2020, approved in November 2011, included targets for ocean energy (100 MW of installed power by 2020). However, these targets seem now difficult to achieve since the Spanish Government is reviewing all the policies to support renewables.
Despite the temporary situation regarding renewables support, the Spanish ocean energy industry is progressing with the participation of big companies such as Abengoa, Iberdrola or Repsol and the involvement of two regional governments: Basque Country and Canary Islands. The most advanced project is the Mutriku OWC plant, which has fulfilled two years of operation.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The current ocean energy policy in Spain was approved in November 2011 with the inclusion of ocean energy in the "Renewable Energy Plan 2011-2020" for the first time. This plan includes the following targets:

- The first 10MW of installed ocean power are expected by 2016.
- An annual growth rate of 20-25MW between 2016 and 2020 is expected to accumulate to 100MW by 2020.

The plan foresees an important growth of ocean energy after 2020 with the following phases:

- 1. Reliability confirmation (2010-2015): simulation, modelling and prototypes will be key aspects. Cost of the electricity is not a major issue during this phase.
- 2. Technology development (2016-2020): demonstration of full scale prototypes with generation costs between €21 and €33 per MWh.
- 3. Technology consolidation (2021-2030): commercial deployment of ocean power plants with a cost reduction of the electricity down to €7-€15 per MWh.

Spain has participated, together with Portugal, France, Ireland and UK, under the coordination of the Directorate General for Maritime Affairs and Fisheries (DG MARE) of the European Commission, in the definition of an action plan for a Maritime Strategy in the Atlantic Area, which includes marine renewable energy as one of the key sectors to be considered for delivering smart, sustainable and inclusive growth.
Regarding standardisation issues, AENOR, the Spanish standardisation body, created a national group in 2008 which is working in collaboration with the international committee IEC/TC 114 in the establishment of standards for marine energy.
One Spanish region has defined specific strategies and targets for ocean energy: the Basque Government approved, in December 2011, its Energy Strategy for 2020 which includes a specific initiative to speed up technology and commercial development of wave energy and sets a target of 60MW by 2020.

1 ACKNOWLEDGEMENT
This report has been prepared with the collaboration of APPA-Marina, the ocean energy section of the Spanish Renewable Energy Association. APPA-Marina represents the voice of the Spanish ocean energy industry.

MAIN SUPPORT INITIATIVES

The Spanish Renewable Energy Plan 2011-2020 included some strategic actions to facilitate the achievement of its targets, covering technology and non-technology aspects. All of these strategic actions are under revision due to an important change in renewable energy policies in Spain.

The first Royal Decree of the Spanish Government in 2012 meant a serious step back for ocean energy and other renewables with the suspension of the feed-in tariffs support to all the new renewable energy installations. This situation has not changed in 2013: the Ministry of Industry, Energy and Tourism is working on a new support framework for renewable energy sources based on reasonable profitability, which is still under definition.

With the objective of analysing the specific situation of marine renewable energy in Spain, the Ministry of Economy and Competitiveness is coordinating a group with the participation of the main industrial players in this sector, two technology platforms, several public institutions and the different Spanish research infrastructures for marine energy. The main objectives of this group are as follows:

- To define research priorities to be incorporated into national R&D programmes.
- To strengthen the international position, in terms of both R&D and market, of the Spanish marine energy sector.
- To involve all of the ministries whose competence is necessary for developing and implementing a coordinated strategy.
- To strengthen the collaboration with regional governments.

At regional level, the Basque Government, through EVE, its Energy Agency, has launched a funding programme for the demonstration and validation of emergent marine renewable energy technologies. This funding mechanism was published in October 2013 and has a €3 million budget with a maximum of €1.5 million per project. It is based on the 800/2008/EC regulation and it is aimed to support the testing at open sea conditions of full scale wave energy converters, offshore floating wind platforms or other auxiliary equipment.

NATIONAL SEA TEST FACILITIES

In Spain, there are two sea test facilities under construction:

bimep

The Biscay Marine Energy Platform, an open sea test facility promoted by EVE in the Basque Country, has already obtained all the administrative permits and is now facing the very last phase of its construction. Last summer, the four subsea cables, totalling 20MW of power, together with their connectors were deployed. Before that, 7 markers buoys were installed for delimiting the bimep area. Inland works have finished except for the onshore substation, which is expected to be ready in March 2014. As a consequence, this full scale testing infrastructure would be up and running by May 2014, when the first user will hopefully arrive.

Cable installation at bimep

PLOCAN

PLOCAN, the Oceanic Platform of the Canary Islands, offers a marine site for testing new technologies based on ocean energy conversion prototypes. The site will be equipped with a submarine electrical and communication infrastructure, still in the design stage. It will be ready by the end of 2014 offering grid connection for the electricity produced by offshore energy devices. The initial capacity is 15 MW with a

future planned extension up to 50 MW by 2020. Main technologies under testing are expected to be related to wave energy and offshore wind. The PLOCAN test site is ruled by the Spanish Government (50%) and the Regional Government of the Canary Islands (50%).

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

The Royal Decree 1028 of July 2007 establishes the administrative procedure to apply for an authorization for electricity generation installations at sea. It consists of three main parts:

- Part 1 is introductory and sets the scope and competences.
- Part 2 is specific for offshore wind and introduces a competitive procedure between promoters due to the lack of qualified areas with adequate depth.
- Part 3 covers other marine renewables and the competitive procedure is eliminated.

The Royal Decree 1028/2007 includes several additional provisions such as the inability to deploy marine energy projects in certain areas due to environmental restrictions. It also identifies the different public bodies involved in the licensing process:

- The Ministry of Industry, Energy and Tourism through the Directorate General for Energy Policy, as the substantive body, provides the administrative authorization.
- The Ministry of Agriculture, Food and Environment, through the Directorate General of Coasts, grants the concessions for the occupation of the maritime-terrestrial public domain. It also acts as the main body for environmental assessments.
- The Ministry of Public Works, through the Directorate General of Merchant Shipping, allows the precise activities when they affect maritime safety, navigation and life at sea. In case of occupation of public ports, the competent port authority shall grant the authorization or concession.
- The Ministry of Agriculture, Food and Environment adopts protective measures and restoration of fishery resources.
- Other administrations, such as regional governments, can participate in accordance with their competences.

The open sea test facility *bimep* has followed the procedure defined by this Royal Decree while installations sited in coastal waters can follow a different route. For example, PLOCAN was environmentally authorized by the Environmental Body of the Regional Government of the Canary Islands in April 2013 with the corresponding Environmental Statement.
Regarding environmental regulation, the Spanish Standardisation Body, AENOR, is working on a new standard to establish general criteria and guidelines for the preparation of Environmental Impact Studies for marine renewable energy installations. This standard is expected to be published in 2014.

RELEVANT DOCUMENTS RELEASED

No relevant documents have been released in Spain in 2013. Apart from the Renewable Energy Plan (2011) and the suspension of feed-in tariffs for renewable energy sources (2012), there are no additional changes in the current Spanish legislation regarding ocean energy.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

TECNALIA, the largest Spanish private research organisation, is leading the R&D activities on ocean energy in Spain, aiming at creating and developing business opportunities for different agents of the

ocean energy supply chain. TECNALIA develops new and sustainable solutions through innovation with a global approach focused on the deployment of ocean energy parks and their cost effectiveness during the whole life cycle. TECNALIA coordinates Spanish R&D activities with other European organizations in the framework of the European Energy Research Alliance (EERA) Joint Research Programme (JP) on ocean energy. The EERA Ocean Energy JP was launched in 2011 led by Edinburgh University and it is based around six key research themes: Resource, Devices and Technology, Deployment and Operation, Environmental Impact, Socio-economic Impact and Research Infrastructure, Education and Training. Spain is participating in all the Research Themes and TECNALIA is leading the "Deployment and Operation" theme together with the German centre Fraunhofer IWES.

Spain has two relevant test infrastructures for ocean energy devices:

- The Cantabria Coastal and Ocean Basin (**CCOB**) was funded by the Spanish Government and the Regional Government of Cantabria and is managed by **IH Cantabria**. Its primary mission is to provide scientific and technological knowledge, technology and services for the development of marine engineering (offshore and coastal) both in Spain and abroad. The conceptual design of CCOB is global, unique in the world in the field of maritime engineering, and structured through the integration of three systems: an experimental management system, a physical modelling system and a numerical modelling system.

- **CEHIPAR** is a public and independent, internationally recognized hydrodynamic centre for model tests, projects and research. It is a service and consulting company for customers from the administration and the industry, such as shipyards, engineering offices, manufacturers, ship-owners, research centres, as well as from sports associations, and individuals.

OceanLider, the most important Spanish R&D project on ocean energy running since 2009, has presented its main results in a public event celebrated in the Naval School of the Polytechnic University of Madrid, in November 2013, with the participation of representatives of the Spanish Government. OceanLider, led by Iberdrola Ingeniería, has carried out several R&D activities covering resource assessment, technology development of wave, tidal and hybrid systems, electrical transmission, operation, maintenance and safety systems and environmental issues. The project had a budget of €30 million (€15 million public funding), duration of 40 months, and the participation of 20 industrial partners and 24 research centres.

Iberdrola Ingeniería is also coordinating another R&D project with the participation of eight leading Basque companies: OCEANTEC, Guascor, Ingeteam, Itsaskorda, JEMA, Obeki, Vicinay and ZIGOR, and the collaboration of TECNALIA as the main R&D subcontractor. The so called UHINDAR project, with a budget of €8 million and partially funded by the Basque Government, aims at developing a floating wave energy converter and defining the electric infrastructure and mooring systems for a complete wave energy farm.

Several Spanish organisations are actively participating in European R&D projects such as:

- MaRINET - Marine Renewables Infrastructure Network - is a €9 million EU-funded initiative to provide access to test facilities in specialized marine renewable energy centres across Europe. MaRINET supports testing of concepts and devices in areas such as wave energy, tidal energy, offshore wind energy and the environment. The network consists of 42 testing facilities at 28 research centres in 12 countries. In Spain, EVE and TECNALIA are key partners in this initiative: TECNALIA is offering its Electrical PTO lab testing facilities, and EVE is offering its Mutriku OWC plant and bimep testing facilities.

- MARINA-Platform, led by ACCIONA and with the participation of TECNALIA, deals with the evaluation of multi-purpose platforms for marine renewable energy and plans to produce a set of design and optimisation tools addressing, inter alia, new platform design, component engineering, risk assessment, spatial planning, platform-related grid connection concepts, all focused on system integration and reducing costs. These tools are being used to produce a number of multi-purpose renewable energy platforms.

- DTOcean - Optimal Design Tools for Ocean Arrays – is a new R&D project funded by the European Commission. It started in October 2013 with an overall value of over €6 million. The University of Edinburgh leads a consortium of 18 international partners, with the Spanish participation of TECNALIA, Iberdrola and Prysmian. The DTOcean project will provide a comprehensive set of design tools for the development and deployment of ocean energy arrays. The key focus areas of hydrodynamic array layout, electrical system architecture, moorings & foundations, lifecycle logistics and system control & operations have been identified as the areas which must be addressed in order for the ocean energy sector to reach commercialization through array deployment.

- OceaNET is a new EC training network of engineers and researchers coordinated by WavEC Offshore Renewables in Portugal, with the participation of TECNALIA and IH Cantabria from Spain. The project is funded by the European FP7 Marie Curie Initial Training Network programme with a €3.4 million budget. The aim of the OceaNET is to train a new generation of engineers and scientists in the area of floating offshore wind and wave renewable energies to support the emerging offshore renewable energy sector.

- TROPOS - Modular multi-use deep water offshore platform harnessing and servicing Mediterranean, subtropical and tropical marine and maritime resources - led by PLOCAN, is a European collaborative project funded by the European Commission under the "Ocean of Tomorrow" initiative. Its main objective is to develop a modular floating platform, adapted to deep waters, focused on Mediterranean, subtropical and tropical regions. Thanks to its different modules, the floating platform system will be able to integrate a wide range of uses: ocean renewable energy, aquaculture, hub for maritime transport, innovations in the leisure sector and oceanic observation activities.

- HiWave project - Iberdrola ingeniería is driving a European R&D project focused on efficient wave power with a budget of €15 million partially funded by the European Institute of Innovation and Technology (EIT) through one of its knowledge and innovation communities (KIC InnoEnergy). The Spanish company is carrying out this innovative proposal in partnership with the Swedish company CorPower Ocean and the Portuguese marine research centre WavEc. HiWave envisages the demonstration of a new wave power harnessing device and the subsequent design of an offshore farm using this technology.

- TidalsenseDemo is a €3 million demonstration project started in February 2012 and funded by the European Commission under a Small and Medium Enterprises (SME) support programme. The results of the previous Research project Tidalsense are being demonstrated by applying a novel condition monitoring system to key composite elements in full scale tidal devices under working conditions. EnerOcean is one of the leading companies of a 12 - entities consortium coordinated by InnotecUK and also includes the participation of the University of Cadiz (UCA). EnerOcean participated in the sensor installation in a prototype of the Scottish Company Nautricity Ltd and in the installation of sensors in two full scale sails designed by the Norwegian SME Aqua Energy Solutions. One on these sails has been installed by UCA and EnerOcean in the Cadiz bay in order to carry out environmental impact assessment tests.

TidalsenseDemo encapsulations and monitoring system installed in Nautricity Device

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

Apart from its participation in R&D projects, **IBERDROLA**, through its UK subsidiary Scottish Power Renewables, is promoting projects based on ocean energy devices (wave & tidal) out of Spain. As regards wave energy, the company is building a plant using the Pelamis P2 technology in Scotland. As for tidal energy, it is partnering with the Austrian company Andritz Hydro Hammerfest and the French corporation Alstom in a project totalling up to 10 MW in the Sound of Islay, also in Scotland. These two plants are currently being developed at the European Marine Energy Centre (EMEC).

Abengoa Seapower has continued the development of several activities in ocean energy, including R&D projects in wave and tidal energy, engineering for construction of marine energy projects, and the development of different tools.

Repsol New Energy Ventures and TOCARDO International BV, a Dutch producer of hydraulic turbines, are collaborating on the development of renewable generation projects from river and ocean currents, by combining the knowledge of Tocardo on turbines and the access to energy markets worldwide provided by Repsol.

SENER, an engineering and construction company backed by more than 50 years' experience, is in charge of the engineering property and construction management of *bimep*. SENER has also been an active partner in the OceanLider project, in relation with the design and calculation by finite elements methods of floating structures.

OPERATIONAL OCEAN ENERGY PROJECTS

Mutriku Oscillating Water Column (MOWC) plant, promoted by EVE, is the first multi-turbine wave energy facility in the world. It is integrated within the breakwater of Mutriku (Basque Country, Spain) and consists of 16 air chambers and 16 sets of "Wells turbines plus electrical generator" of 18,5 kW each. The air chamber dimensions are 4.5m wide, 3.1m depth and 10m high (over Maximum Equinoctial Spring Tide Low Water). The diameter of the hole at the top is 0.75m. The turbine gallery dimensions are 100m long, 6.1m wide and 5.4m high. The plant was connected to the grid and started its operation in July 2011 with an estimated annual production of 600 MWh. After two years of operation the real production has been a bit lower due to some operational problems arising from extreme sea conditions.

Turbines of the Mutriku OWC plant

The main purpose of the MOWC plant is the production of electricity. However, EVE has a clear commitment with research activities to promote wave energy and MOWC, integrated in the MaRINET network, is also intended for testing new solutions of OWC wave energy converters. With this aim, one of the air chambers will be able to host new concepts of air turbines, electrical generators or control systems to be tested without grid-connection. The users of the test facility will be able to compare the performance of these new components with the rest of the "conventional" OWC systems and they will have access to historical data of wave resources and air pressure in the chambers. The users of the MOWC research infrastructure will be able to use a monitoring system for analysing the impact on underwater noise of the new components

PLANNED DEPLOYMENTS

Ocean Power Technologies (OPT) is developing a new wave energy device (PowerBuoyR) in the Spanish coast under the WavePort EU project. In this project, OPT is collaborating in a consortium with the University of Exeter, UK Intelligent Systems Research Institute, Fugro Oceanor, WavEC and Degima SA. The project will build, deploy and demonstrate a commercial scale PowerBuoyR wave energy converter with an innovative Real Time Wave by Wave Tuning System. Forward knowledge of the approaching wavetrain delivered by the prediction system will allow advanced control of the PowerBuoyR, recovering more energy from the ocean and substantially improving the device efficiency. This will drive down the levelized cost of energy. The project has progressed well and the consortium forecasts deployment of the PowerBuoy and completion on the sea trials during 2014.

Metalurgica Marina is developing the Kostalde project, a wave energy converter which extracts energy using three forces: the thrust due to the inertia of the wave, the action of the principle of Archimedes by a submerged front float, and the rise and fall of the tides. After some laboratory testing and sea trials, Kostalde is currently looking for investment to prove a ½ scale prototype, with an installed capacity of 93kW in 1.9m wide.

UNDIGEN is a project partially funded by the Spanish Ministry of Economy and Competitiveness, led by the Spanish tech-company WEDGE GLOBAL in collaboration with FCC, CIEMAT and PLOCAN. UNDIGEN is aimed to design, build and deploy a new wave energy converter prototype including an innovative electrical PTO with a nominal value up to 200 kW. After completion of the mechanical and electrical design & manufacturing phase during 2012-2013, as well as the studies related to the operation site, the effective deployment at the PLOCAN site is expected by February 2014.

Buoy developed under the Undigen Project.

INNPACTO Wave Energy Project is aimed to develop and demonstrate the usefulness of R&D projects based on the APC-PISYS technology of PIPO Systems, through the construction and location in the marine environment of two operative prototypes:

- An autonomous observation and maritime surveillance device (5 kW of installed power).
- An electricity generation system (200 kW of installed power).

The autonomous device for observation and maritime surveillance satisfies an existing demand and its development will be very useful for the optimisation of higher power systems.

The **Magallanes Project** aims to develop a high-stability floating platform to support a 1MW tidal turbine with currents over 1,5m/s. The project started in 2007 with the challenge of developing a technology able to extract power from tidal currents and it has become a reality thanks to its soundness and to a multidisciplinary team. This project has been recognized by the European Marine Energy Centre as the first Spanish tidal developer. A 1:10 scale prototype has been already developed based on a design focused on a simple and strong platform, with a minimum number of underwater mobile parts, facilitating the maintenance tasks and guaranteeing a long useful life.

The **PROCODAC-GESMEY project**, led by the Naval School of the Polytechnic University of Madrid, has the objective of developing a device to harness energy from ocean currents. The first step of the project has been developed in collaboration with Astilleros Balenciaga and Soermar and consisted of the design, construction and testing on a real marine environment of a 1:10 scale prototype. The next step is the development of a 1MW full scale prototype complemented by an underwater buoy that was designed to operate in areas of 40 meters depth.

ITALY

Gerardo Montanino
GSE

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

According to the Italian National Renewable Energy Action Plan (NREAP) the ocean energy total contribution (in terms of installed capacity) expected to meet the binding 2020 European renewable energy sources (RES) targets will be of 3 MW in 2020. For this reason, the Italian increasing interest in the exploitation of wave and tidal technology to produce clean and renewable energy can be recognized either in some Government initiatives (e.g. higher incentive for such sources) or in the research activities. Mainly universities and companies specialized in researches and innovative design are involved in R&D in this field, thanks to which Italy is at forefront in research, development and demonstration at a prototypal level.

MAIN SUPPORT INITIATIVES

The Ministerial Decree on renewable energy sources (DM 6 July 2012) reviews the support schemes (till the end of 2012 based on feed in tariffs and green certificates) for grid connected renewable energy power plants (non PV). The Decree concerns plants put into operation since 1 January 2013 (with capacity ≥ 1 kW). The Decree identifies four different ways of access to incentives: direct access, bid auctions (Dutch Auctions), registries for new power plants, for fully reconstructed power plants, for reactivated, empowered and hybrid power plants and registries for rebuilding intervention. The Decree defines the criteria to access to the Registries and the Dutch Auctions and establishes specific limits for the annual capacity eligible to incentives. These limits are set up differently for each kind of renewable energy sources and for all the different ways of access to incentives (registries or bid auctions).

In general, the Decree grants a fixed tariff plus, in some cases, a specific premium, to provide incentives to net electricity fed into the grid. The fixed tariff is different according to each source, technology and capacity range considered. Power plants with a capacity > 1 MW can only receive the incentive (fixed tariff minus electricity hourly zonal price, plus premiums if foreseen). Power plants with a capacity ≤ 1 MW can receive, instead of the incentive, a feed in tariff composed by the fixed tariff plus, in some cases, a specific premium.

In the Dutch Auctions the maximum requested value of the tariff cannot be higher than a 2% discount of the reference value and the minimum value cannot be lower than a 30% discount of the reference value. The incentives last for the average conventional plant life of each typology of power plant.

All the support schemes are managed by GSE (the Manager of Energy Services, a governmental company that provides incentives).

New, fully reconstructed, reactivated or empowered wave and tidal energy power plants can access directly to incentives if their capacity is not greater than 60 kW, otherwise they must apply for access to Registries.

TYPOLOGY OF POWER PLANT	CAPACITY	
	≥ 1 kW and ≤ 60 kW	> 60 kW and ≤ 5 MW
Wave and tidal power plants	Direct Access *	Registry

* If the power plant is built by the Public Administration the maximum capacity eligible to direct access is doubled (120 kW).

For wave and tidal energy power plants, the total annual capacity (MW) eligible to access to Registries from 2013 to 2015 and so to obtain the incentives is indicated in the table below:

	2013	2014	2015
Oceanic total annual capacity (tides and waves) - MW	3	0	0

If the total installed capacity in a certain year is less than the capacity to be supported in that year according to the Decree, the residual capacity can obtain the incentives in the following year. In 2012 and in 2013, there were no requests to enrol to the Register.
The wave and tidal energy rebuilt power plants can only access directly to incentives and their capacity must not be higher than 60 kW. The Decree does not provide Dutch Auction for wave and tidal energy power plants.
For new wave and tidal energy power plants entering into operation in 2013, the incentives are defined as follows:

SOURCE / TYPOLOGY	CAPACITY (KW)	CONVENTIONAL PLANT'S LIFE (YEARS)	FIXED TARIFF €/MWH
Oceanic (tides and waves)	1< P ≤ 5000	15	300
	P > 5000	20	194

In general, the tariffs for plants entering into operation from 2014 on will decrease by 2% (compared to the values provided by the Decree) in each of the subsequent years until 2015, except in case of failure to reach 80% of the yearly capacity quota provided for the Register. In the case of wave and tidal energy power plants, the above mentioned curtailment will not apply because the total capacity provided by the Decree is still fully available.

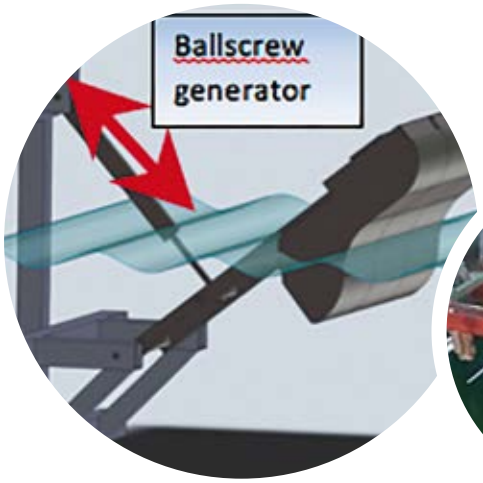
RESEARCH & DEVELOPMENT

Universities and renewables companies are key players involved in research regarding the exploitation of marine tidal and river current to produce energy. Among these two flagship examples are the University of Naples and Enel Green Power. The University of Naples "Federico II" distinguishes for its GEM project started in 2003. In fact, the public/private consortium SEAPOWER Scarl, made by a private company and the University of Naples, thanks to the collaboration between ADAG applied research group (www.adag.unina.it) belonging to the Department of Industrial Engineering - Aerospace division, University of Naples "Federico II" and Eng. Nicola Giorgio Morrone, developed one of the most attractive projects over the last period in the field of renewable energy production using marine sources, GEM: *The Ocean's Kite* (http://www.adag.unina.it/english/research/renewable/gem.html)

The SEAPOWER public/private consortium is waiting for the final permit to set up and manage a real field laboratory in the Strait of Messina open to Italian and to foreign companies for testing their tidal current devices. The laboratory will provide assistance in deploying the devices, data handling and certification for the prototypes installed and tested in the area available to the consortium. The consortium is waiting for the final permit to build the laboratory.

In the field of wave energy, SEAPOWER has also started cooperation with Umbra Group www.umbragroup.it, world leader company in ball screws and linear actuators, to develop a system aimed to harvest energy from wave motion. The system has been designed keeping it as simple as possible with reliability and survivability as main driving criteria. Numerical and experimental test on 1:5 scaled model have already been performed in the towing tank of the Department of Industrial Engineering of the University of Naples "Federico II".

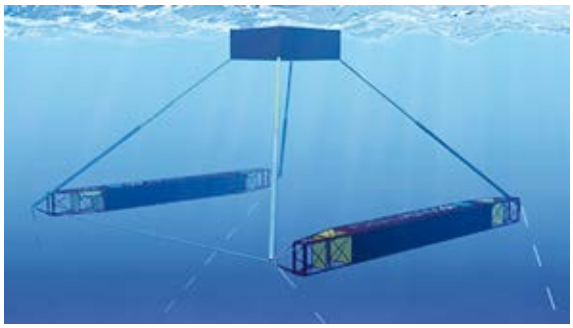
Set up and validation of numerical codes have already been done and 60 kW prototype is being designed to be deployed on the Italian coast in order to verify its performance in real field.



CAD image of the system

Wave tank test on 1:5 model scale

Enel Green Power in its effort to utilize new renewable resources is engaged in R&D on marine energy converters, their installation and O&M as well as on environmental feasibility studies. Further strengthening its technological partnership with 40South Energy, a group that designs, manufactures and markets wave energy converters, EGP will support, through 40South Energy, the develop a new wave energy converter with a nominal capacity of 2 MW, building upon the operational systems employed and maintaining the essential features of the model R115 currently being tested in Italy. Such R&D effort relies on the know-how gained through the R115 as well as benefitting from EGP experience on managing renewable generation facilities worldwide.



40South Energy wave energy converter

In order to lay down the ground for an industrial development of marine energy converters Enel Green Power is also researching the best methods and procedures for resources modelling, installation, operation and maintenance of marine energy converters while assessing the environmental feasibility of such devices,

participating, among others programs, through its sister company *Enel Ingegneria e Innovazione*, in the European Project Mermaid for Innovative Multi-purpose off-shore platforms.

TECHNOLOGY DEMONSTRATION

TIDAL ENERGY

GEM project

GEM, *the Ocean's kite*, has been patented and the concept consists of a submerged floating body linked to the seabed by means of a tether. The main hull houses electrical equipment and auxiliary systems. Two turbines are installed outside the floating body and are exposed to the external currents.
Due to a relatively safe and easy self-orienting behaviour, GEM, The Ocean's Kite, is a good candidate to solve some problems involved with oscillating and reversing streams, typical of tidal currents. An additional advantage of its configuration is related to the possibility of avoiding the use of expensive submarine foundations on the seabed, because these are replaced with a flexible cable connected to a single mooring point. Releasing the anchorage cable allows the system to pop-up for easy maintenance. A special diffuser (shroud) has been designed to double the output power keeping the blade length small.
After several numerical investigations, a series of experimental tests on two different scaled models has been carried out in the towing tank of the Department of Industrial Engineering – Naval Division at the University of Naples.
The models tested were completely instrumented so that a dynamic behaviour and the off-nominal working conditions were investigated.
The real scale prototype system of 100 kW, with 5 knots of water current speed, has been built and has been deployed nearby Venice in a very slow speed current of about 3 knots downscaling the power to 20 kW.
This prototype has been built by a consortium of Venetian companies thanks also to a financial contribution of Veneto Regional Authority.
The real field tests have demonstrated the fully correspondence of the system behaviour with respect to what has already been measured on the 1:5 model during the test campaign in naval towing tank.
A full scale prototype of 200 kW at 2.5 m/s water current speed is being designed and it will be deployed in the Strait of Messina to definitively assess all the performances of the system.

GEM: Artist impression

Real scale prototype

THE KOBOLD TURBINE

The "Kobold Turbine" has been developed since 1998 by ADAG Group of Department of Industrial Engineering, the University of Naples "Federico II", in collaboration with "Ponte di Archimede international Spa", a company that works in the field of research and development into alternative and renewable energy sources, specialising in the environmental aspects of this work.
The Kobold consists of a submerged vertical-axis turbine for exploitation of marine currents installed in the Strait of Messina, 150 metres off the coast of Ganzirri, since 2002. The realization of the Enermar prototype has been financed by Ponte di Archimede Company, together with a 50% fund paid by the Sicilian Region Administration (Regione Siciliana), in the framework of European Union Structural Funds. This project has been disseminated among the developing countries in which the United Nations Industrial Development Organization (UNIDO) operates and the first three countries that expressed interest were the People's Republic of China, the Philippines, and Indonesia. A joint-venture was created, under the auspices of UNIDO, between "Ponte di Archimede" and the Indonesian Walinusa Energy Corporation.

WAVE ENERGY

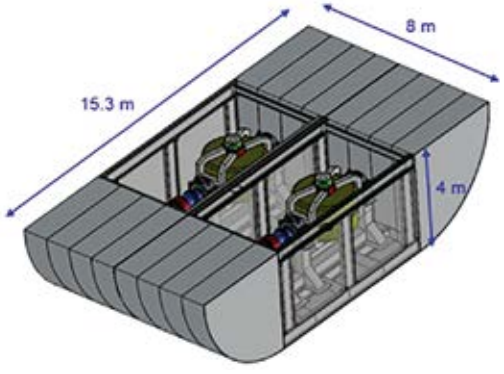
ISWEC Project

Sea waves are one of the most interesting and well distributed renewable energy sources in the world. At the current state of the art, all the existing sea wave energy conversion systems are designed to operate offshore, mainly in the oceans where the waves' height is definitely high. In the Mediterranean Sea, waves are generally low, except under particular meteorological conditions. Thus, it is necessary to develop devices that can exploit other properties of the waves instead of their height, like wave slopes.
The mechanical conversion system, called ISWEC, that will be used for the development of the project has been analysed by Politecnico di Torino and results show that the system possesses good potential for energy conversion.
ISWEC device is composed mainly of a floating body with a slack mooring to the seabed. The waves tilt the buoy with a rocking motion that is transmitted to the gyroscopic system inside the buoy. The gyroscopic system is composed of a spinning flywheel carried on a platform. As the device works, the gyroscopic effects born from the combination of the flywheel spinning velocity $\dot{\varphi}$ and the wave induced pitching velocity $\dot{\delta}$ create a torque along the ε coordinate. Using this torque to drive an electrical generator, the extraction of energy from the system – and therefore from the waves – is possible.

The conversion device to be built will have the following features:

- Floating positioning system, with no need for rigid linking devices or foundations on the seabed
- Functioning is based on a resonant inertial system with gyroscopic ;
- Sealed hull, with no movable parts exposed to marine environment;
- Adaptability to wave variations;
- Reduced environmental impact;
- Ease of maintenance.

Trials at various levels have been carried out. In the first phase, a set of "dry tests" has been done on a controlled position mobile platform. In the second phase, a series of tests have been performed in the INSEAN wave tank, with suitably generated and controlled waves.
Finally the system has been placed and tested on Pantelleria Island for the real sea tests. Further tests will be carried out in order to develop and tune optimized control algorithms.
Currently the real scale prototype is under development and it will be launched in 2014.



Full scale ISWEC drawing (CAD) with two gyros

EGP – 40 South Energy

Enel Green Power, a world leader in renewable energy generation, and 40South Energy, a group of highly innovative companies operating in the field of marine energy at the international level, began, last June, the installation and commissioning of a first R115 generator, with a nominal capacity of 150 kW and installed capacity of about 100 kW, generating electricity from the energy produced by the waves of the sea around Tuscany. The 40South Energy wave energy converters comprise one fully submerged section – called Lower Member – and energy interceptors – called Upper Members – at different depths. The relative motion of the Lower and Upper Members is converted directly into electricity on the machine. The depth of the machines is controlled automatically to respond dynamically to changing sea conditions. This ability to vary depth dynamically and automatically in response to any changes in the state of the sea also guarantees that the same machines can operate across the globe. Whether the installation is in Orkney, Tuscany, or Oregon, the machine will work within the same operational limits. The new generator ensures full integration into the marine environment and ease of maintenance, and according to initial estimates will enable the generation of about 220 MWh per year, enough to meet the needs of over 80 households. The results of the initial phase of testing terminated last December confirmed the expected performance of the machine in a marine environment and the extreme ease of its installation. Furthermore, the testing revealed a number of refinements for making the machine more durable in water. Armed with this field experience, the partners are continuing to work on optimizing the materials and structure of the machine during first half of 2014 with the goal of installing the machine and connecting to the network on the Elba Island during the second half of the year and soon installing other machines of the same class in the Mediterranean Sea and in an ocean environment.

Installation R115 – 40 South Energy

GOVERNMENT FUNDED R&D

A list of the projects that Politecnico di Torino (POLITO) managed/currently manages along with a brief description regarding the objectives of each project is given below:

National project "Evaluation of Effective Productivity of Floating System for Energy Generation from Mediterranean Saw Wave"(2011-2012).

In the frame of the Italian national agreement between ENEA and Ministry of Economic Development on the National Energy Research Set Plan, a special contract is signed (2011-2012).
The partnership is formed by POLITO and ENEA aiming at the evaluation of the effective productivity of a floating system for sea wave energy conversion.
In particular, the following actions will be pursued:
- Wave analysis in Pantelleria with numerical methods;
- Productivity estimation of a gyroscopic converter device and possible integration into the power grid.

Regional project S.PO.S.DE.T. "Self Powered Floating Device for Sea Traffic Detection and Transmission" - Regione Piemonte (2009-2011)

In the frame of regional research plan (Regione Piemonte), a project was financed regarding the development of ISWEC, an innovative device (scale 1:8 with respect to the Pantelleria typical wave) for energy generation and sea wave energy conversion. The complex system is currently under testing at the Pantelleria premises and further development is foreseen.

Regional project PROMO - Produzione di Energia da Moto Ondoso - Regione Piemonte (2012-2014)

In the frame of regional research plan (Regione Piemonte), Politecnico di Torino has received a grant for design, development and testing of a full scale device for sea wave energy converter. Politecnico di Torino, in cooperation with Wave for Energy, is currently working for the device integration on the energy power grid, in order to evaluate the quality of energy produced from renewable sources.

PARTICIPATION IN COLLABORATIVE INTERNATIONAL PROJECTS

FP7-ENERGY-2012: SINGULAR- Smart and Sustainable Insular Electricity Grids Under Large-Scale Renewable Integration

A large share of the recent renewable energy sources (RES) installed capacity has already taken place in insular electricity grids, since these regions are preferable due to their high RES potential. However, the increasing share of RES in the generation mix of insular power systems presents a big challenge in the efficient management of the insular distribution networks, mainly due to the limited predictability and the high variability of renewable generation, features that make RES plants non-dispatchable, in conjunction with the relevant small size of these networks. The Smart Grid Initiative, integrating advanced sensing technologies, intelligent control methods and bi-directional communications into the contemporary electricity grid, provides excellent opportunities for energy efficiency improvements and better integration of distributed generation, including RES, such as wind and photovoltaic systems, coexisting with centralized generation units within an active network.
POLITO studies the possible integration of wave energy production in various applications to grid connected renewable energy generation.

FP7-OCEAN.2011-1 "Multi-use offshore platforms"

MERMAID will develop concepts for the next generation of offshore platforms which can be used for multiple purposes, including energy extraction, aquaculture and platform related transport. The project does not envisage building new platforms, but will theoretically examine new concepts, such as combining structures and building new structures on representative sites under different conditions. The 28 partner institutes forming MERMAID are Universities, Research institutes, Industries and Small and Medium Enterprises from many regions in EU.

NEW ZEALAND

John Huckerby
AOTEAROA WAVE AND TIDAL ENERGY ASSOCIATION

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The New Zealand Government has a national Energy Strategy, which sets out an aspirational target to generate 90% of its electricity from renewable sources. The present proportion of renewably generated electricity varies seasonally between 64% and 81%. For the year to June 2013 the renewable proportion was 74%.

The Government also has a greenhouse emissions reductions target to reduce emissions by 50% from 1990 levels by 2050.

There are presently no strategies or targets that are specific to the development of marine energy.

MAIN SUPPORT INITIATIVES

Between 2008 and 2011 the NZ Government operated a Marine Energy Deployment Fund (MEDF) to stimulate the deployment of marine energy prototype devices in NZ waters. The MEDF supported the development of six projects, one of which was successful in putting a ½ scale wave prototype device in the water in mid 2012. All of the funded projects have now either ended or are on hold.

R&D funding has and is available for a number of Government sources. The largest present funding was awarded to Otago University in late 2012 ($940 K for evaluation of tidal energy array capacity and organization).

NATIONAL SEA TEST FACILITIES

A number of parties came together in July 2010 to develop a New Zealand Marine Energy Centre. The Government favorably reviewed the project proposal in early 2012 and the parties continue to develop the structure, organization and funding sources for this centre.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

Nearshore project developments fall under the Resource Management Act 1991 and four consents for device deployments have been granted to date. Offshore projects greater than 12 nautical miles offshore will fall under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act, when it comes into force in 2014.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

As noted Otago University is presently undertaking a Marsden Fund sponsored project on tidal energy array capacity and organization.

Between 2009 and 2012 the National Institute of Water and Atmospheric Research (NIWA) has received funding from the Ministry of Research, Science and Technology to review tidal energy optimization and tidal surges.

The long lasting Wave Energy Technology – New Zealand (WET-NZ) research programme between Callaghan Innovation and Power Projects Limited came to an end in September 2013. The project had previously deployed two 20 kW prototype devices, one off the coast of Wellington in mid-2012 and a second device off the coast of Oregon in the third quarter of 2012.

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

Todd Energy, the largest privately owned integrated energy company in NZ, now owns 100% of the largest consented tidal project (200 MW project in the Kaipara Harbour). Consents for that project were granted in 2012 but there have been no moves to develop the project to date.

OPERATIONAL OCEAN ENERGY PROJECTS

There are presently no operational projects in New Zealand waters.

PLANNED DEPLOYMENTS

At the end of 2012 there were seven marine energy projects. Most of those projects have now come to an end or are on hold pending securing funding to continue development.

SWEDEN

Maria Olsson
SWEDISH ENERGY AGENCY

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The Swedish energy policy is based on the same foundations as energy cooperation in the European Union (EU) and seeks to reconcile environmental sustainability, competitiveness and security of supply. The vision is that, by 2050, Sweden has a sustainable and resource efficient supply of energy and no net emissions of greenhouse gases in the atmosphere.
In order to realize the vision and implement the EU Renewables Directive, the following national targets for renewable energy and efficient use of energy in Sweden by 2020 have been set:

- The share of renewable energy in 2020 should be at least 50 percent of total energy use.
- The share of renewable energy in the transport sector should also be at least 10 percent.
- A further goal is 20 percent more efficient energy use in 2020, expressed as a reduction in energy intensity of 20 percent between the years 2008-2020.

The forecast for Sweden in 2013 is that by 2020 the first two goals will be achieved with margin, while the last goal concerning efficient energy use is more uncertain.

MAIN SUPPORT INITIATIVES

Fundamental to the long-term Swedish energy policy are general economic policy instruments such as carbon tax, international emissions trading and tradable certificates for renewable electricity. From the perspective of ocean energy technology development, the renewable electricity certificate system (a tradable green certificate system) is the most relevant policy instrument.

The electricity certificate system is a market-based support system for cost-effective expansion of electricity production from renewable sources. By design, the system does not specifically target a particular renewable electricity conversion technology, i.e. is technology neutral. Electricity certificates are issued to those who produce electricity from one or more renewable energy sources, or from peat, and who have had their production plants approved by the Swedish Energy Agency. To date, certificates have been issued to producers of electricity from biofuels and peat, wind power, hydro power and solar electricity. While wave energy is one of the renewable energy sources for which producers would be eligible for certificates, none have been issued so far.

In 2011, Sweden and Norway entered into an agreement to form a joint electricity certificate market, which has been in operation since the beginning of 2012. Together with Norway, annual production from renewable sources, in 2020, shall have increased by a further 13,2 TWh compared to production in 2012.

The main public funding mechanism for research, business and technology development and technology demonstration are Swedish governmental agencies tasked to support academic and private sector R&D in the various stages of innovation. There is currently no funding body with a dedicated funding scheme that targets ocean energy. Nonetheless, there are a number of governmental agencies from which researchers and developers can apply for funding.

- The Swedish Research Council, www.vr.se, which, among other things, is tasked to fund fundamental research and expensive equipment for research purposes within a large number of topic areas.
- The Swedish Energy Agency, www.energimyndigheten.se, is the Swedish agency responsible for facilitating a sustainable energy system in Sweden. As such, the agency funds research, business- and technology development and technology demonstration which is relevant for the sustainability of the energy system and the sustainability for the energy industry sectors.
- The Swedish Governmental Agency for Innovation Systems (VINNOVA), www.vinnova.se, supports business- and technology development. VINNOVA also acts as contact point for the European Community FP7 for research and development.

In addition, regional authorities are able to grant funding to varying extents.

NATIONAL SEA TEST FACILITIES

At the moment there are no national sea test facilities in Sweden. However, there are two research sites in Sweden, Lysekil wave power research site and Söderfors marine currents research site. Both sites are operated by Uppsala University. A third site, Sotenäs wave power demonstration facility, is under development and the project is led by Seabased Industry AB in cooperation with Fortum. Interest has been expressed to expand the Lysekil wave power research site and thus allow access to other universities and developers from Sweden and Europe. Additionally there is a project that has been carried out during 2013, in which the research institute SP has been financed by VINNOVA to investigate the possibilities of establishing a national sea test facility.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

Claims increase to use the sea around Sweden, for example, for fishing, shipping, energy production, energy distribution, communication, and tourism.

The Swedish Agency for Marine and Water Management is therefore working on a new system for marine spatial planning. This will determine how the utilities and space of the sea should be divided and provide guidance to authorities and municipalities when considering claims for the use of the areas. A law concerning the marine spatial planning is expected to come into force on 1 April 2014.

In order to establish test sites for research and development and sites or parks for technology demonstration in Swedish marine environments, permits must be obtained from the local County Administration Board. The permits are granted after an extensive environmental impact assessment court procedure.

RELEVANT DOCUMENTS RELEASED

- The Swedish National Action Plan for the promotion of the use of renewable energy. Available at http://www.biomassinnovation.ca/pdf/BioenergyMissionToEurope/national_renewable_energy_action_plan_sweden_en-1.pdf
- The Electricity Certificate System 2013, ET2013:19. Available at the webpage of the Swedish Energy Agency www.energimyndigheten.se.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Technical Research Institute of Sweden

SP applies its internationally leading competence to the development and evaluation of technologies, material, products, and processes to meet its customers' needs and provide an effective link between research and commercialization. SP consists of several technical departments in which SP Structural and Solid Mechanics is carrying out research within the ocean energy area. Some of the projects that SP is involved in are:

- Offshore Väst, which aim is to establish and support the offshore sector in Sweden through a setup of projects and strategies. Offshore Väst is owned by a consortium of dedicated companies, universities, institutes and authorities. SP is the project manager and coordinator for the work package concerning offshore energy production from wind, wave and current.
- Pilot study – Test site for marine applications. This project was carried out during 2013 and investigated the possibilities of establishing a national sea test bed. It included topics like market research, geographical position, metrology study, consent process and grid connection. SP was the project manager and coordinator.
- Buoy to grid aims at supporting the ocean energy industry with applied research focusing on electrical systems, reliability and marine safety. SP is the project manager and coordinator.
- Strategic Innovation Agenda for Marine Electricity Production. This will start in 2014 and SP will participate in the project group that will put together a combined agenda for wind and ocean energy.
- During 2014, SP will also be involved in a project assigned by the Swedish Energy Agency, which includes a mapping of stakeholders and actors in the field and their visions. This will lead preliminary to a start-up of a national ocean energy programme.

Uppsala University

The Division of Electricity at Uppsala University conducts research on wave energy technology and hydrokinetic energy conversion from tidal currents and rivers. Wave energy activities are focused on a full system approach including system modelling and control, generator and buoy design and model development. Marine current research projects include resource potential studies as well as system modelling from water currents, via turbine and generator, to grid. In order to facilitate field testing and verification of research results, two research sites are operated by Uppsala University; the Lysekil wave power research site, which has been in operation since 2006, and the Söderfors marine currents research site. At the Lysekil wave power research site wave climate can be monitored and environmental impact studies are performed. The environmental impact studies include both the impact of the WEC (wave energy converter) and how biofouling will affect the buoy's ability to extract energy. The site has permission for several WECs that are operated for research purposes. The technology is based on wave point absorber with linear generator. The site is currently not grid connected.

The Söderfors marine currents research site is located in Dalälven River. The site was chosen as it seemed suitable for experiments at low water velocities. Research is carried out with regards to both the resource and the technology. The resource is studied through resource assessments and velocity measurements with Acoustic Doppler Current Profilers (ADCPs). The technology that is being tested on the site consists of a fixed pitch vertical axis turbine connected to a directly driven permanent generator.

Uppsala University has also been involved in project WESA in collaboration with Ålands Teknikkluster and Univeristy of Åbo (Turku) in which a wave power research site was established at Hammarudda (Finland).

The purpose was to investigate how seasonal ice interacts with surface floating buoys. The project was finalized in the end of 2013.
Uppsala University is additionally the coordinator of the project Strategic Innovation Agenda for Marine Electricity Production mentioned previously.

Chalmers University of Technology

At Chalmers University of Technology ocean energy research projects on mooring design, power transmission and mooring fatigue started up in 2011. The research is being carried out at the departments of Shipping and Marine Technology and Energy and Environment in collaboration with the Ocean Energy Centre (OEC) which was also initiated in 2011.
OEC is an innovation platform for collaboration, cooperation and communication among ocean energy stakeholders hosted by the department of Shipping and Marine Technology at Chalmers University of Technology. OEC is a partnership between the Swedish development companies Minesto, Ocean Harvesting Technologies, Vigor Wave Energy and Waves4Power, the technical research institutes SP and SSPA, Chalmers University of Technology and the Region of Västra Götaland, which is the main financial partner.

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

Seabased Industry AB is a spin-off company from the wave energy research made at Uppsala University. It was founded in 2001 and covers industrial research and development as well as production, marketing and environmental studies. Together with the power company Fortum they are now building a commercial wave energy plant outside Sotenäs (see figure 1).

Fig 1. Wave power buoys outside Lysekil

Fig 2. The energy converter being deployed in Dalälven river on the 7th of March 2013

Fortum is also involved in ocean energy activities outside of Sweden. Together with DCNS and AW-Energy and with the support of La Région Bretagne they will develop a joint 1.5 MW wave power demonstration project in France using the WaveRoller™ technology.

E.ON and Vattenfall are two other power companies that are involved in ocean energy activities, but, for the moment, primarily outside of Sweden, although Vattenfall has partly financed some of Uppsala University´s work (CFE II). Vattenfall is cooperating with Pelamis Wave Power to develop a wave power farm at the coast of Shetland. E.ON has also worked with Pelamis Wave Power and has helped developing their second generation Pelamis machine.

Among the smaller but still progressing industry players that have received funding from the Swedish Energy Agency, CorPower Ocean AB, Minesto and Ocean Harvesting Technologies can be mentioned.

CorPower Ocean AB has developed an advanced compact high-efficiency Wave Energy Converter (WEC), inspired by the pumping principles of the human heart. CorPower has initiated cooperation with the Spanish power company Iberdrola that will be involved in developing an offshore farm later on.
Minesto develops tidal and ocean current power plants called Deep Green. Deep Green is currently undergoing long-term ocean trials in quarter scale in Strangford Lough, Northern Ireland.

Ocean Harvesting Technologies (OHT) offers an ingenious power take-off for wave power. A mechanical gearbox and a gravity accumulator convert the highly intermittent and irregular power captured from the wave motion into a smooth speed and torque to the generator. Next phase is to design a small scale hub system. E.ON has supported OHT with money and expertise.

OPERATIONAL OCEAN ENERGY PROJECTS

Many ocean energy projects are still in the early phase of development. The only projects that are executed in Sweden and operational, although not commercialized, are the Lysekil wave power project and the Söderfors marine current project mentioned previously. Both are operated by Uppsala University.

The Lysekil wave power project installed the first wave energy converter in 2006. Since then the number has increased to ten. The installed capacity is 230 kW but with an expected capacity of 350-400 kW later on.

For the Söderfors marine current project the energy converter was deployed in Dalälven on 7 March 2013. The turbine is rated at 7.5 kW at a water speed of 1.3 m/s, and it is designed to operate in the range of velocities from 0.5 to 2 m/s.

PLANNED DEPLOYMENTS

The Sotenäs project was initiated in November 2011 and is planned to become one of the largest wave energy plants in the world. The project is in two stages, with a first 1 MW stage to be commissioned in the end of 2014. The second, 9 MW, stage will be launched subsequent to the evaluation of the first 1 MW, probably later during 2014. The wave power plant, when completed, will thus have a total installed power of 10 MW. The Sotenäs project is funded by the Swedish Energy Authority, the power company Fortum and by Seabased Industry AB.

AUSTRALIA

Alison Demaria
CLEAN ENERGY COUNCIL

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

Australia has very large potential ocean energy resources, which have been confirmed in a study conducted by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and syndicated with industry and government [13].

The key challenges facing both the ocean energy and the broader renewable energy industry are the current climate of policy uncertainty and instability, and substantial decline in electricity demand. In September 2013, the federal election saw a change of government to the conservative Liberal Coalition, with the balance of power in the Senate to be controlled by a variety of micro-parties from July 2014. This will have implications for national energy strategy and targets:

Renewable Energy Target - Australia has currently a Renewable Energy Target (RET) which mandates an electricity supply target of 20% by 2020 for liable retailers. Renewable energy certificates are created for each megawatt hour of generation which are then traded to meet obligations. The scheme is split into two components: the large-scale target (LRET) and the small scale scheme (SRES). The latter is focused largely on domestic solar photovoltaic systems. The LRET has no specific bands or allocations for different technologies and so is met largely by onshore wind. The incoming government has committed to perform a legislative review of the RET in early 2014, and will consider calls to reduce the fixed 41,000 GWh LRET to reflect falling electricity demand.

Carbon Tax/Trading Scheme - from July 2012, a carbon tax of $23/t of CO2 on the top 200 "polluters" has been effective. This is due to transition to an emission trading scheme in July 2014, with the price linked to the European scheme. As part of its election commitment, the Coalition has vowed to repeal the carbon tax immediately. The legislation has been drafted but it is still unclear whether it will pass through the Senate prior to July 2014.

Energy White Paper - In their Energy White Paper released in 2012, the former government acknowledged the magnitude of Australia's ocean energy resources. However this was not translated into clear generation potential. The new Federal Government has indicated they will release an Energy White Paper in early 2014. This paper will set out a strategic policy framework to address the challenges in the energy sector. Prior to the election, the Coalition released its Policy on Resources and Energy [14] which does not provide any clear direction for renewable energy. The industry will be working hard to get the generation potential of ocean energy recognised in this document.

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13 www.csiro.au/ocean-renewable-energy
14 http://lpaweb-static.s3.amazonaws.com/Coalition%202013%20Election%20Policy%20%E2%80%93%20Energy%20and%20Resources%20%E2%80%93%20Final.pdf

MAIN SUPPORT INITIATIVES

The Australian Renewable Energy Agency (ARENA) was established in July 2012 and is currently the only funding mechanism available to ocean energy systems.

With a (current) budget of around $3 billion out to 2022[15], ARENA inherited the management of the previous government grant programmes and is tasked with the objectives of improving the competitiveness of renewable energy technologies and increasing the supply of renewable energy in Australia. It provides support for the research, development, demonstration and commercialisation of developing renewable energy technologies through a suite of largely technology-agnostic programmes.

ARENA will support "measures" and activities that build on the developments internationally in ocean technologies and contribute to capacity building and knowledge generation for the ocean energy sector. Pilot-scale ocean energy projects are also currently being funded and new project applications encouraged. The funding programmes have an open application process and do not set limits on the amount requested or the ratio of applicant to ARENA funding.

The Federal Government has expressed support for ARENA, however, in the legislation recently tabled to repeal the carbon tax, changes to ARENA's overall quantum of funding, and the annual funds available have been proposed. If the legislation passes, this will take effect in July 2014 and reduce the overall budget to around $2.5 billion.

NATIONAL SEA TEST FACILITIES

There are currently no national sea test facilities in Australia.

LICENSING AND ENVIRONMENTAL IMPACT ASSESSMENT

Currently, there is no legislation or regulation designed to deal specifically with offshore renewables at any level of Australian Government. Australia's high level Standing Council on Energy and Resources (SCER), comprising representation from all States, Territories and the Commonwealth, has stated 'Developing a nationally consistent approach to clean energy technology development and deployment' as one of its priority issues. SCER's Clean Energy Working Group (CEWG) is working to develop a national framework for wave, tidal and other marine based renewable technologies. In parallel, the Australian Government is investigating options for a legislative framework that could be adopted for marine renewables located in Commonwealth waters (outside three nautical miles).

Currently projects are required to obtain licences and planning approval through a myriad of state based regulations.

Environmental impact assessments are taking place within the demonstration projects and through the research of the CSIRO.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Government funded R&D

The majority of ocean energy research is done through the Australian university research system financed largely by the Australian Research Council (ARC). A number of Australian universities are involved in ocean energy research. These include the University of Tasmania's Australian Maritime College, Swinburne University of Technology's Centre for Ocean Engineering, Science and Technology, the University of New South Wales Water Research Laboratory, Curtin University, the University of Sydney and spinoff companies from the University of Queensland testing facilities. The research focuses on a wide range of topics of general interest in the ocean energy domain.

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15 www.arena.gov.au

Geoscience Australia is a Federal Government department that provides geoscientific information to industry. They are currently updating the ocean energy resource assessment which will be released in the Australian Energy Resource Assessment in late 2013.
CSIRO's research has been focused on Australia's ocean energy resource base and the economics of inclusion of ocean energy in Australia out to 2050. Current objectives are the development of a national high resolution wave energy resource atlas, multiple-use marine mapping, and application of marine impacts capabilities to the ocean energy industry.

Industry funded R&D and advocacy

The Clean Energy Council (CEC) works with the Ocean Energy Industry Association (OEIA) to represent and develop the industry. This is progressed through public advocacy, ocean development strategy and industry best practise. The CEC has a strong strategic relationship with ARENA.
The companies active in Australia vary in scale from concept development to demonstration to commercial deployment. The industry sums invested are commensurate with the scale of achievement. Those companies which have been successful in gaining government grants have had to invest at significant scale.

Participation in collaborative international projects

Several Australian companies have strong links with overseas partners assisting to develop their technologies. These include Carnegie Wave Energy, Ocean Power Technologies, Oceanlinx, Bombora.
At present, Australia is involved with the Ocean Energy Systems Implementing Agreement through CSIRO. Currently, a temporary (observer status) agent is being used to maintain OES links until a permanent Executive Committee member and alternate are appointed.

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

Ocean energy development continues to be active in Australia. There are eighteen identifiable ocean energy developers consisting of ten wave, six tidal and two companies involved in both wave and tidal energy as shown below. Currently, there are four major government-supported commercial or pilot scale installations under construction, together with plans for other ocean energy activities in both wave and tidal at various stages of development.

COMPANY	RESOURCE	STATUS	COMPANY	RESOURCE	STATUS
Advanced Wave Power	Wave	No update	Wave Rider Energy	Wave	See below
AquaGen	Wave	No update	BioPower Systems	Wave and tidal	See below
Bombora Wave Power	Wave	See below	Oceanlinx	Wave and tidal	See below
Buoyancy Hydro	Wave	No update	Atlantis Resources Corporation	Tidal	No update
Carnegie Wave Energy	Wave	See below	Cetus	Tidal	No update
Marine Power Technology	Wave	No update	Elemental Energy Technologies	Tidal	No update
Ocean Power Technologies	Wave	See below	Tenax Energy	Tidal	No update
Perpetuwave Power	Wave	See below	Tidal Energy Australia	Tidal	See below
Proteus Wave Power	Wave	No update	Tidal Energy Company	Tidal	No update

OPERATIONAL OCEAN ENERGY PROJECTS

Currently, Australia has no commercial ocean energy projects in operation but several under development.

Ocean Power Technologies Australia

The largest project proposed is the Ocean Power Technologies (OPT) 19 MW wave power project off the coast of Victoria. The plant is expected to be built in three phases, and will comprise a 28-buoy array of OPT's modules. The project was awarded a $66.5 million grant by the Federal Government in 2009. They have currently commissioned a detailed seabed survey and are looking to reach financial close on the first stages of the project this year.

Carnegie Perth Wave Energy Project

Carnegie Wave Energy Ltd. was awarded a $13.1 million Federal Government grant and $7.3 million from the Western Australian Government to demonstrate commercial viability of its CETO technology. Four CETO units are to be deployed, with each "buoyant activator" of 11 metres in diameter delivering 240 kW. The project is developing to schedule, with power delivery to the grid planned for the end of 2013.

Port Fairy Pilot bioWAVE Energy Demonstration Project

BioPower Systems has received a $5.6 million Federal Government grant and $5 million from the Victorian Government to develop a $15 million bioWAVE pilot demonstration project off the coast of Victoria. The 250 kW project is making steady progress with design for the foundation and structural components well-advanced, as the electrical design for the subsea cabling and onshore infrastructure. BioPower Systems has been secured a conditional licence to occupy the offshore site, and has an off-take agreement with the grid operator. The bioWAVE deployment is scheduled to occur during late 2014 to early 2015.

Port Macdonnell Wave Energy Pilot Project

Oceanlinx has received a $4 million Federal Government grant for a $7 million project to demonstrate the operation of their GreenWAVE (shallow water) oscillating water column technology 4 km off the South Australian coast. The project was deployed in late October, with grid connection anticipated for the end of 2013.

PLANNED DEPLOYMENTS

Perth based Bombora Wave Power completed its prefeasibility study in January 2013, achieving the technical milestone of delivering the complete wave to wire conversion with its 1:10 scaled prototype in its privately developed tank testing facility. Bombora is in the process of finalising its first external investment to further develop the Front End Engineering Design and feasibility work.

Following a successful sea trial for the proof-of-concept of their wave energy conversion technology, in July 2013 Wave Energy Rider announced the next phase of its multi-million dollar project with the construction of a new pre-commercial Wave Rider Platform that will become the operating module.

Perpetuwave Power is currently working towards completing scale testing of its high efficiency Wave Harvester technology to move to a TRL of 6. An accurate 1:7 scale prototype with full SCADA electronic control system is soon to be tested in limited fetch ocean waters. This is expected to be completed in 2014, with plans to then develop and test a full scale 460 kW pilot plant.

Tidal Energy Australia was granted planning approval from the Western Australian Government for a 40 MW tidal barrage power station. The approval is subject to conditions on nearby network construction and a suitable off-take agreement.

SOUTH AFRICA

Thembakazi Mali
SANEDI

South Africa has an attractive wave and ocean current energy resource that can be exploited for electricity generation. South Africa has established expertise and facilities to conduct research but the level of funding and activity for ocean energy remain small. R&D has been mainly conducted by Stellenbosch University, namely on design, numerical modelling and tank testing of wave energy devices, at University of Cape Town on environmental and regulatory requirements and at University of the Witwatersrand related with the linear synchronous generator.

The South Africa´s Integrated Resource Plan (IRP 2010) prepared in 2010 expects 42% capacity from renewable energy by 2030 (solar, wind, small hydro and bioenergy). Ocean energy has not been included in the Plan but efforts have been done to form a Marine Energy Association with the goal of promoting ocean energy and try to get ocean energy targets in the IRP in the next period of review. Immediate actions being discussed include the preparation of a country roadmap for marine energy and a proper ocean energy atlas.

REPUBLIC OF KOREA

Keyyong Hong
KOREA RESEARCH INSTITUTE OF SHIPS AND OCEAN ENGINEERING

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

A preliminary report for the second national energy master plan updated from the first one released in 2008 is under review and its final version was published in the end of 2013. The national energy demand is expected to increase from 205mTOE in 2011 to 254mTOE in 2035, while the national electricity demand is estimated to rapidly rise from 39mTOE to 70mTOE during the same period. Korea targets to supply 11% of national energy demand from new and renewable energy by 2035. Though the total proportional contribution from new and renewable energy on national energy demand remains the same as the previous one, the strategic development plan of each resource suggests a significant modification. The second national energy master plan reveals more contribution from photovoltaic and wind. However, ocean energy provision reduces from 5% to 1% of the national new and renewable energy supply.

The current strategic plan of ocean energy development in Korea is based on "The 3rd National Plan for Technology Development, Use and Diffusion of New and Renewable Energy" in which the national vision, long-term goal, strategy and action plan for new and renewable energy development for the period of 2009~2030 were established. It also proposed an establishment of laws and regulations for the efficient enforcement of the strategic plan. The national ocean energy development plan will be updated accordingly to the second national energy master plan soon.

MAIN SUPPORT INITIATIVES

The renewable portfolio standard (RPS) as a primary promotion tool for renewable energy, including ocean energy, was enforced to 13 utility companies with a total capacity larger than 500MW in 2012, replacing the FIT (Feed-In Tariff) policy initiated in 2002. It requires the companies to supply 2% of total electricity production by renewable energy in 2012 and to increase its portion to 10% in 2022.

YEAR	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
RPS(%)	2.0	2.5	3.0	3.5	4.0	5.0	6.0	7.0	8.0	9.0	10.0

Renewable Portfolio Standard Enforced to 13 Utility Companies

The RPS policy is supplemented by tradable renewable energy certificates (REC) whose value varies depending on resource type and conditions such as distance from coastline, capacity and installation method. The REC of tidal barrage with embankment is 1.0 while the one without embankment is 2.0. The REC has not been determined for other ocean energies but the ocean thermal energy for air conditioning is approved to be one of renewable energy resources that are obligatorily applied for public buildings.The introduction of tradable renewable energy certificates (REC) is further being discussed for tidal current and wave energy.

The public funding for renewable ocean energy is led by two Government ministries - MOF (Ministry of Oceans and Fisheries) and MOTIE (Ministry of Trade, Industry and Energy) - which operate the national RD&D programme for ocean energy. MOF supports mainly demonstration projects under the "Practical Ocean Energy Technology Development Programme". MOTIE funds mostly fundamental R&D projects under the "New and Renewable Technology Development Programme". The involvement from private sectors has been continuously increased, particularly in the tidal current device development.

NATIONAL SEA TEST FACILITIES

There are no sea test facilities for marine renewable energy in Korea. However, a feasibility study for the construction of test beds for wave and tidal energy devices has been carried out, in which preliminary target sites were identified and a project for extensive survey was recommended. In addition, the expansion of operational pilot plant sites to be used for test beds has been suggested and it includes Uldolmok tidal power plant, Yongsoo OWC wave energy plant and Goseong ocean thermal energy plant.

RELEVANT DOCUMENTS RELEASED

The national strategy and roadmap for renewable ocean energy development is still based on the "RD&D Strategy 2030 for New and Renewable Energy – Ocean" and the "Development of Activity Plan on Ocean Energy R&D Programme" in 2009, which are released by MOF and MOTIE respectively. MOTIE published the bi-annual "White Paper on New and Renewable Energy 2012" in early 2013. A report of the second national energy master plan is currently being finalized and will be released soon.

RESEARCH & DEVELOPMENT

KEY TIDAL ENERGY R&D INSTITUTIONS AND RELEVANT PROJECTS

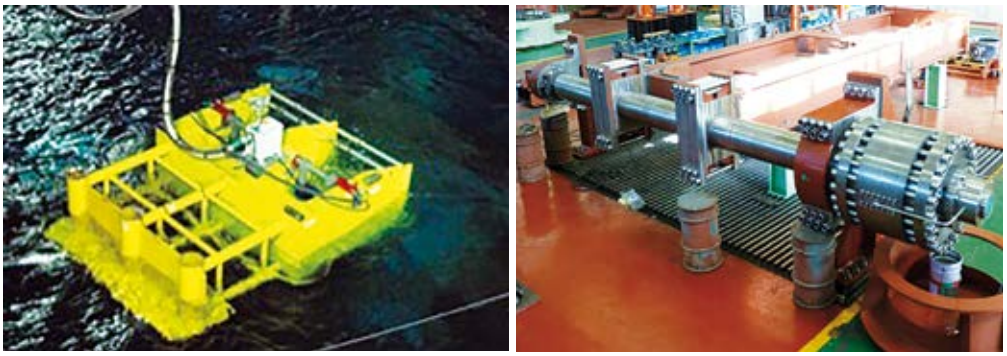
PROJECT (CHARGED BY, FUNDED BY)	TYPE OF CONVERTER	STRUCTURE	POWER CAPACITY	PROJECT PERIOD	REMARKS
Tidal Current Energy RC (KMOU, MOTIE)	(Turbine Design)	(Underwater Design)	(Resource Assessment)	2009~2014	Joint Research Centre
MW Class Tidal Current Device (HHI, MOTIE)	Pitch Control	Pile	>2X500kW	2010~2015	Sea Test in 2014
Hydraulic Turbine for Tidal Barrage (HHI, MOTIE)	Bulb	Caisson	7MW (Development) 30MW (Design)	2011~2014	Applicable to Hydraulic Dam
Flexible Turbine for Tidal Current (KIOST, MOTIE)	Oscillating Hydrofoil	Pile	10kW	2011~2014	Efficiency > 26%
Active Control Tidal Current System (KIOST, MOF)	HAT with Pitch Control	Varying by Water Depth	300kW	2011~2017	Sea Test in 2016
Semi-active Flow Control Turbine (Inha Univ., MOTIE)	HAT with Flow Control	Moored Submergible	10kW	2013~2016	Based on CFD

KMOU: Korea Maritime and Ocean University / HHI: Hyundai Heavy Industries Co., Ltd. / KIOST: Korea Institute of Ocean Science and Technology

Active Control Tidal Turbines: Horizontal Axis, Vertical Axis, Flapping Hydrofoil

KEY WAVE ENERGY R&D INSTITUTIONS AND RELEVANT PROJECTS

PROJECT (CHARGED BY, FUNDED BY)	TYPE OF CONVERTER	STRUCTURE	POWER CAPACITY	PROJECT PERIOD	REMARKS
Yongsoo OWC (KIOST, MOF)	OWC with Impulse Turbine	Gravity Caisson	2X250kW	2003~2015	Pilot Plant in 2014
AWS with 4-sided Linear Generator (Yonsei Univ., MOTIE)	Submerged Pressure Differential	Bottom-fixed Submerged Buoy	200kW	2010~2013	10kW Prototype Test in 2013
Resonant Vertical Oscillator (Gyeongju Univ., MOTIE)	Point Absorber	Single Point Moored Buoy	-	2010~2013	Prototype Test in 2013
Pendulum WEC (KIOST, MOF)	Oscillating Surge	Floating Twin Hull	300kW	2010~2016	Sea Test of Pilot Plant in 2013
Cross-Flow Hydraulic Turbine (KMOU, MOTIE)	Wave Induced Flow	Moored Floating Hull	-	2011~2014	Sea Test in 2014
Swinging Semi-Sphere with Hinged Arm(Ulsan Univ., MOTIE)	Floating Point Absorber	Jack-up Platform	Expandable 15kW Units	2013-2016	Sea Test in 2016



Pendulum Wave Energy Converter System and Rotary Vane Pump

OTHER OCEAN ENERGIES ENERGY R&D INSTITUTIONS AND RELEVANT PROJECTS

PROJECT (CHARGED BY, FUNDED BY)	PROJECT PERIOD	REMARKS
Promotion Programme for Ocean Energy Education (KIMST, MOF)	2009~2018	MLTM programme promoting ocean energy education, research and development in universities
OTEC Using Deep Ocean Water (KIOST, MOF)	2010~2015	Cooling & heating system of 60RT in 2011, 500RT in 2012 and 1,000RT in 2013 OTEC pilot plant of 20kW in 2013 and 200kW in 2014
Hybrid System of OWT and Tidal Current Converter (Inha Univ., MOTIE)	2011~2013	Development of fundamental technologies for hybrid power system utilizing offshore and tidal current energies
Hybrid OTEC Using Plant Array (KEPRI, MOTIE)	2011~2014	Use of cooling water discharged from power plant Pilot plant of 10kW in 2014
Standardization of Mooring System for OES (KR, MOTIE)	2011~2014	Development of international standards for design and evaluation of mooring system applicable to ocean energy devices
Establishment of Infra System for Ocean Energy (KAIST, MOTIE)	2011~2016	Education programme for ocean energy experts in graduate school
Sea Test Bed for Ocean Energy (KOMERI, MOTIE)	2012~2013	Feasibility study and field survey on coastal test bed sites for wave energy converters and tidal energy devices
Standardization of OTEC (KR, MOTIE)	2012~2014	Development of international standards for design and evaluation of ocean thermal energy utilization system

KIMST: Korea Institute of Marine Science and Technology Promotion
KEPRI: Korea Electric Power Research Institute
KR: Korea Register of Shipping
KAIST: Korea Advanced Institute of Technology
KOMERI: Korea Marine Equipment Research Institute

OTEC and Seawater Air-conditioning System

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

NAME OF UTILITY	TYPE OF INVOLVEMENT
Korea Water Resources Corporation (K-water)	Operation of Sihwa tidal barrage power plant
Korea East-West Power Co., Ltd.	Operation of Uldolmok tidal current pilot plant
Korea Western Power Co., Ltd.	Feasibility study on Garorim tidal barrage power site
Korea Hydro and Nuclear Power Co., Ltd.	Feasibility study on Incheonman tidal barrage power site
Korea Midland Power Co., Ltd.	Feasibility study on Ganghwa tidal barrage power site
Hyundai Heavy Industry Co., Ltd.	Full-scale demonstration of 1MW tidal current device
Korea Electric Power Corporation	Prototype demonstration of attenuator with liquid column oscillator Basic research on OTEC utilizing discharged water from power plant

OPERATIONAL OCEAN ENERGY PROJECTS

The world's largest tidal barrage power plant at the artificial sea-water Lake Sihwa, with an output capacity of 254MW, began its operation in August 2011. It has produced 51GWh in 2011, 466GWh in 2012 and 395GWh from January to September 2013. It is still in the controlled test operation when it monitors and evaluates the performance of system components as well as the influence to the sea environment. It is expected to produce 552GWh annually as it operates fully. A Renewable Cultural Centre is being built at the Sihwa tidal barrage theme park and its completion is expected in 2014.
Since Uldolmok tidal current power plant of 1MW capacity was completed in May 2009, its operation has been optimized in various tidal conditions, resulting in the significant improvement of power production. It is equipped with a couple of helical turbines of 500kW capacity and the jacket frame is applied as a basic structure.

Operational Ocean Energy Projects

PLANNED DEPLOYMENTS

The construction of the 500kW OWC pilot plant in Yongsoo of Jeju Island has been delayed, and its completion is now expected in the second half of 2014. The Yongsoo wave power plant developed by KIOST and funded by MOF will be equipped with a couple of turbines and generators of 250kW capacity. The plant that is located at 1km off the coastline will be connected to a national grid by the 22.9kV AC underwater cable of about 1.5km length. Future plans for the deployment of ocean energy devices in Korea include 300kW pendulum wave energy converter of KIOST at Jeju in 2015, 1MW twin horizontal axis tidal turbine of HHI at Jangjuk in 2014, 300kW active control tidal turbine of KIOST at Uldolmok in 2016 and 200kW deep seawater utilizing OTEC of KIOST at Goseong in 2014.

Construction of Yongsoo OWC Pilot Plant

CHINA

Dengwen Xia
NATIONAL OCEAN TECHNOLOGY CENTRE

INTRODUCTION

In 2013, the Chinese Government promulgated the "Twelfth Five-Year" Plan of Energy Development, which envisions that the share of non-fossil energy in the gross generation could increase to 30% by 2015, and the carbon emission per unit of GDP in 2015 would decrease by 17% relative to 2010. The fourth round of the special funding programme sponsored by the Ministry of Finance (MOF) and the State Oceanic Administration (SOA) of the People's Republic of China to support the demonstration and public service platform of marine renewable energy (MRE) comes into effect. The National Development and Reform Commission (NDRC) published the "provisional regulations on distributed generation" and the "notice on the issues concerning the adjustment of renewable energy electricity price tariff and environmental protection electricity price" to provide electricity production subsidy and electricity price tariff for MRE. The MRE entered the "guiding catalogue of key products and services in strategic emerging industries", as one of the 125 developing projects; the MRE industry will attract more and more social investments.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

In January 2013, the Chinese Government promulgated the "Twelfth Five-Year" Plan of Energy Development, which envisions that the proportion of the non-fossil energy consumption could increase from 8.6% in 2010 to 11.4% in 2015, the share of non-fossil energy in the gross generation could increase to 30% by 2015, and the carbon emission per unit of GDP in 2015 would decrease by 17% relative to 2010. Also, the plan would "steadily boost the development and utilization of renewable energy, including MRE"; "expedite the distributed utilization of renewable energy, including wind energy, solar energy, MRE and so on".

MAIN SUPPORT INITIATIVES

In July 2013, NDRC published the "provisional regulations on distributed generation", which would provide constructing subsidy or electricity production subsidy to distributed generation of new energies including wind energy, solar energy, biomass energy, geothermal energy and marine renewable energy.
In August 2013, NDRC published the "notice on the issues concerning the adjustment of renewable energy electricity price tariff and environmental protection electricity price", which would improve the renewable energy electricity price tariff from 0.8 cent to 1.5 cent per kWh.
In September 2013, the 4th round of special funding programme for MRE (SFPMRE), sponsored by MOF and SOA, initiated. The total amount of financial support is RMB200 million (around USD30 million). 12 projects have been confirmed mainly for R&D and demonstration technologies in two good resources areas, that is to say, Zhoushan, Zhejiang province, for tidal energy technology and Wanshan, Guangdong province, for wave energy technology.

NATIONAL SEA TEST FACILITIES

The small-scale wave energy and tidal current energy test site, designed by NOTC, is located in the Yellow Sea, adjacent to Shandong province, 3 km off the coastline. The first berth (300 kW) capacity building projects have been confirmed in August 2012. But the consent of local government is under progress. It is difficult to negotiate because of the conflict of use of sea area.

To fulfil the national target of MRE in the "Twelfth Five-Year" Plan of Renewable Energy Development and the "Twelfth Five-Year plan of Energy Development (2011-2015) in China, we have been engaged in promoting the development and utilization of MRE public service platform.

According to the planned programmes, 2 main demonstration bases for MRE communities in rich MRE resources areas of China would be built to foster the MRE industrialization, one for tidal energy (1 MW) in Zhoushan, Zhejiang province, the other for wave energy (300 kW) in Wanshan, Guangdong province. The 1 MW tidal current energy test site and demonstration zone will include 6 demonstration berths and 3 test berths. The 300 kW wave energy test site and demonstration zone will include 6 demonstration berths and 3 test berths (2 berths with depth of 30-50 m and 1 berth with depth of 10-30 m). In the support of the 4th round of SFPMRE, the site selection and in situ observation will continue until 2014.

RELEVANT DOCUMENTS RELEASED

In January 2013, SOA published the "Twelfth Five-Year" Plan for Development of National Marine Affairs, which encourages expediting the utilization of MRE, building the MRE test platform, and establishing the MRE standard system, thus to accelerate the MRE industrialization process.

In February 2013, the Chinese Government promulgated the Medium- and Long-Term Plan for the Construction of National Major Scientific and Technological Infrastructure (2012-2030), which will demonstrate the infrastructure construction for energy capture, storage, conversion and grid-connection of low energy density RE, including biomass energy, geothermic energy and MRE.

RELATED ACTIVITIES

In May 2013, the 2nd China Marine Renewable Energy Conference, hosted by NOTC and ACMRE and sponsored by SOA, Chinese Society for Oceanography (CSO) and China Association of Oceanic Engineering (CAOE), was held in Guangzhou, Guangdong province. The theme of the annual conference is "pioneering and innovative, the way to Blue Energy". In total, 270 participants from central and local governments, universities, research institutes, industries and stakeholders and delegates and guests of 24th IEA-OES ExCo Meeting participated in the conference.

Delegates of 24th ExCo meeting participated in 2nd CMREC

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

TIDAL ENERGY

Ocean University of China (OUC): "Site selection and pre-feasibility study on **Rushan estuarine** tidal power station (40MW)" was completed in January 2013. The EIA and technical & economic feasibility analysis indicates that 6 tubular turbines with 40.2 MW total installed capacity would need more than RMB 2 billion (around USD 300 million), that is $8000 per kW. Meanwhile, the environmental benefit could reach $0.016/kWh, and the aquiculture benefit is $0.135/kWh. More important, the station would reduce more than 60000 t of CO2 emission annually.

The "pre-feasibility study on **Bachimen** tidal power station (30 MW)", also implemented by OUC, and the "pre-feasibility study on **Maluan Bay** tidal power station (24 MW)" implemented by Datang Fujian Power Generation Co., Ltd. has accomplished the site selection and the engineering pre-selection in 2013.

TIDAL CURRENT ENERGY

Harbin Engineering University (HEU): in the support of the National Key Technology R&D Programme (NKTRDP), **Haineng I** vertical-axis tidal current energy device (2×150 kW) continued to be tested in Guishan Channel, Zhejiang province in August 2013 (the first deployment and test time is in July 2012). The device carrier is a catamaran-type with 24×13.9×2m dimension, the diameter of the turbine is 4 meter, with 1.8m/s of cut-in speed and 2.5m/s of cut-out speed.

Haineng III vertical-axis tidal current energy device (2×300 kW) was supported by the first round of SFPMRE, the floating device designed by HEU was deployed in Daishan, Zhejiang province, for sea trial. The diameter of the turbine is 6 meters, with 1.2m/s of cut-in speed and 3.5m/s of cut-out speed.

Haineng II horizontal-axis tidal current energy device (2×100 kW) was supported by the first round of SFPMRE, the floating device designed by HEU was assembled in June 2013 for sea trial. After the in-situ modulation, the device is planned to be deployed in Zhaitang Island, Shandong province in December 2013. The diameter of the turbine is 12 meters, with 0.6m/s of cut-in speed and 2m/s of cut-out speed.

Ocean University of China: OUC Turbine (2×50 kW) is a fixed horizontal-axis tidal current energy device, supported by the first round of SFPMRE. The device was assembled in August 2013 for sea trial. After the in-situ modulation, the device is planned to be deployed in Zhaitang Island, Shandong province, in December 2013. The diameter of the turbine is 10.5 meters, with 0.9m/s of cut-in speed and 2.5m/s of cut-out speed.

Haineng I 300kW tidal current device in test

Haineng III 600kW tidal current device in test

Haineng II 200kW tidal current device in the dock

OUC 100kW tidal current device assembled

WAVE ENERGY

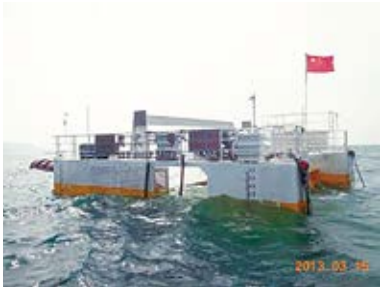
Guangzhou Institute of Energy Conversion (GIEC) of CAS: in the support of the first round of SFPMRE, GIEC has developed a serial of DUCK wave energy device, from DUCK I, DUCK II to DUCK III. In April 2013, a 100 kW **DUCK III** device was deployed in Wanshan Island, Shandong province, for sea trial. The width of the energy-capturing structure is 10 meters, and the weight of the DUCK III is about 350 tonnes. The sea test proved the simple structure and high energy capture efficiency, but the stability of the nodding duck WEC is not perfect.

Eagle I WEC (10 kW) was supported by the second round of SFPMRE. Based on the advantages and experiences of the nodding duck WEC, GIEC developed the sharp eagle WEC, which could effectively absorb the incident wave and reduce the transmission wave. The Eagle I WEC was deployed in Wanshan Island, Shandong province, for test from 28th December 2012 to 24th January 2013, from 14th March 2013 to 11th April 2013 and form 6th May 2013 to 11th June 2013. The accumulative operating time is 2261 hours; the total conversion efficiency is 16.76%.

Nezha II WEC (20 kW) was supported by the first round of SFPMRE. Based on Nezha I WEC (10 kW), GIEC developed the point-absorber WEC. The diameter of the floating body is 4.8 meters. Nezha II was deployed in February 2013, but was destroyed during the tropical storm (YAGI) on 8th June 2013. The accumulative operating time of the device is 1860 hours; the maximum power is 11.47 kW.

National Ocean Technology Center (NOTC): in the support of the NKTRDP, the **FLB** 100 kW bottom-mounted wave converter developed by NOTC has been deployed in Daguan Island, Shandong province, since July 2013. The rated significant wave height is 2m, and the average conversion efficiency is 14%. Unfortunately, the hydraulic device was destroyed by the typhoon. Now, NOTC is collaborating with Tsingtao Haina Co. to develop an optimized converter of 50 kW rated capacity in the support of SFPMRE. It is expected to be deployed for sea trial in next two years.

DUCK III 100kW WEC in test



Eagle I WEC in test

Nezha II 20kW WEC in test

FLB in the maintenance

TECHNOLOGY DEMONSTRATION

MAJOR INDUSTRY PLAYERS

China Longyuan Power Group Corporation Limited (China Longyuan, the former China Longyuan Power Technology Developing Corporation): founded in January 1993 and affiliated to China National Department of Energy. In June 1996, China Longyuan, Zhongneng Technology Company, Fulin Company consolidated into China Longyuan Power Group. At the end of 2002, the corporation is affiliated to China Guodian Corporation in China's reform of electricity industry. With the approval of the State-owned Assets Supervision and Administration Commission of the State Council, China Longyuan Power Group Corporation was officially transformed into China Longyuan Power Group Corporation Limited on 9 July 2009.

By the end of 2012, the crew of the company had amounted to over 6000. The company dedicates mainly to the design, development, construction, management and operation of wind farms. In addition, it also runs other projects, such as thermal power, solar power, tidal power, biomass power and geothermal power. Meanwhile it offers services to wind farms, including consultation, repair, maintenance, and training.

The Jiangxia Tidal Test Power Station owned by China Longyuan is the largest tidal power station in China; the installed capacity is 3900 kW. After years of accumulation, the company has gradually formed unique advantages in marine engineering maintenance, tidal turbine maintenance, and tide integrated utilization.

OPERATIONAL OCEAN ENERGY PROJECTS

Jiangxia Tidal Power Plant: the total installed capacity is 3.9 MW and the annual electricity generated is 7200 MWh. With the upgrading of one existing turbine from 500 kW to 700 kW, the total installed capacity will be 4.1 MW in 2014.
Jiangxia Tidal Power Plant has operated well for more than 30 years. The successful operation of the Jiangxia Tidal Power Plant has proven that the construction of a tidal power plant would not cause the serious siltation of the cove, nor have a significant environmental impact on local marine ecological environment.

Daguan Island Isolated Hybrid Power Demonstration Station: the demonstration station (105 kW) supported by the Ministry of Science and Technology (MOST) has been in operation since June 2011 and has provided electricity for residents in Daguan Island continuously for 30 months. The station includes the 30 kW wave energy device, 60 kW wind turbines and 15 kW solar cells. Unfortunately, the wave energy device suspended operation in December 2012.It is expected to be recovered next year.

PLANNED DEPLOYMENTS

Zhaitang Island Isolated Hybrid Power Demonstration Station: the demonstration station (500 kW) was supported by the first round of SFPMRE and implemented by China National Offshore Oil Corporation (CNOOC). The 150 kW wind generator and 50 kW solar panel has been installed. The 2×100 kW floating tidal energy device (HEU) and the 2×50 kW fixed tidal energy device (OUC) have been assembled and will be deployed soon.

Wanshan Island Isolated Hybrid Power Demonstration Station: the demonstration station (500 kW) was supported by the first round of SFPMRE and implemented by GIEC, which includes 300 kW (2×150kW) nodding duck wave energy devices and a 200 kW wind generator. One of the two wave energy devices was deployed in November 2013. The wind generator has been installed.

Guanshan Island Isolated Hybrid Power Demonstration Station: the demonstration station (600 kW) was supported by the first round of SFPMRE and implemented by Daishan County Science & Technology Development Centre (DCSTDC), which includes 2×300 kW floating vertical axis tidal energy devices (HEU).

NIGERIA

Lawrence Awosika
NIGERIAN INSTITUTE FOR OCEANOGRAPHY AND MARINE RESEARCH

The Nigerian Institute for Oceanography and Marine Research (NIOMR), the Federal Government approved contracting agency on Ocean Energy Systems(OES), in collaboration with FOT-K Consortium- the approved alternate delegate to OES, is undertaking research activities and putting together a proposal to the Nigerian Government to undertake a feasibility study that will explore and identify suitable locations for the implementation of Ocean thermal energy conversion (OTEC) facilities offshore the Nigerian Continental shelf. The scope of work that will be carried out in this feasibility study will include geological, oceanographic, engineering, socioeconomic and other environmental activities. This will involve other agencies in Nigeria with mandate for ocean activities. Internationally, we intend to involve professionals from other parts of the industry to enhance our work.

The draft policy direction/roadmap on the ocean energy activities in Nigeria is currently been considered by the Federal Government of Nigeria. Government is also considering setting up an ocean energy activity centre: CENTRE FOR OCEAN RENEWABLE ENERGY RESOURCES (CORER). This centre is to be located on approval, within the existing Nigeria Institute for Oceanography & Marine Research (NIOMR), with its operational board drawn from all relevant government agencies that are statutorily involved in ocean research, security, management, energy generation and distribution sectors of the economy.

MONACO

HE Bernard Fautrier
GOVERNMENT OF THE PRINCIPALITY OF MONACO

INTRODUCTION

On the instigation of H.S.H. Prince Albert II, the environment and subjects related to sustainable development are among the most important political priorities in the State of Monaco, on both a national and international level. The actions of the Princely Government take into account the topics of biodiversity, the management of resources and the reduction of greenhouse gases and also a specific policy towards the establishment of a sustainable city.

The Principality of Monaco is the newest country that joined the OES in June 2013. This action was part of the Government concerns for combating climate change and recognizing the relevance for international cooperation. Monaco is a coastal country with 2,02 km^2 of area, bordered by the Mediterranean Sea, with a coast length of 3829 m.

In Monaco, ocean energy projects have been demonstrated through the usage of sea water heat pumps to generate energy.

ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The Government pursues a decisive sustainable development policy aimed at achieving full compliance with the Principality's undertakings, in particular with the Kyoto Protocol. This intention is expressed through local initiatives on the Monegasque territory and through cooperation work in developing countries.

In line with the provisions of the Kyoto Protocol, Monaco has set itself the target of improving energy efficiency by 20% and achieving 20% of final energy consumption from renewable sources by 2020.

To this end, the deployment of the Climate and Energy Plan includes technical, regulatory, financial and awareness-raising campaigns.

Carbon neutral by 2050

During his participation at the 15th United Nations Climate Change Conference in 2009 in Copenhagen, H.S.H. the Sovereign Prince unveiled new directions for the Principality.
Monaco will take part in efforts to stabilize the global warming of the planet by reducing its greenhouse gas emissions by 30% in 2020 and 80% in 2050 (by which time the Principality will be carbon neutral) with respect to the reference date of 1990.
In addition, the Princely Government funds projects in several developing countries, forming part of the Clean Development Mechanisms (CDMs) laid down by the Kyoto Protocol.

National Sea Test Facilities

Monaco wishes to develop ocean energy. Currently, sea water heat pumps produce a significant share of the Principality's energy needs.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Several avenues for research and development exist.

Firstly, the Climate and Energy Plan has created a dedicated funding instrument, the Energy-Sustainable Development Fund. The money is generated through the sale of electricity and creates funds for the promotion of renewable energies and other sustainable development objectives.

Secondly, the OPTIMA PAC initiative is a research project that checks how well the existing demonstration projects in Monaco perform against three targets:

- Offering an industrial range of sea water heat pumps compatible with sustainable development;
- Controlling environmental impacts;
- Optimising design and operation.

Partners include a wide range of energy companies. The budget of the initiative amounts to €2,391 million over 42 months.

TECHNOLOGY DEMONSTRATION

OPERATIONAL OCEAN ENERGY PROJECTS

In Monaco, the sea is used as a renewable energy source for the development of a heat pump system. The first heat pump with sea water in Monaco dates back to 1963. Today, 64 heat pumps produce 17% of the energy consumed in the Principality. Many buildings located on the coast benefit from this reversible system, for heating in winter and air-conditioning in summer. These save the equivalent of 15,000 metric tons of oil per year. One example is the reference project in the Grimaldi Forum (Congress Centre). Five sea water heat pumps have a cold exchange capacity of 5.1 MW and a heat exchange capacity of 6.5 MW.

06

STATISTICAL OVERVIEW OF OCEAN ENERGY

The information provided in this section refers to the year 2013
and was compiled from information provided by each delegate member.

6.1

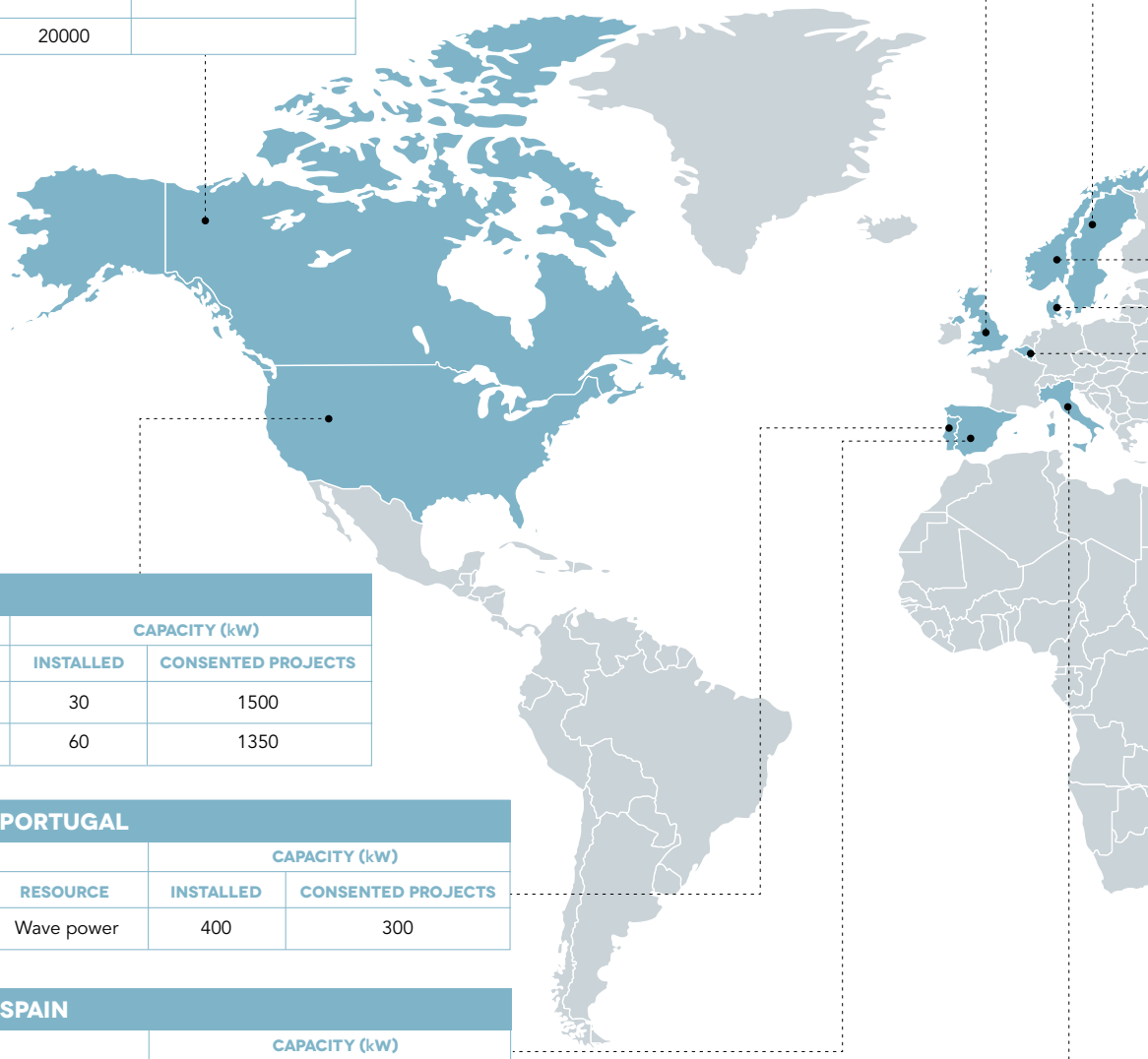
OCEAN POWER IN OES COUNTRIES (2013)

UNITED KINGDOM

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	3850	40000
Tidal currents	5200	96000

CANADA

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Tidal and river currents	250	5500
Tidal Power	20000	



USA

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	30	1500
Tidal currents	60	1350

PORTUGAL

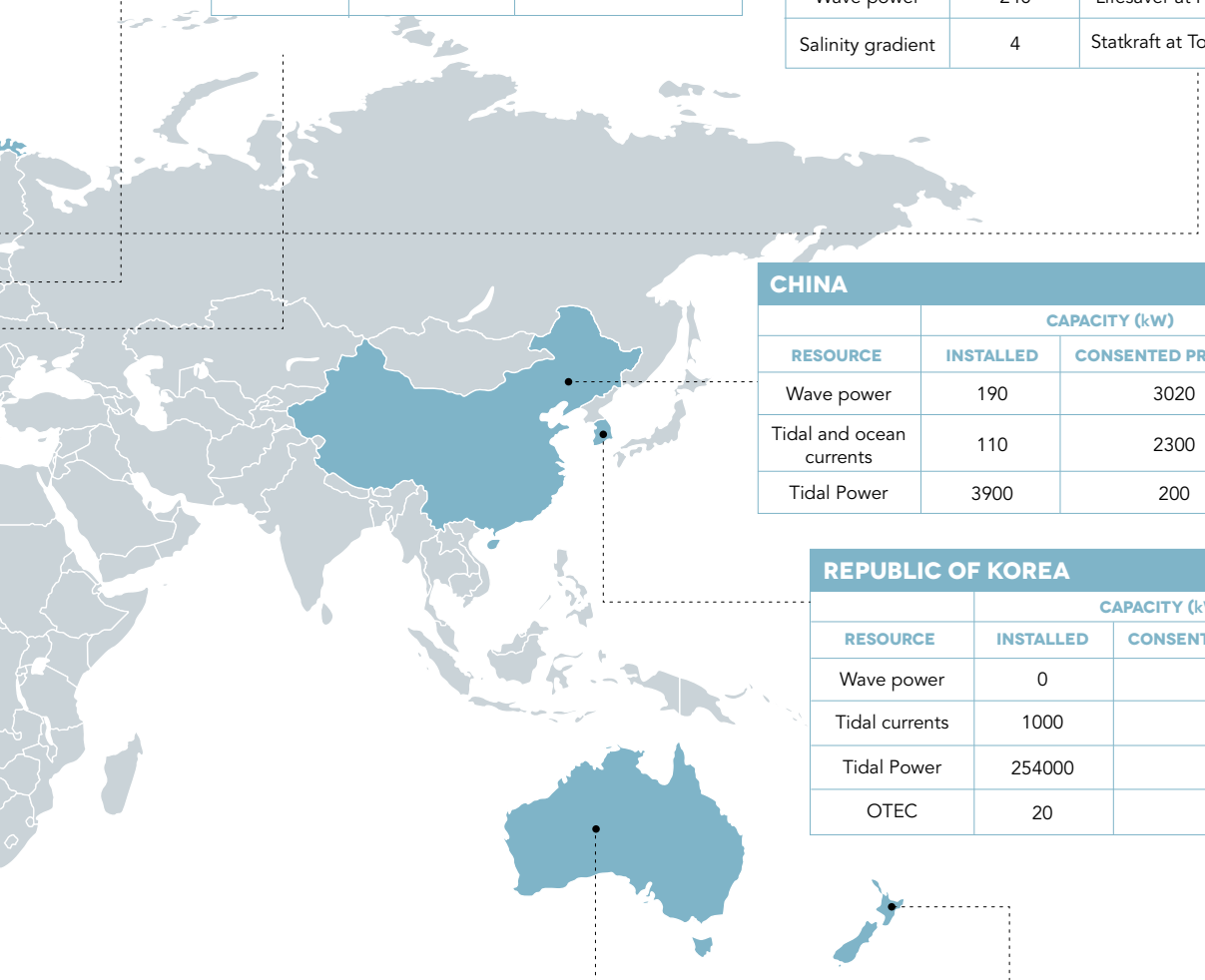
	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	400	300

SPAIN

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	296	300

ITALY

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	150	200
Tidal currents	60	



SWEDEN

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	230	10000+(350-400)
Tidal and ocean currents	7,5	

DENMARK

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	NA-2013	

BELGIUM

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power		Up to 20000

NORWAY

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	240	Lifesaver at Falmoth, UK
Salinity gradient	4	Statkraft at Tofte, Norway

CHINA

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	190	3020
Tidal and ocean currents	110	2300
Tidal Power	3900	200

REPUBLIC OF KOREA

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	0	800
Tidal currents	1000	1300
Tidal Power	254000	0
OTEC	20	200

AUSTRALIA

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power		21210

NEW ZEALAND

	CAPACITY (kW)	
RESOURCE	INSTALLED	CONSENTED PROJECTS
Wave power	0	22040
Tidal currents	0	201000

6.2

OPEN SEA TESTING FACILITIES

UNITED KINGDOM

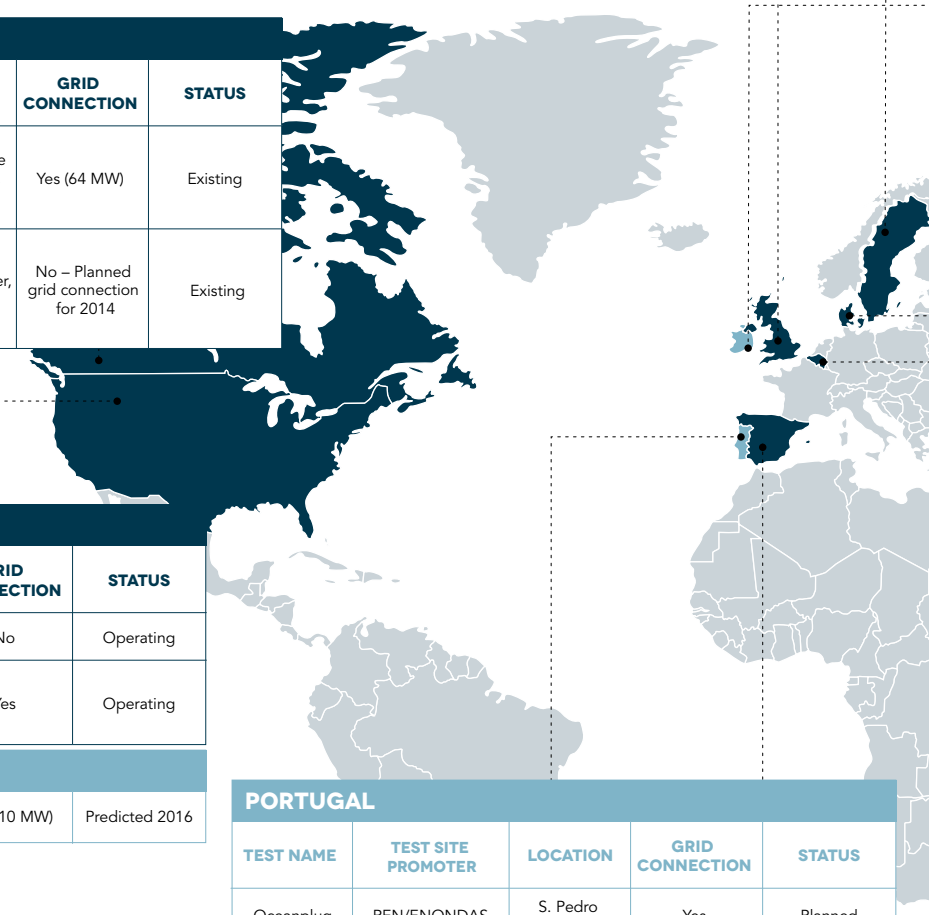
TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
EMEC	Neil Kermode	Orkney, Scotland	Yes (11MW)	Existing
WaveHub	Claire Gibson	Hayle, Cornwall	Yes (20MW)	Existing
FabTest	Falmouth Harbour Commissioner	Falmouth, Cornwall	No	Existing

UNITED KINGDOM

Solent Ocean Energy Centre	Isle of Wright Council	St. Catherine's Point, Isle of Wright	Yes (20MW)	Planned (construction to begin 2015)

CANADA

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
Fundy Ocean Research Centre for Energy (FORCE) – Tidal Energy	FORCE	Minas Passage (Nova Scotia, Canada)	Yes (64 MW)	Existing
Canadian Hydrokinetic Turbine Test Centre (CHTTC) – River Current Energy	Lead: University of Manitoba	Winnipeg River, Manitoba	No – Planned grid connection for 2014	Existing



USA

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
PMEC - NETS	NNMREC and OSU	North of Yaquina Head	No	Operating
Kaneohe Site	HINMREC	Marine Corps Base Hawaii, Kaneohe Bay, Hawaii	Yes	Operating

USA

PMEC – SETS	NNMREC and OSU	Newport, Oregon	Yes (~10 MW)	Predicted 2016

PORTUGAL

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
Oceanplug	REN/ENONDAS	S. Pedro de Moel	Yes	Planned

SPAIN

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
Bimep	EVE	Armintza, Bilbao	Yes (20MW)	In operation

SPAIN

PLOCAN	Promoter: PLOCAN Consortium (integrated by the Ministry of Economy and Competitiveness and the Autonomous Government of the Canary Islands)	Canary Islands	Yes (15 MW)	Planned (end 2014)

Operational

Under Development

IRELAND

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
Galway Bay Quarter Scale Wave Energy Test Site	Marine Institute	Galway Bay	No	Operational
Atlantic Marine Wave Energy Test Site (AMETS)	SEAI	Belmullet	Yes	Under development

SWEDEN

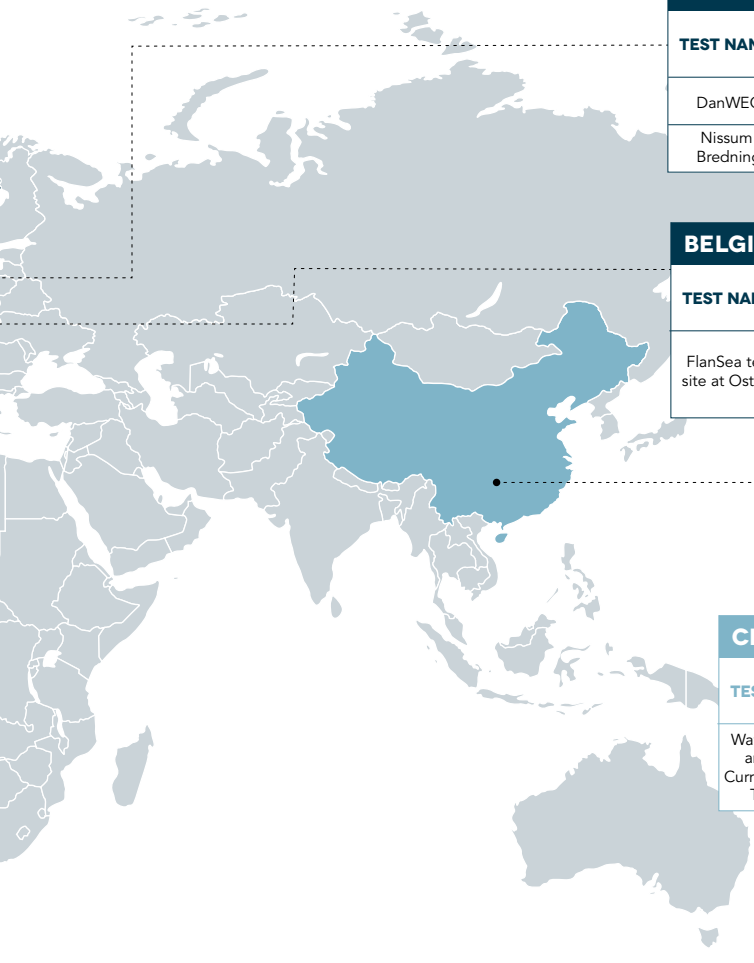
TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
Lysekil wave power research site	Uppsala University	Islandsberg	No	Existing (2006)
Söderfors marine currents research site	Uppsala University	Söderfors, Dalälven river	No	In operation
DGO - Deep Green Ocean	Minesto	Strangford Lough, UK	No	Existing

DENMARK

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
DanWEC	DanWEC	North Sea Hanstholm	Planned in 2015	Operational
Nissum Bredning	Aalborg University	Benign site	Yes (20 kW)	Operational

BELGIUM

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
FlanSea test site at Ostend	Port of Ostend	Ostend, Belgium	No	Ready



CHINA

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
Wave Energy and Tidal Current Energy Test Site	National Ocean Technology Center	Chengshantou (Shandong Province)	Yes (0.3MW)	Consenting process under progress

NEW ZEALAND

TEST NAME	TEST SITE PROMOTER	LOCATION	GRID CONNECTION	STATUS
NZ Marine Energy Centre	AWATEA and HERA	Wellington region	1 MW planned	Planned (2015)

6.3

ELECTRICAL UTILITIES INVOLVED IN R&D

COUNTRY	NAME OF UTILITY	TYPE OF INVOLVEMENT
BELGIUM	Electrabel (Suez GDF)	Planning project development
CANADA	NALCOR – Newfoundland and Labrador	Technology development for microgrid management
	EMERA / Nova Scotia Power	Open Hydro investor, technology demonstrator, planning project development
	Hydro Quebec	Engagement with technology demonstrations
	Ontario Power Authority	Waterpower Feed in Tariff for project development
	Manitoba Hydro	Access to site for R&D and technology demonstration
	BC Hydro	Standing offer amended to allow technology demonstration; site access for technology demonstration of river current
CHINA	China Longyuan Power Group Corporation Limited	R&D
	Datang Fujian Power Generation Co., Ltd.	technology demonstration
	Datang Shandong Power Generation Co., Ltd.	technology demonstration
	Huaneng Renewables Corporation Limited	project development
DENMARK	Dong Energy	Partnership with Wavestar and Floating Power Plant
IRELAND	Electricity Supply Board	Participates in the development of a number of wave and tidal technologies in Ireland and elsewhere. ESBI also works to develop the AMETS open ocean wave test facility. The ESB is lead partner in developing the Westwave 5MW demonstration project.
	Bord Gais Eireann (BGE)	In 2012 BGE was awarded a lease for the development of a 100MW tidal energy project, using Open Hydro technology, in Northern Ireland.
ITALY	Enel green Power	R&D, Technology Demonstrations and Projects Development.
MEXICO	CFE	Pilot projects
NETHERLANDS	Delta NV	Engaging with project and technology developers on tidal opportunities in the region of Zeeland, PPAs
	Eneco	Tidal barrage system in Brouwersdam (expressed interest), PPAs

	Greenchoice	Low head hydro sites throughout the Netherlands, PPAs
NEW ZEALAND	Todd Energy	Majority owner of Crest Energy Kaipara Limited (owner of consented project for 200 x 1 MW tidal turbines in Kaipara Harbour
NORWAY	Arendal Fossekompani	Part owner of tidal/current energy concept Flumill
	Statkraft AS	Develops osmotic power
	Hammerfest Energi AS	Part owner of Hammerfest Strøm AS
	Dalane energi	Supports Langlee wave concept
REPUBLIC OF KOREA	Korea Water Resources Corporation (K-water)	Operation of Shihwa tidal barrage power plant
	Korea East-West Power Co., Ltd.	Operation of Uldolmok tidal current pilot plant
	Korea Western Power Co., Ltd.	Feasibility study on Garorim tidal barrage power site
	Korea Hydro and Nuclear Power Co., Ltd.	Feasibility study on Incheonman tidal barrage power site
	Korea Midland Power Co., Ltd.	Feasibility study on Ganghwa tidal barrage power site
	Hyundai Heavy Industry Co., Ltd.	Full-scale demonstration of 1MW tidal current device
	Korea Electric Power Corporation	Prototype demonstration of attenuator with liquid column oscillator
		Basic research on OTEC utilizing discharged water from power plant
SPAIN	IBERDROLA	R&D, technology demonstration and project development.
	REPSOL	R&D
	FCCE	Technology Demonstration
SWEDEN	Fortum	The Sotenäs Project is partly funded by the utility Fortum.
	Vattenfall	CFE II is partly funded by the utility Vattenfall
	Statkraft	CFE II is partly funded by the utility Statkraft
UNITED KINGDOM	EoN	Technology Demonstration/Project Development
	Scottish Power Renewables	Technology Demonstration/Project Development
	Scottish and Southern Electric	Technology Demonstration/Project Development
	Vattenfall	Technology Demonstration/Project Development
UNITED STATES	Snohomish Public Power District	Technology Demonstration Project in Puget Sound

APPENDICES

Appendix 1

ABOUT THE IEA

The International Energy Agency (IEA) is an autonomous agency established in 1974. The IEA carries out a comprehensive programme of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The aims of the IEA are to:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

To attain these goals, increased co-operation between industries, businesses and government energy technology research is indispensable. The public and private sectors must work together, share burdens and resources, while at the same time multiplying results and outcomes.
The IEA provides a framework for countries around the world, businesses, industries, international organisations and non-government organisations to work together in collaborative multilateral technology initiatives, which enable participants to optimise resources, speed progress and share results. Covering portfolios from basic research to deployment and information exchange on energy supply, transformation and demand, its 42 initiatives (also known as **Implementing Agreements**) focus on:

- Cross-Cutting Activities (information exchange, modelling, technology transfer)
- End-Use (buildings, electricity, industry, transport)
- Fossil Fuels (greenhouse-gas mitigation, supply, transformation)
- Fusion Power (international experiments)
- **Renewable Energies and Hydrogen (technologies and deployment)**

These IEA energy technology initiatives – the **Energy Technology Network** - operates under the guidance of the Committee on Energy Research and Technology (CERT), which has in turn established expert bodies or "Working Parties' to assist with this task. The Renewable Energy Working Party (REWP) is the principal advisory body to the CERT on all matters relating to renewable energies. This particular network comprises ten "Implementing Agreements" on individual technologies:

- Bioenergy
- Geothermal
- Hydrogen
- Hydropower
- **Ocean Energy Systems**
- Photovoltaic Power Systems
- Renewable Energy Technology Deployment
- Solar Heating and Cooling
- SolarPACES
- Wind Energy Systems

Appendix 2

ABOUT THE OES

THE OES ROLE

Connect organisations and individuals working in the ocean energy sector to accelerate development and enhance economic and environmental outcomes

Educate people globally on the nature of ocean energy systems, the current status on development and deployment, and the beneficial impacts of such systems, improve skills and enhance research.

Inspire governments, agencies, corporate and individuals to become involved with the development and deployment of ocean energy systems

Facilitate education, research, development and deployment of ocean energy systems in a manner that is beneficial for the environment and provides an economic return for those involved.

THE OES ORGANISATIONAL VALUES THAT GUIDE OES ACTIONS

Integrity Any information provided can be relied upon.

Outcome-oriented We are driven by pragmatic solutions that enhance the global community.

Knowledgeable All information is based on fact and we ensure that we always have the most relevant and up-to-date researched facts available.

Inspirational Our performance and our members are committed to providing inspired and collaborative information to accelerate the implementation of environmentally friendly ocean energy systems globally.

Collegial We are committed to working professionally with each other in the pursuit of our audacious goal.

OES BRAND VALUES

Trusted Independent Source where the information gained is trusted to be up-to-date, free of any commercial or other vested interests, relevant and practical such that reliance on it will enable forward momentum.

Substantiated Knowledge where the information gained is supported by respected and well researched and documented fact rather that the opinion of the author/supplier.

Inspiring a relationship with OES will provides inspiring and supportive leadership in the global development of ocean energy systems throughout the total supply chain.

Caring for Society and the Environment from every perspective the development of ocean energy systems is done in a manner that enhances the global community, protects the environment and provides a base from which improvement to society will emerge.

Collaborative Sharing we will all succeed as a result of collaboration and sharing in all areas of the ocean energy supply chain. OES will live out this value in all that is does.

Appendix 3

CONTRACTING PARTIES TO OES

YEAR OF SIGNATURE	COUNTRY	CONTRACTING PARTY
2001	Portugal	Laboratório Nacional de Energia e Geologia (LNEG)
	Denmark	Ministry of Transport and Energy, Danish Energy Authority
	United Kingdom	Department of Energy and Climate Change (DECC)
2002	Japan	Saga University
	Ireland	Sustainable Energy Authority of Ireland (SEAI)
2003	Canada	Natural Resources Canada
2005	United States of America	United States Department of Energy (DOE)
2006	Belgium	Federal Public Service Economy
2007	Germany	The Government of the Federal Republic of Germany
	Norway	The Research Council of Norway
	Mexico	The Government of Mexico
2008	Spain	TECNALIA
	Italy	Gestore dei Servizi Energetici (GSE)
	New Zealand	Aotearoa Wave and Tidal Energy Association (AWATEA)
	Sweden	Swedish Energy Agency
2009	Australia	CSIRO
2010	Republic of Korea	Ministry of Oceans and Fisheries
	South Africa	South African National Energy Development Institute (SANEDI)
2011	China	National Ocean Technology Centre (NOTC)
2013	Nigeria	Nigerian Institute for Oceanography and Marine Research
	Monaco	Government of the Principality of Monaco

Status at 31 December 2013

Appendix 4

MEMBERSHIP OF THE EXECUTIVE COMMITTEE

CHAIRMAN
Mr. Jose Luis Villate
TECNALIA
Spain

VICE-CHAIR
Mr. Eoin Sweeney
SEAI
Ireland

VICE-CHAIR
Mr. Michael Reed
DOE
USA

SECRETARY
Dr. Ana Brito e Melo
WavEC – Offshore Renewables
Portugal

DELEGATES

COUNTRY	DELEGATE	ALTERNATE
AUSTRALIA	Dr. Alex Wonhas CSIRO	
BELGIUM	Dr. Ludovic Mouffe Federal Public Service Economy	Prof. Julien de Roeck Ghent University
CANADA	Mrs. Tracey Kutney Natural Resources Canada	Mrs. Monika Knowles Natural Resources Canada
CHINA	Mr. Xia Dengwen National Ocean Technology Center, SOA	Mr. Lin Cui National Ocean Technology Center, SOA
DENMARK	Mrs. Hanne Thomassen Energistyrelsen	Dr. Kim Nielsen Ramboll
GERMANY	Mr. Ullrich Bruchmann Federal Ministry for the Environment, Nature Conservation and Nuclear Safety	Mr. Jochen Bard Fraunhofer Institute for Wind Energy and Energy System Technology IWES
IRELAND	Mr. Eoin Sweeney Sustainable Energy authority of Ireland	Dr. Tony Lewis Hydraulics and Maritime Research Centre, University College Cork
ITALY	Mr. Gerardo Montanino Gestore dei Servizi Energetici (GSE)	Mr. Carlo Papa Enel Green Power
JAPAN	Dr. Yasuyuki Ikegami Institute of Ocean Energy, Saga University	Dr. Shuichi Nagata Institute of Ocean Energy, Saga University
KOREA	Mr. Hyun Tae Kim Ministry of Oceans and Fisheries	Dr. Keyyong Hong Korea Research Institute of ships and Ocean Engineering
MEXICO	Dr. Sergio Alcocer Instituto de Ingeniería UNAM	Dr. Gerardo Hiriart Energias Alternas, Estudios y Proyectos SA de CV
MONACO	Mr. Bernard Fautrier Government of the Principality of Monaco	
NEW ZEALAND	Dr. John Huckerby AWATEA	Mr. Nick Eldred AWATEA
NIGERIA	Prof. Lawrence Awosika Nigerian Institute for Oceanography and Marine Research	Mr. Kola Onadipe FOT-K Consortium
NORWAY	Mr. Harald Rikheim Research Council of Norway	Mr. Tore Gulli Fred Olsen Ltd
PORTUGAL	Dr. Paulo Justino Laboratorio Nacional de Energia e Geologia (LNEG)	Prof. António Falcão Instituto Superior Técnico
SOUTH AFRICA	Dr Thembakazi Mali SANEDI	Ms. Kubeshnie Bhugwandin Eskom Research, Testing & Demonstration
SPAIN	Mr. Angel Chamero Ferrer Ministerio de Industria, Turismo y Comercio	Mr. José Luis Villate TECNALIA
SWEDEN	Ms. Maria Olsson Swedish Energy Agency	Ms. Angelica Pettersson Swedish Energy Agency
UK	Mr. Trevor Raggatt Department of Energy and Climate Change (DECC)	Mr. Henry Jeffrey The University of Edinburgh
USA	Mr. Michael Reed U.S. Department of Energy	Mr. Robert Thresher National Wind Technology Center

Appendix 5

EXECUTIVE COMMITTEE MEETINGS

PAST MEETINGS

MEETING	DATE	PLACE	
1	19 October 2001	IEA, Paris	FRANCE
2	21 - 22 March 2002	London	UK
3	31 October 2002	Brighton	UK
4	4 March 2003	Paris	FRANCE
5	15 - 16 September 2003	UCC, Cork	IRELAND
6	26 - 27 February 2004	INETI, Lisbon	PORTUGAL
7	4 - 5 November 2004	DEA, Copenhagen	DENMARK
8	4 March 2005	IEA, Paris	FRANCE
9	16 - 17 November 2005	EC, Brussels	BELGIUM
10	1 - 3 May 2006	Vancouver, BC	CANADA
11	14 - 15 November 2006	INETI, Lisbon	PORTUGAL
12	20 - 21 March 2007	UNAM, Mexico City	MEXICO
13	16 - 17 October 2007	Messina	ITALY
14	15 - 16 April 2008	New York city	USA
15	13 - 14 October 2008	Ifremer, Brest	FRANCE
16	30 - 31 March 2009	Bilbao	SPAIN
17	4 - 5 September 2009	Statkraft, Oslo	NORWAY
18	22 - 23 April 2010	Wellington	NEW ZEALAND
19	30 Sep - 1 Oct 2010	Dublin	IRELAND
20	26 - 27 April 2011	Washington DC	USA
21	13 - 14 September 2011	Madeira	PORTUGAL
22	17 – 18 May 2012	Daejeon	KOREA
23	22 – 23 October 2012	Aalborg	DENMARK
24	14 – 15 May 2013	Guangzhou	CHINA
25	22 – 23 October 2013	Cape Town	SOUTH AFRICA

PLANNED MEETINGS

MEETING	DATE	PLACE	
26	13 – 14 May 2014	Paris	FRANCE
27	November 2014	Halifax	CANADA

Appendix 6

COMPLETED ANNEX PROJECTS

NAME	ANNEX II – DEVELOPMENT OF RECOMMENDED PRACTICES FOR TESTING AND EVALUATING OCEAN ENERGY SYSTEMS
OBJECTIVE	The objective of this Annex was to develop recommended practices for testing and evaluating ocean energy systems (wave and marine currents). There are a number of different resource types within ocean energy systems (including waves, tidal range, tidal and ocean currents, salinity gradients, OTEC and hydrothermal vents) and several different approaches to extracting energy from each resource type. The present lack of technology convergence creates difficulty in comparing systems. Annex II attempted to address this issue by providing guidelines, with the intent of laying the groundwork for the future establishment of standards and protocols, for theoretical, model and pro¬totype testing, preliminary cost assessments and the presentation of results.
OPERATING AGENT	Dr. Kim Nielsen, Ramboll – Denmark
DURATION	The Annex was set up in 2001 to address laboratory testing and, in 2006, the Executive Committee agreed to extend the Annex to address prototype testing. The Annex was concluded in March 2011.
REPORTS	***Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems, Summary Report*** K. Nielsen (2010) ***Generic and Site-Specific Wave Data*** K. Nielsen and T. Pontes (2010) ***Guidelines for the Development & Testing of Wave Energy Systems*** B. Holmes (2010) ***Guidelines for the design Basis of Marine Energy Converters*** P. Davies (2009) ***Guidance for Assessing Tidal Current Energy Resources*** Cornett (2008) ***Tidal Energy Development Protocol*** S. Bahaj, L. Blunden and A. A. Anwar (2008) ***Preliminary Wave Energy Device Performance Protocol*** G. Smith and J. Taylor (2007) ***Preliminary Tidal-current Energy Device Performance Protocol*** S. J. Couch and H. Jeffrey (2007) *All reports are available at www.ocean-energy-systems.org*

NAME	ANNEX III – INTEGRATION OF OCEAN ENERGY PLANTS INTO DISTRIBUTION AND TRANSMISSION ELECTRICAL GRIDS
OBJECTIVE	The overall aim of this Annex is to provide a forum for enabling co-operative research activities related to integration of wave and tidal current power plants into electrical grids.
OPERATING AGENT	Dr. Gouri Bhuyan, Powertech Labs – Canada
DURATION	This Annex was commissioned in 2008 and was concluded in March 2011
REPORTS	***Potential Opportunities and Differences Associated with Integration of Ocean Wave and Marine Current Energy Plants in Comparison to Wind Energy*** J. Khan, G. Bhuyan and A. Moshref (2009) ***Key Features and Identification of Needed Improvements to Existing Interconnection Guidelines for Facilitating Integration of Ocean Energy Pilot Projects*** J. Khan, G. Bhuyan, and A. Moshref (2009) ***Dynamic characteristics of wave and tidal energy converters & a recommended structure for development of a generic model for grid connection*** D. O' Sullivan, D. Mollaghan, A.Blavette and R.Alcorn (2010) ***Integrating Wave and Tidal Current Power: Case Studies through Modelling and Simulation*** M. S. Múgica, F. S. Fernandez , J. L. Mendia , J. Khan, D. Leon, S. Arabi, A. Moshref, G. Bhuyan, A. Blavette, D. O'Sullivan, R. Alcorn (2011) *All reports are available at www.ocean-energy-systems.org*

Appendix 7

TERMINOLOGY FOR OES

TERM	DEFINITION
ANNEX	addendum to an Implementing Agreement (IA) and an integral part thereof, which sets forth the manner, including the financial undertakings and other means of support, by which the activities (sometimes called Tasks) of the Annex will be implemented by the Participants.
CERT	Committee on Energy Research and Technology is one of the IEA Standing Committees. Comprised of representatives from each IEA Member country and supported by the Secretariat, the CERT formulates and supervises the execution of the IEA's R&D programme, including national programme reviews, technology reviews, studies on strategic planning and oversees the IAs. The CERT is supported by four Working Parties on Renewable Energy, End Use Efficiency, Fossil Fuels, and Fusion Power.
COMMON FUND	fund established by the Executive Committee into which the financial contributions of the Participants are placed.
CONTRACTING PARTY (CP)	Signatory of an IA.
EXECUTIVE COMMITTEE (EXCO)	the body, comprising representatives of all the Participants in an Implementing Agreement, which supervises the work of the IA and is the decision making body of the IA.
EXCO REPRESENTATIVE	the individual designated by each Participant to be the Participant's representative on the Executive Committee.
IMPLEMENTING AGREEMENT (IA)	the contractual relationship established by at least two IEA Member countries and approved by the Governing Board to carry out programmes and projects on energy technology research, development and deployment.
OPERATING AGENT (OA)	the legal entity designated in the IA text, or by the ExCo, or by the Participants in an Annex, to manage part or all of the Programme of Work of an IA and/or of its Annexes.
PROGRAMME OF WORK	the overall plan of activities determined by the Executive Committee to be implemented under the Implementing Agreement.
TASK	particular collaborative R&D activity within the IA's Programme of Work in which some, but not all, Participants may choose to participate. The activity, and the means of participation in the activity, is described in an Annex to the IA.
WORKING PARTY (WP)	one of the current Working Parties mandated by the CERT to carry out specified work in energy technology and to initiate, evaluate and review IAs in its special field. At present, the Working Parties are: the Working Party on Energy End Use Technologies (EUWP); the Working Party on Fossil Fuels (WPFF); the Working Party on Renewable Energy Technologies (REWP); and the Fusion Power Co ordinating Committee (FPCC).

CONTACTS

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