ANNUAL REPORT

IMPLEMENTING AGREEMENT *on* OCEAN ENERGY SYSTEMS

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CHAIRMAN'S MESSAGE

MR. JOSÉ LUIS VILLATE
TECNALIA . OES Chairman 2013 - 2016

I am delighted to be able to continue working towards the OES mission so that ocean energy may make an important contribution to world energy supply.

Mid-way through the third 5-year mandate and fourteen years after its foundation, the OES is continuing to grow with two new members joining in 2014: Singapore and The Netherlands, making a total of 23 countries. This growth is assisting us in our mission of international collaboration to accelerate the viability, uptake and acceptance of ocean energy systems in an environmentally acceptable way.

To fulfil this mission, the OES has been setting up new activities and consolidating on-going ones. In 2014, the OES Executive Committee decided to start up two new projects on Ocean Thermal Energy Conversion and technology roadmapping. Furthermore, we have identified other topics of interest to work on in 2015 such as numerical modelling validation, best practice for open water test centres, policies to local wave energy resource characteristics, ocean energy applications in remote areas, mooring systems or a sensors database. As far as current activities, I would like to highlight two web tools: Tethys, an online knowledge management system, which currently includes 82 project sites and 57 research studies and it continues to expand and to increase user interactions; and the GIS Database for Ocean Energy, an interactive web application with detailed global information such as ocean energy facilities, resources, relevant infrastructure, in conjunction with the respective location on a global map.

Greater repercussion for these activities has also been sought through international collaboration. In this context, a notable contribution was made with our support to the organisation of ICOE2014, held in Halifax, Canada, in November. The OES had its Executive Committee meeting immediately after this event. Previously we had held another Executive Committee meeting at the IEA headquarters in Paris to engage with IEA experts in technology roadmapping. Concurrently with this meeting a workshop was also run on "Exploring the Prospects for Marine Renewable Energy to 2030" to feed inputs to an OECD project on the "Future of the Ocean Economy". The OES participation in the European Ocean Energy Forum, in particular in a working group on Environment and Consenting issues, is also worth mentioning.

The OES mission is a long term one; ocean energy is still a small actor in the energy landscape. The contribution from ocean energy is very low and will not be significant in the foreseeable future. The global economic downturn is not helping to accelerate ocean energy development and we are living through some uncertainties affecting iconic ocean energy companies. On the other hand, we have seen real commitment from some project developers and, as the OES Chairman, I am very happy to see three of them giving their views here about ocean energy challenges and opportunities. I would like to thank DP Energy, EMERA and ESB for their contribution to this annual report.

I could not finish this address without giving thanks for the great effort shown by delegates from the member countries and in particular for entrusting me to continue as Chairman for two more years. I would like to give special thanks to the two Vice-Chairmen who left their positions in 2014: Eoin Sweeney (Ireland) and Michel Reed (US). May I also welcome our two new Vice-Chairmen Keyyong Hong (Republic of Korea) and Henry Jeffrey (UK). I am delighted to be able to continue working towards the OES mission so that ocean energy may make an important contribution to world energy supply. It is a pleasure for me to work with a magnificent team and the tireless support of Ana Brito e Melo, OES Secretary, who will now introduce the contents of this Report.

EXECUTIVE SUMMARY

DR. ANA BRITO E MELO
OES Executive Secretary

***Ocean Energy Systems** (OES) is the short name for the international technology initiative on Ocean Energy under the International Energy Agency (IEA), known as **'Implementing Agreement on Ocean Energy Systems'**. This Annual Report presents an overview of the activities undertaken within OES in 2014.*

INTRODUCTION

As of end of 2014, 23 countries had signed the Implementing Agreement, with invitations extended to several others. This membership, from Africa, Asia, the Americas, Europe and Oceania, provides a broad international base of experience and knowledge.

National governments appoint a Contracting Party to represent the country on the Executive Committee and there is a diversified representation of interests: governmental departments, utilities, universities and research organizations, energy agencies and industry associations. By information sharing and collaborative activities, participants gain an international perspective on ocean energy issues, opportunities and present challenges.

The OES held two ExCo Meetings in 2014: The 26th and 27th meetings were convened in Paris, France (14 – 15 May 2014), and Halifax, Canada (10 – 11 November 2014).

OES began operating in 2001 and has released an annual report every year since then.

Chapter 1 is an introductory chapter addressing the role, values and benefits of OES. **Chapter 2** provides information about present membership, gives a status overview of the OES programme of activities and interactions with the IEA during the year. **Chapter 3** addresses dissemination activities while key accomplishments during 2014 are presented in **Chapter 4.**

As in previous years **Chapter 5** presents a contribution by acknowledged project developers. Three leading project developers in ocean energy (**DP Energy, Emera** and **ESB**) were invited to respond to the following questions:

1. The ocean energy sector needs the first pre-commercial projects in the water, and your organization has a leading role worldwide. Could you give some information of your short to medium term plans given the current conditions?

2. Project development involves a wide variety of risks, including technical, regulatory and financial. Could you describe the most critical that you have encountered/ encounter and how could they be overcome?

3. If support measures are put in place in order to overcome those barriers, can you identify the responsible stakeholders for delivering solutions, such as governments, supply chain, research sector, etc., and what would be the expected improvement in terms of your project pipeline and cost reduction achievable?

4. How do you see that international collaboration could accelerate ocean energy growth and what, specifically, is the role that you would like OES to play in supporting the development of ocean energy?

Under **Chapter 6** each OES member country presents its national programme activities over the last year. The final **Chapter 7** is a compilation of statistical information provided by all country representatives. Background information is presented in the appendixes.

This Executive Summary provides an introduction to the 2014 OES Annual Report. It synthesizes progress with the OES collaborative activities and outlines the political initiatives and demonstration projects worldwide presented by each OES member country.

OES COLLABORATIVE ACTIVITIES

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 coordinating each project and reporting on progress to the Executive Committee (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).

In 2014, OES participants contributed to the following data collection and analysis effort and worked on specific research topics:

▸ ***Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal and Current Energy Systems* (Annex IV)** - providing access to knowledge and information related to research, monitoring, and evaluation of environmental effects of offshore renewable energy, accessed from *Tethys*, an online knowledge management system. *Tethys* currently includes 82 project sites and 57 research studies and it continues to expand and to increase user interactions. During 2014, researchers, regulators, developers, and stakeholders provided over a hundred peer review comments on the content and functionality of *Tethys*; Annex IV sponsored two workshops (Scotland and Nova Scotia), three webinars and two experts' forums.

▸ ***The Exchange and Assessment of Ocean Energy Device Project Information and Experience* (Annex V)** - promoting the sharing, interchange, evaluation, and compilation of information on OES projects from participating member countries. To this end, Annex V has been sponsoring a series of workshops, bringing international experts together to exchange data that can be used to develop an assessment of the fundamental knowledge of ocean energy. Two workshops have already been held: the first was on the site development and operations for open water testing and the second was on computational modelling and analysis of marine energy converters. The third workshop was on " Designing for Reliability of Wave and Current Marine Energy Converters" and is to be held in Lisbon, Portugal in February 2105. A fourth workshop on cost of energy is being planned for the fall of 2015.

▸ **Worldwide Web GIS Database for Ocean Energy** – interactive web based GIS mapping application launched in the first quarter of 2014 with detailed global information related to ocean energy in an easy to use yet visually striking way. Information has been updated on ocean energy facilities, resources, relevant infrastructure, in conjunction with the respective location on a global map.

▸ **Cost of Energy Assessment for Wave, Tidal and OTEC** – engaging a large number of international stakeholders to deliver a reliable and credible LCOE assessment together with the identification of the routes to maximise rapid cost reduction at a global level taking into account the experience from other technologies.

▸ **Consenting Processes for Ocean Energy on OES member countries** – with inputs from all OES member countries providing a coherent overview of several aspects of the consenting processes, addressing: Marine Spatial Planning policies and site selection for ocean energy development, regulatory issues, environmental impact assessment requirements, consultation and challenges to the consenting process.

The ExCo approved the development of an International Ocean Energy Technology Roadmap in line with the IEA own technology roadmapping work. This initiative will be conducted during 2015. Another activity expected to move forward in 2015 is an international joint research project on OTEC aiming to investigate a number of issues, such as its current situation, methodologies for OTEC evaluation, environmental assessment, cost of energy, operation and safety.

In 2014, OES was much involved in the organisation of the programme of the International Conference on Ocean Energy (ICOE 2014) held in Halifax, Canada, hosted by Marine Renewables Canada. During this event OES organized of a "poster award", a cash prize to 3 students selected by an international jury, composed of members of the ExCo. An international seminar on ocean energy in Argentina was sponsored by the OES. Another important event in 2014 was the workshop in Paris within the framework of the OECD project on the future of the ocean economy, with special emphasis on the potential development of emerging ocean based activities. This event was co-organised by the OES as part of the OES contribution for the study.

The OES continues to develop a suite of information dissemination tools that will assist the OES in becoming a leading authority on ocean energy. The OES has been continuously interacting with the IEA by providing current information and contribution to IEA publications, such as the Energy Technology Initiatives.

OCEAN ENERGY POLICY IN OES MEMBER COUNTRIES

OES member countries recognise that commercialisation and deployment of ocean energy will help meet the goal of clean and sustainable energy supply.

National targets for ocean energy have been set up in several countries under their Renewable Energy Action Plans or Strategic Action Plans for Energy Development to help drive policy measures for the deployment of renewables in general and ocean energy in particular. In some countries however the original targets seem difficult to achieve due to the lack of a specific national strategy for ocean energy development. Several countries have been working on a national maritime strategy aiming to present actions for a sustainable development of the industries related to the sea, which in a way includes ocean energy.

Roadmapping initiatives concerning prioritization of research and demonstration activities for marine energy are being conducted in several OES member countries.

The development of national marine spatial plans by most of the OES member countries is also expected to provide a framework for all activities in the sea and for improving licensing arrangements for ocean energy projects.

Several countries do not have explicit legislation and regulation dedicated to ocean energy yet. The permitting process for ocean energy projects remains a challenge. OES member countries tend to deal with projects on a case-by-case basis, using existing regulatory requirements applicable to other sectors. Efforts have been done to promote national planning including ocean energy and to clarify the regulatory process in the sea.

No dedicated consenting process exists in Spain for ocean energy technologies but the new law approved in December 2013 simplifies the environmental evaluation of marine energy projects. Also in Portugal the Environmental Impact Assessment (EIA) legislation released by the end of 2013, created a web based "one-stop-shop" facility for the environmental licensing of projects thus enabling clarification of the timeline of the licensing procedures.

In particular in 2014, a dialogue concerning the use of the sea in Denmark took place with the authorities. In Norway, the licensing process for demonstration projects is efficient and pragmatic as it concerns, at this stage, small installations, limited in time. New Swedish legislation on marine spatial planning came into force on 1 September 2014.

In UK, plans to run a leasing process for tidal range projects were confirmed in 2014, following an industry engagement exercise to understand the market interest in future tidal range and lagoon projects around the UK. Furthermore, in Wales a new organisation, the Natural Resources Wales (NRW), created in 2013, has been assuming the responsibility for the administration of marine licensing for the Welsh Government.

In the United States, there are several key pieces of federal legislation currently under consideration and significant progress has been made to expedite the permitting process for ocean energy projects. In Canada, the Government of Nova Scotia continues to develop legislation specific to marine renewable energy and in 2014 established a feed-in tariff approval process for larger-scale tidal projects, aiming to encourage the industry investment in Nova Scotia over the next 5-6 years.

PUBLIC FUNDING PROGRAMMES

Several OES member countries have public funding programmes designed to encourage renewable energy development in general and most of these programmes also apply to ocean energy. In some countries there are dedicated funding programmes for ocean energy R&D. However, in a few OES member countries such as South Africa, Nigeria and New Zealand, there are very limited opportunities for funding ocean energy projects.

The UK has in place several consistent funding mechanisms from different funding bodies to support R&D projects, from basic strategic and applied research to medium size projects up to deployment of demonstration arrays.

Notable is the total amount of financial support to ocean energy projects in China, in 2014, around RMB 800 million, with more than 90 marine energy projects supported.

In the United States, the Water Power Program has a clear role in expediting the development and deployment of innovative ocean energy technologies. The Water Power Program's annual budget for ocean energy R&D climbed from $31.6 million in 2013 to $41.3 million in 2014.

To date Canada has committed approximately $37 million to marine renewable energy RD&D since 2010, with an additional $13 million to demonstration projects that include in-stream tidal, river-current and wave energy technologies. Several projects have also received support from provincial economic development agencies.

The European Commission is a significant source of funding for ocean energy. Several OES members have been involved in R&D projects with support from the FP7, the European Union's Research and Innovation funding programme for 2007-2013, the predecessor of H2020 launched last year. In 2014, OCEANERA-NET was further set up by the European Commission as a network of funding agencies of R&D programmes, from 9 countries, in the field of ocean energy.

SEA TESTING FACILITIES ENCOURAGING OCEAN ENERGY DEVELOPMENT

Sea testing facilities are in general pre-consented areas, where an infrastructure is provided, from grid connection to marker buoys, as well as trained and experienced personnel and appropriate equipment, thereby reducing timing uncertainties and reducing costs to developers.

The development of open sea test facilities encourages the development of ocean energy, facilitating the administrative and legal requirements and enabling practical experience of installation, operation and maintenance of prototypes.

UK has 3 world class sea testing facilities (EMEC, WaveHub, FaBTest) and a strong commitment from the Government to support the continuing development of the marine energy sector. The European Marine Energy Centre (EMEC), on the Orkney Islands (Scotland), continues to attract developers; Wave Hub, in South West England, has been able to secure customers for all four of its berths and FaBTest has been operating as a non-grid connected site since November 2011.

Ireland has a ¼ scale test wave energy site in Galway Bay and is developing the Atlantic Marine Energy Test Site (AMETS), located offshore at Belmullet, for full scale, open ocean testing.

In Denmark, the Danish test site for Wave Energy Conversion (DanWEC) has included the 1:10 Nissum Bredning site as part of its portfolio. Belgium has a test facility at approximately 1 km from the Harbour of Ostend.

There are two test sites in Sweden, Lysekil wave power research site and Söderfors marine currents research site, both operated by Uppsala University. A third site, Sotenäs wave power demonstration facility, is under development, led by Seabased Industry AB in cooperation with Fortum.

Runde Environmental Centre (REC) located on Runde Island, off the Norwegian west coast is a research centre with activities on marine biology and oceanography and available for wave energy testing.

In the Netherlands, a tidal test site was set up in the Marsdiep, near Texel, operated by Tidal Testing Centre NL.

In Portugal, Enondas, a subsidiary of the Portuguese Grid Transmission System Operator (REN), holds a 45-year lease for 320 km^2 of seabed, since 2010. In 2014, the geophysical characterisation of the test site, the environmental impact assessment and the access regulation for developers have been published.

Bimep (Biscay Marine Energy Platform) located on the Basque coast of Spain obtained all the required administrative permits for wave energy trials and further the licensing procedure for offshore wind testing has been initiated. The Oceanic Platform of the Canary Islands (PLOCAN) offers a marine test site for testing wave energy prototypes and it is expected to be grid connected by the end of 2015.

The Pacific Marine Energy Center (PMEC) operated by the Northwest National Marine Renewable Energy Center (NNMREC) in the United States has a variety of test sites for wave and tidal current. The Southeast National Marine Renewable Energy Center (SNMREC) continues to develop a test site for small scale ocean current turbines. The Hawaii National Marine Renewable Energy Center (HINMREC) plans to support the operation of the open wave energy test site operated by the U.S. Naval Facilities Engineering Command (NAVFAC) in Hawaii. The permitting process in this site has been completed and the construction of two additional grid connected test berths for wave energy devices has been initiated.

FORCE, the Fundy Ocean Research Centre for Energy, located in the Bay of Fundy, Nova Scotia, Canada, successfully installed four subsea power cables during the course of 2014 and has been able to secure customers for all four of its grid connected berths (full-scale demonstrations and arrays).

In other OES countries, plans for open sea test sites are in progress: NZ-MEC is a proposed R&D and test site in New Zealand, off the Wellington coast. In Korea, sea test sites for wave and tidal energy devices are currently being planned and feasibility studies have been carried out for a few sites. In China, a small scale test site was authorized for a 40-year lease and additionally, two full scale test sites (for wave and tidal current) are being planned.

PROJECTS GOING TO THE WATER

The recent news of pioneering companies failing to secure funding for the continuous development of their projects presents additional challenges to the sector. Nonetheless, in several OES member countries around the globe we have seen good progress with several demonstration projects going to the water.

▸ **UK:** EMEC, the European Marine Energy Centre on the Orkney Islands, was very active throughout 2014: 5 wave energy projects and 7 tidal current energy projects were tested. Other deployments have been reported in different parts around the UK: Wavehub and Falmouth Bay Test (FaBTest) Site. Marine Current Turbine's Seagen machine (1.2 MW) has been operational in Strangford Lough, Northern Ireland since 2008 and a new technology, Minesto, has also successfully been deployed in this area. Tidal Energy Limited unveiled soon to be installed in Wales and the first phase of a planned 380 MW tidal array scheme by MeyGen Limited is advancing in the Pentland Firth in Scotland.

▸ **Portugal:** Pico Plant owned by WavEC, in Azores, continues to deliver electricity to the grid; while the grid connected WaveRoller demonstration project in Peniche completed another series of tests in the autumn of 2014.

▸ **Spain:** the Mutriku OWC breakwater promoted by EVE (the Basque Energy Agency) using Voith Hydro technology has already produced more than 650 MWh since starting operation in July 2011. A few other projects have been progressing: Wedge Global tested their wave energy demonstration project at Plocan site, Canary Islands, and the Magallanes tidal current project has been tested at EMEC.

▸ **Italy:** the tidal current submerged floating concept, known as GEM, has been tested near Venice in a very slow speed current, and a full scale prototype is being designed for deployment in the Strait of Messina. The Kobold Turbine, developed since 1998, is now very close to being installed on Lombok Island, Indonesia, under the auspices of UNIDO. During 2014, Enel Green Power and 40South Energy, began the installation and commissioning of a wave energy converter in Tuscany.

▸ **The Netherlands:** 2 tidal current projects were operational in 2014, as well as the salinity gradient energy pilot plant Friesland/Afsluitdijk (50 kW), with a few other projects planned for deployment, including an OTEC pilot plan in Curacao (Caribbean Sea).

▸ **Denmark:** the wave energy converter known as Crestwing has been tested at sea and support from Energinet.dk has been granted for the design, building and testing of 3 Danish prototypes.

▸ **Norway:** Havkraft deployed in the sea a 200 kW demonstration wave energy converter and Andritz Hydro Hammerfest is now taking the step into commercial delivery of their tidal current energy project. There are other active Norwegian developers moving forward.

▸ **Sweden:** two projects were operational during 2014, the Lysekil wave power project and the Söderfors marine current, both operated by Uppsala University. Sotenäs Project is progressing with the installation of their wave energy units in the sea expected to achieve a total installed power of 10 MW. Other Swedish developers are progressing towards the testing of their devices in the sea.

▸ **The United States:** several projects were deployed and tested during 2014 with grant support from the US Department of Energy (DOE). These included the M3 Wave project tested off the coast of Oregon, the Oscilla Power wave energy converter tested off the coast of New Hampshire and the RivGen Power deployed in Alaska. Several other deployments are planned with funding from DOE: Northwest Energy Innovations (NWEI), Resolute Marine Energy and Columbia Power Technologies. Fred Olsen's Lifesaver device is planned to be deployed in Hawaii with the support of U.S. Navy funding.

▸ **Canada:** in December 2014, four developers received FIT approvals to be developed at FORCE site, totalling 17.5 MW; a number of river current technologies have been tested at the Canadian Hydrokinetic Test Centre. The 20 MW Annapolis Royal tidal barrage power plant continues to operate today by Nova Scotia Power.

▸ **Korea:** in 2014, KRISO achieved two important milestones: the successful construction of the 500 kW demonstration OWC plant on Jeju Island and the 200 kW OTEC plant. Further the 300 kW floating wave energy converter (pendulum-activated) completed its detail design.

▸ **Singapore:** the company Hann-Ocean Energy has been testing its first commercial pilot project since August 2013, comprising 4 units of Drakoo-B0004 wave energy converters delivered to Jurong Shipyard Pte Ltd.

▸ **New Zealand:** Northwest Energy Innovations (NWEI) have successfully completed sea trials with pilot scale projects in New Zealand and Oregon with the AzuraWave (former Wave Energy Technology New Zealand or WET-NZ) and the project is preparing to move now to Hawaii.

▸ **China:** The Jiangxia Tidal Power Plant, the largest tidal power station in China with more than 30 years of operation, is being upgraded from 3.9 MW to 4.1 MW. In some Chinese islands the concept of hybrid power stations (combining ocean, wind and solar energy) is being developed: one of these projects, on Zhaitang Island, has been in operation, since June 2013.

01. INTRODUCTION

VISION, ROLE AND VALUES

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.

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.

VISION

The Strategic Plan (2012 – 2016) proposes a new International Vision for OES:

"As the authoritative international voice on ocean energy we collaborate internationally to accelerate the viability, uptake and acceptance of ocean energy systems in an environmentally acceptable manner."

ROLE

Using its unique position as an intergovernmental organisation, the OES role within the context of this vision is to:

CONNECT

Connect organisations and individuals working in the ocean energy sector

EDUCATE

Educate people globally on the nature of ocean energy systems and the current status on development and deployment

INSPIRE

Inspire governments, corporations, agencies and individuals to become involved

FACILITATE

Facilitate education, research, development and deployment of ocean energy systems

ORGANISATIONAL VALUES

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 (INCLUDING A COMMITMENT TO EACH OTHER) . we are committed to working professionally with each other in the pursuit of our goal.

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.

THE OES VISION FOR INTERNATIONAL DEPLOYMENT OF OCEAN ENERGY

OES has a succinct brochure, which sets out the OES Executive Committee's views of the potential for and development of ocean energy to 2050, including some specific and measurable goals for ocean energy, relating to job creation and emissions reductions.

Utilization of ocean energy resources will contribute to the world's future sustainable energy supply. Ocean energy will supply electricity, drinking water and other products at competitive prices, creating jobs and reducing dependence on fossil fuels. It will reduce the world energy sector's carbon emissions, whilst minimizing impacts on marine environments.

BENEFITS OF OCEAN ENERGY

The resurgence of interest in marine energy arises from social and political changes requiring emissions reductions and replacement of fossil fuel generation with renewable energy generation. Governments around the world are setting renewable energy targets, both statutory and aspirational, whilst putting in place mechanisms and policies to secure greenhouse gas emissions. Some forms of ocean energy may be constant enough for baseload electricity generation, whilst most forms of ocean energy are reasonable forecastable and reliable, such that both diversity and security of supply can be enhanced. Some forms of ocean energy will yield alternative products, including drinking water, heating, cooling and biofuels. New industries may be created or transferred from declining industries, which will lead to creation of new jobs and/or promote investment in new skills and capabilities.

SYNERGIES WITH OTHER SECTORS

Future development of the ocean energy sector will be linked with developments in other sectors, such as offshore wind energy, exploiting positive synergies in technology developments (e.g., components), infrastructure, supply chain and policies. There will be significant opportunities for co-location of technologies; for example, ocean energy and offshore wind energy, utilizing common platforms or wave/wave or wind/tidal hybrid systems. Mutual learning processes, shared infrastructure and innovations from a shared supply chain will be of great benefit to the future expansion of both the ocean energy sector and related sectors.

INDUSTRIAL GOAL

By 2050 ocean energy will have 337 GW of installed capacity

SOCIETAL GOAL

By 2050 ocean energy will have created 1.2 million direct jobs and saved nearly 1 billion tonnes of CO^2 emissions.

BENEFITS FROM INTERNATIONAL COLLABORATION

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 Executive Committee (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.

KEY OES ACHIEVEMENTS IN 2014

January	**Mid Term Report:** Preparation of the Mid Term Report with an overview of the activities and achievements of the first two years (2012 and 2013) of the OES third mandate period and submission to the Committee on Energy Research and Technology (CERT), the governing body of the IEA.
February	**Publication:** Results of the OES workshop "Open Water Testing" were published on the OES website, as part of the *Annex V - The Exchange and Assessment of Ocean Energy Device Project Information and Experience.*
March	**Publication:** Launch of the Report *Ocean Energy: Supporting Policies Review* with contribution from all member countries, followed by the launch of the 2013 Annual Report with an interview to six acknowledged industry experts, on their perspectives about worldwide ocean energy development.
April	**Database:** Launch of the Worldwide Database for Ocean Energy, a new interactive web-based Geographical Information System (GIS) mapping application developed by Fraunhofer to the OES.
May	**Workshop:** Organisation of the workshop "Exploring the Prospects for Marine Renewable Energy to 2030", co-hosted by the OES and the OECD, within the framework of the OECD project on the future of the ocean economy.
July	**INORE@AWTEC 2014:** Sponsorship of the 1st INORE workshop at AWTEC, in Tokyo, to encourage early-stage researchers in Asia joining INORE. OES further sponsored other INORE initiatives, among them the scholarships to encourage exchange of students.
August	**Collection of information:** Collection of information about consenting processes for ocean energy from all member countries.
September	**New members:** Two new countries joined the OES, Singapore and The Netherlands. Two other countries – France and India - and The European Commission are close to join the OES.
October	**New project:** The project "Cost of Energy Assessment for Wave, Tidal and OTEC" was initiated with the goal to deliver a reliable and credible Levelized Cost of Energy (LCOE) assessment for wave, tidal, and OTEC technologies, together with identification of the routes to maximise rapid cost reduction.
November	**ICOE2016:** Participation of OES delegates in the 5th International Conference on Ocean Energy, Halifax, Canada
December	**Video on ocean energy:** Launch of a new video about ocean energy prepared by the OES, available on the OES website

02. REPORT OF THE EXECUTIVE COMMITTEE

MEMBERSHIP

The Implementing Agreement on Ocean Energy Systems (OES) was initiated by three countries in 2001. As of December 2014, 23 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, Monaco, Singapore and The Netherlands, ordered by sequence of joining the Agreement.

Singapore joined the OES on 2 September 2014 and the signatory entity is the Nanyang Technological University.
The Netherlands joined the OES on 10 September 2014 and the signatory entity is the Netherlands Enterprise Agency.

Communication has continued with other countries/institutions invited to join the OES: Brazil, Chile, India, France, Indonesia, Russia, Finland, Costa Rica and the European Commission. Some efforts have been made to attract other countries with activities or interest on ocean energy, such as Malaysia, Malta, Cuba, Philippines and Peru.

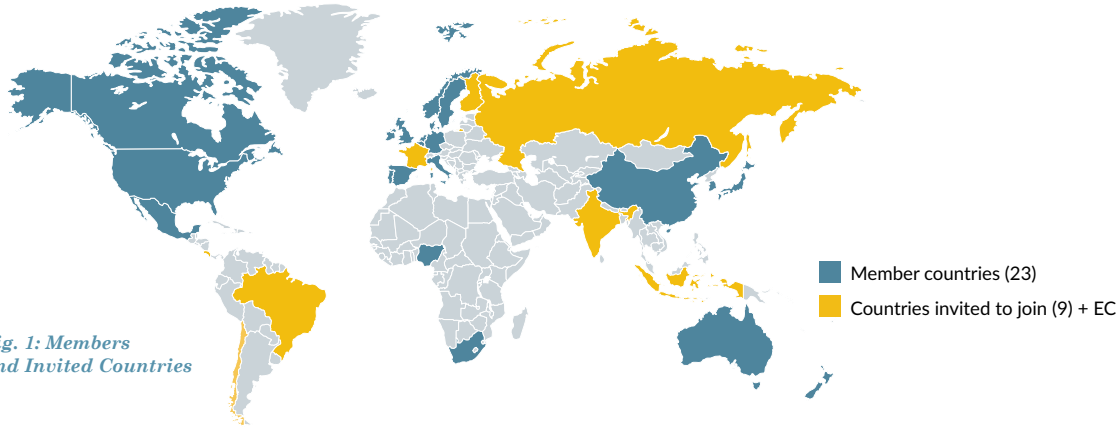


Fig. 1: Members and Invited Countries

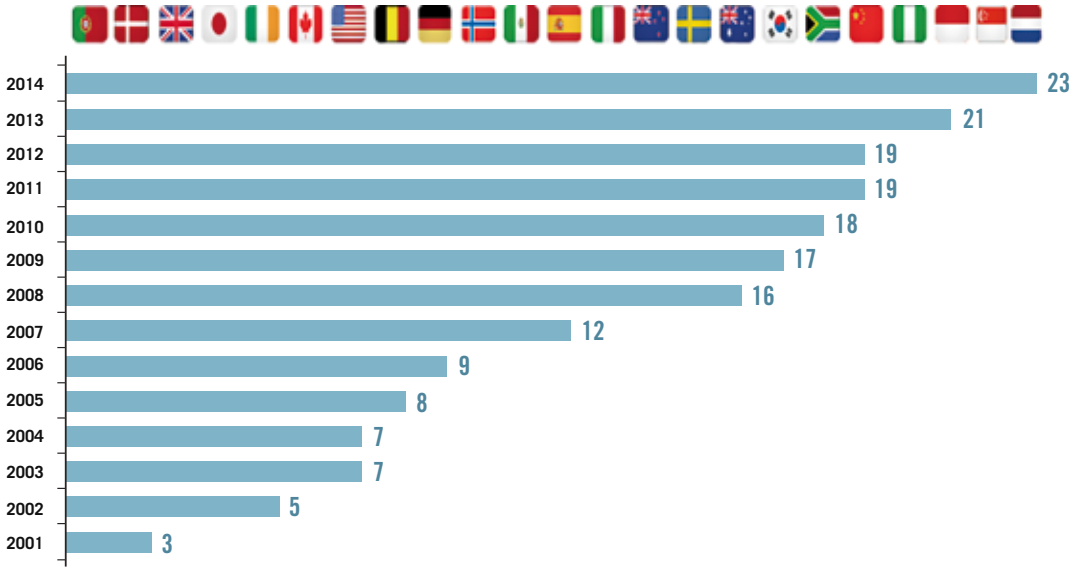


Fig. 2: OES Membership Growth

National governments appoint a Contracting Party to represent the country in the Executive Committee (ExCo) (Table 1). 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.

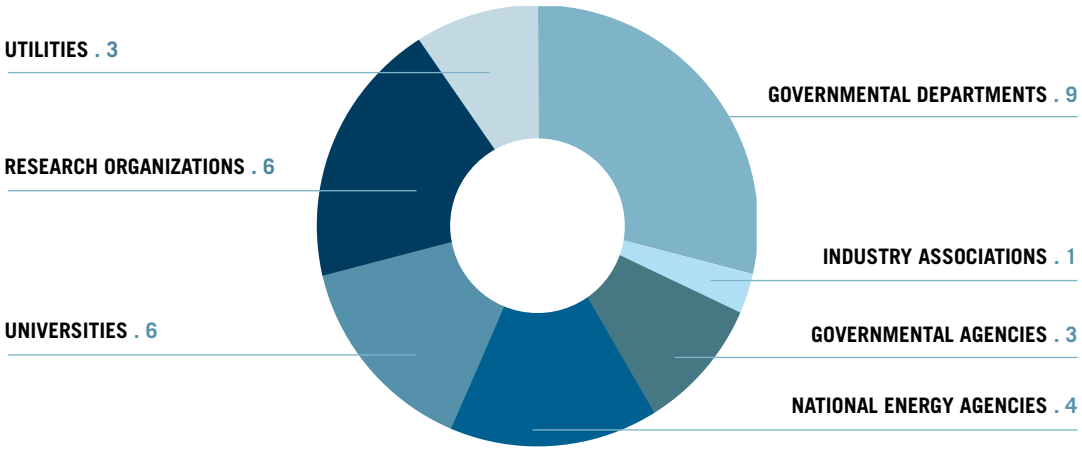


Fig. 3: Diversified representation of interests in the ExCo

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 (Suspended in 2014)
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
2014	Singapore	Nanyang Technological University
	The Netherlands	Netherlands Enterprise Agency

Table 1: Contracting Parties (Status in December 2014)

EXECUTIVE COMMITTEE

The Executive Committee (ExCo) is the decision-making body of the OES and meets twice a year to discuss its Work Programme and share information among members. It comprises one voting delegate from each participating country.

Contracting Parties pay an annual membership fee to the Agreement Common Fund, which covers administrative expenses incurred in connection with the ExCo, including the secretariat functions, communication and dissemination activities, as well as sponsorship activities and short duration projects. The present membership subscription fee is € 7,000.

The ExCo elects a Chairman and two Vice-Chairs, who serve for a 2-year term. Together with the Secretary, the Chairman and Vice-Chairs form the Cabinet, which manages the day-to-day decision-making to implement the annual Work Programme. In 2014, two new Vice-Chairs have been elected: Mr. Henry Jeffrey (UK) and Dr. Keyyong Hong (Korea); the Chairman, Mr. José Luis Villate (Spain), has been re-elected for two more years.

The 26th and 27th meetings of the ExCo were held during 2014. These were convened in Paris, France (14 – 15 May 2014), and Halifax, Canada (10 – 11 November 2014).

26th ExCo meeting in Paris (14 – 15 May 2014)

27th ExCo meeting in Halifax (10 – 11 November 2014)

Where possible, the ExCo tries to locate its meetings to coincide with major international ocean energy conferences or other relevant events.

In Paris, the delegates were are also invited to attend the workshop "Exploring the Prospects for Marine Renewable Energy to 2030", co-hosted by the OES and the OECD, and organised within the framework of the OECD project on the future of the ocean economy. The workshop was held on 15 May 2014 at the IEA Headquarters, moderated by Mr. Eoin Sweeney from the Irish Marine Institute.

The meeting in Halifax, Nova Scotia, Canada was organised in conjunction with the International Conference on Ocean Energy (ICOE 2014) on 4-6 November 2014. A technical tour to the Fundy Ocean Research Centre for Energy (FORCE), located on the Palmiet River near Cape Town, was further organized on 9 November 2014 for the ExCo delegates.

MANAGEMENT & WORK PROGRAMME

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 coordinating each project and reporting on progress to the Executive Committee (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).

The collaborative research and development activities carried out by the OES ExCo are undertaken within Annexes to the Work Programme, each of which has a particular project focus and agreed work plan. 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. The work is managed by an Operating Agent (OA), and only participants in the project contribute. These work plans, and their respective budgets, are typically set for a three-year period.

OES members can further develop short term projects into topics relevant to all member countries. These may be particularly one-off activities or result in the development of an Annex or other avenues for pursuing more in-depth consideration. These short-time duration tasks approved by the ExCo are usually financed by the Agreement Common Fund.

Further details on active Annexes and short-term tasks are given in Section 3, while the completed projects are summarised in Appendix 4.

LARGE PROJECTS "ANNEXES"	SHORT DURATION TASKS
I. Review, Exchange and Dissemination of Information	Web-based GIS application for ocean energy
II. Recommended Practices for Testing and Evaluating OE (concluded)	Cost of Energy Assessment
III. Integration of OE Plants into Electrical Grids (concluded)	Technology Roadmap
IV. Environmental Effects and Monitoring Efforts	
V. Device Project Information and Experience	

Table 2: OES Research Projects (Details on sections 3 and 4)

PLANNED ACTIVITIES

The ExCo is presently developing a number of proposals for new projects and activities on topics of common interest to a number of members, in particular:

- **International Ocean Energy Technology Roadmap:** This project is seen as an opportunity for the OES in collaboration with its members to support the construction and development of an International Ocean Energy Technology Roadmap, engaging with ongoing work in international assessments of LCOE. This is in-line with the International Energy Agency (IEA) own technology roadmapping work. The Terms of Reference for this project were approved in November 2014 and the work should be initiated in the first quarter of 2015.

▸ **Action Plan for the Future of OTEC:** A proposal for an international joint research project on OTEC has been discussed. The goal of this project is to investigate a number of issues related with the promotion of OTEC, such as current situation, methodologies for evaluation, environmental assessment, cost of energy, operation and safety and OTEC Roadmap. A draft document was discussed in November 2014, a set of countries expressed interest in the activity and it was agreed to proceed with preparation of the Terms of Reference.

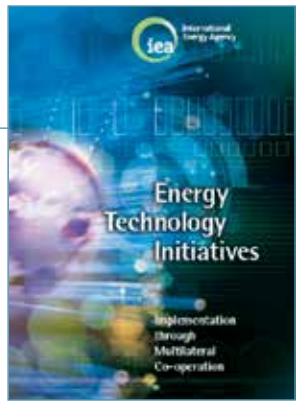
INTERACTION WITH THE IEA

MID TERM REPORT

In 2012, the IEA Committee on Energy Research and Technology (CERT) approved the extension of the OES from 29 February 2012 to 28 February 2017.
In 2014, the OES reached the mid-point of its third mandate period and therefore was invited to present a progress report on the ongoing work to the IEA Renewable Energy Working Party (REWP). This initiative is a way of strengthening communications and exchanging views on current and emerging issues between REWP and OES.

ENERGY TECHNOLOGY INITIATIVES 2015

The OES contributed to the Energy Technology Initiatives 2015 with details about ongoing OES projects that resulted in the most significant outcome or achievement during 2013-2014: the **THETHYS** knowledge management system and the **World Web GIS Database on Ocean Energy**.



THE IEA OPEN ENERGY TECHNOLOGY BULLETIN

The Chairman responded to questions about the recently-developed web-based Geographical Information System (GIS) tool and the future of marine technologies, for the Bulletin Technology Spotlight. It can be viewed here:
http://www.iea.org/media/openbulletin/OESSep2014.pdf

03. DISSEMINATION AND OUTREACH

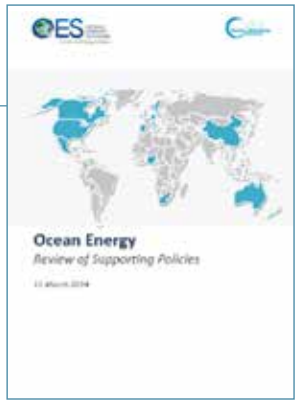
Much of the activities of dissemination are conducted within the Annex I - Review, Exchange and Dissemination of Information on Ocean Energy Systems, which is a mandatory Annex of the OES Work Programme, running since the formation of the OES. The objective of this task is to collate, review and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of ocean energy systems.

COLLECTION AND EXCHANGE OF INFORMATION

ANNUAL REPORT

The Annual Report includes, each year, country reports provided by each member country on ocean energy policies, R&D and technology demonstration. This is intended as the flagship document for OES activities and a marker for industry development. Members ensure that the Annual Report reaches its target audience in the respective countries and its publication is accompanied by a worldwide media release.

OCEAN ENERGY: REVIEW OF SUPPORTING POLICIES



The Report *Ocean Energy: Review of Supporting Policies*, prepared by the end of 2013, under the Annex I, was released in February 2014. In this report, the OES intends to emphasize the range of policy and funding initiatives to promote and accelerate the uptake of ocean energy that its member governments and related organizations have implemented.
This report provides an insight into the diverse ocean energy policies across all member countries, focusing on recent developments. Information on policies which support and have impact on ocean energy development was obtained from the OES member delegates.

CONSENTING PROCESSES FOR OCEAN ENERGY ON OES MEMBER COUNTRIES

The consenting process for ocean energy projects is regarded as a critical barrier for industry and to future progress of the sector.
Ocean energy projects are relatively new to many regulatory bodies and are often considered under legislation developed for other sectors (e.g. oil & gas or aquaculture), which may not be ideally suited to a new technology such as ocean energy. Consequently, separate consents are often necessary for the marine, terrestrial and electrical elements of a project. There is a general opinion that development activities are stimulated in countries that implement a clear and consistent consenting process for ocean energy. As a way to expedite the consenting process, some countries have attempted to "streamline" their procedures so as to improve their operation. Elsewhere streamlining has culminated in the adoption of a "one stop-shop" approach to administration of the consenting process, for example, Scotland.

Maritime Spatial Planning (MSP) and Strategic Environmental Assessment have been identified as tools which can support and inform future consenting of ocean energy projects. Some countries are in the process of developing MSP systems and others have already zoned sea areas for marine renewable energy development. The operation of consenting systems will always be influenced to a large extent by national governance structures, given ultimate authority rests primarily with them. Likewise dedicated policies, strategies and incentives for renewable energy introduced by respective governments can have a significant impact on progressing industry development.

The subject of "Permitting and Licensing" was mentioned as one important topic that the ExCo should address. The present Report prepared under the Annex I addresses the following topics:

- Marine Spatial Planning policies and site selection for ocean energy development
- Regulatory issues and authorities involved in the consenting process
- Environmental impact assessment requirements
- Consultation as part of the licensing process
- Challenges to the consenting process and streamlined licensing processes

SPONSORSHIP AND CO-HOSTING OF CONFERENCES AND WORKSHOPS

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 is to share recent experiences from research and demonstration efforts. Some OES delegates are part of the steering committee of the conference.

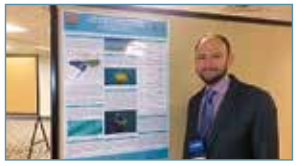
All papers and conference material from previous conferences are available on a dedicated website managed and hosted by the OES: http://www.icoe-conference.com/

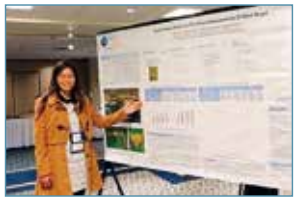
The 2014 ICOE was held in Halifax, Canada, hosted by Marine Renewables Canada in partnership with the Government of Nova Scotia, the Government of Canada, The Nova Scotia Offshre Energy Research Association and the New Brunswick Department of Economic Development. During 2014, the OES was much involved in the organization of the programme of this conference. The OES Chairman organized a session entitled "Showing the world - update on flagship projects", and the OES Secretary moderated a session about international collaboration, which included presentations from 4 member countries (USA, UK, Ireland and China) and an overview from the OES Chairman about the role of OES supporting the development of ocean energy.

THE OCEAN ENERGY SYSTEMS POSTER AWARD:

The OES was also the organizer of a "poster award", a cash prize to 3 students selected by an international jury, composed by members of the OES. This award on behalf of the OES is intended to identify an early career individual expected to continue to make significant contributions in making industrial ocean energy a reality.

PRIZE	NAME	TITLE OF STUDY
1ST PRIZE (€ 1500)	**Amin Abolghasemi** Imperial College London, UK	*Simulating Tidal Turbines with Adaptative Meshes and RANS Turbulence Models*
2ND PRIZE (€ 1000)	**Bret Bosma** Oregon State University, USA	*Design and Modelling of the Floating Power System for the Galway Bay Wave Energy Test Site*
3RD PRIZE (€ 500)	**Qiuin Liu** Tsinghua University, China	*Experimental Study on Performance of Wave Buoys in Measuring Waves*





Poster session winners ICOE 2014 sponsored by the OES

JOINT OECD/OES WORKSHOP "EXPLORING THE PROSPECTS FOR MARINE RENEWABLE ENERGY TO 2030"

This workshop was organised within the framework of the OECD project on the future of the ocean economy. It was held at the IEA headquarters, on 15 May 2014, co-hosted by the Ocean Energy Systems Implementing Agreement and the OECD.

The OECD project "The Future of the Ocean Economy: Exploring the prospects for emerging ocean industries to 2030" aims to conduct a global forward-looking assessment of the ocean economy to 2030, with special emphasis on the potential development of emerging ocean-based activities.

The objective of the workshop was to explore the contribution that ocean energy and offshore wind can make to the growth of ocean economy and its potential for employment and wealth generation. Particular attention was devoted to the risks and uncertainties surrounding the future development of marine renewable energy, the innovations required in science and technology, investment needs, synergies with other sectors, contribution to green growth, environmental and regulatoryimplicationsand the policy options most suited to boost their long-term prospects while managing the ocean in responsible and sustainable ways.

More information about the OECD study is available at: http://www.oecd.org/futures/oceaneconomy.htm

1st INTERNATIONAL SEMINAR ON MARINE ENERGIES IN ARGENTINA

OES was the sponsor of the 1st International Seminar on Marine Energies (SIEMAR) that took place on 26 and 27 November, in Mar del Plata, Argentina.

The Seminar was organised by Unidad Académica de Mar del Plata, Secretaría de Relacionales Internacionales del Rectorado de la Universidad Tecnológica Nacional (International Relations Secretary of the National Technological University) and Ministerio de Ciencia, Tecnología e Innovación Productiva (Ministry of Science, Technology and Innovation).

OES was presented by its Chairman, José Luis Villate, who participated also in the opening session together with Dr. Mentaberry (Executive Coordinator of the Scientific Cabinet of the Ministry of Science, Technology and Innovation of the Argentina Government).

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 provides an annual sponsorship approved each year, particularly to develop membership in new regions, including Asia and the Pacific.

In 2014, the following activities were sponsored by the OES:

▸ **INORE Annual Symposium in Spain:** Award of a travel grant of €500 to a Colombian student from the University of Antioquia (School of Engineering) to attend the symposium, aiming to set up new trans-continental collaborations.

▸ **INORE@AWTEC 2014:** OES sponsored with €1500 the 1st INORE workshop at AWTEC in Tokyo, in July 2014, to encourage early-stage researchers in Asia to join INORE.

▸ **OES-ICIS Scholarships:** OES continues to sponsor 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. In 2014, the OES supported one ICIS grant for a collaborative team: Danny Sale (University of Washington) and Yifan Dong (Shangai Jiaotong University) awarded € 2000 to work together on developing a methodology to support design of full scale marine current turbines.

▸ **INORE New Website:** OES funded with €1500 the crowdfunding campaign set up by INORE to develop a new website.

PRESENCE IN MAIN 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 2014, in which the OES was represented:

EVENT	LOCAL	DATE
7th Global Marine Renewable Energy Conference	Seattle, USA	15 - 18 April 2014
First Meeting of the European Ocean Energy Forum	Brussels, BELGIUM	4 April 2014
Second Meeting of the European Ocean Energy Forum	Dublin, IRELAND	11 June 2014
Business Forum on Ocean Policy and Planning – World Energy Council	New York, USA	28-30 September 2014
ICOE 2014 - International Conference on Ocean Energy	Halifax, CANADA	4-6 November 2014
International Seminar on Marine Energies	Mar del Plata, ARGENTINA	26 – 27 November 2014

OCEAN ENERGY FORUM

The Ocean Energy Forum is a European initiative launched by the European Commission in April 2014 which brings together stakeholders to develop a shared understanding of the problems and to develop solutions. This Forum is a first stage of an action plan to accelerate the progress towards full industrialisation of ocean energy in Europe.
The Forum will run for two years and its ultimate aim is to deliver a Strategic Roadmap for the development of the sector. It is divided into three workstreams: Technology, Finance and Environment & Consenting. Each of these worstreams has its own Steering Group, with representatives from all relevant stakeholder groups. The OES is part of the Steering Group on Environment & Consenting and in 2014 was represented in the two meetings of this group.

PROMOTIONAL MATERIAL

NEW VIDEO ON OCEAN ENERGY

Launch of a new video on Ocean Energy on:
http://www.ocean-energy-systems.org/what-is-ocean-energy/

The goal of the video is i) to promote ocean energy as a viable energy resource and educate decision makers as well as public about what ocean energy is and how it can contribute to a sustainable energy production, ii) to highlight recent developments, challenges faced by technologies deployed in the ocean and the need for adequate national policies to promote ocean energy, iii) to promote international collaboration.

FACT SHEETS

Development of fact sheets for each ongoing project:

WEBSITE

The website (**www.ocean-energy-systems.org**) is the primary source for communicating OES activities to a wider audience. In 2014, a new area, the World of Ocean Energy, was developed; it includes a web-based GIS tool and interactive maps with details about open sea testing facilities and installed capacity based on the information from the Annual Report. The visitor can navigate between the main overview/statistics and the GIS map functionality, in the tabs.

LEAFLET AND NEWSLETTER

Update of the leaflet and preparation of a newsletter issued biannually, immediately after each ExCo meeting, presenting most updated information exchanged by the delegates.
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 has been delivered to prospective member countries and potential contracting parties.

04. ONGOING COLLABORATIVE PROJECTS

ASSESSMENT OF ENVIRONMENTAL EFFECTS AND MONITORING EFFORTS (ANNEX IV)

Project Duration
Phase II: 2013 - 2016
Phase I: 2010 - 2013

Operating Agent
Hoyt Battey (US Delegate), US Department of Energy (DOE)

Partners
Bureau of Ocean Energy Management (US)
National Oceanic and Atmospheric Administration (US)

Technical Consultants
Pacific Northwest National Laboratory (US), assisted by Aquatera Ltd (UK)

Participating countries
Canada, China, Ireland, Japan, New Zealand, Norway, Portugal, South Africa, Spain, Sweden, United Kingdom and United States of America

Further information
http://tethys.pnnl.gov/

OBJECTIVES

Annex IV seeks to be the premier international program engaged in bringing together information and practitioners on environmental effects of marine energy development.

The second phase of Annex IV builds on the work completed during the first phase, by continuing to collect, analyze, and disseminate information, to enhance the development of the marine energy industry by providing access to knowledge and information related to research, monitoring, and evaluation of environmental effects of offshore renewable energy. Supported by the online knowledge management system *Tethys*, developed by PNNL, a commons is being created for Annex IV that facilitates the broadcast and archiving of webinars, expert forums, and workshops focused on important scientific issues that are critical to the siting and permitting (consenting) of marine energy devices worldwide. Annex IV also plays a role in supporting the dissemination of information via international conferences and events, focusing on new environmental research and data on interactions among marine animals, habitats, and marine energy devices. The culmination of phase 2 of Annex IV will be a State of the Science report that summarizes the state of knowledge of environmental effects of marine energy development, and seeks to place that knowledge in context of the progress of the industry worldwide.

ACHIEVEMENTS AND PROGRESS IN 2014

During 2014, Phase 2 of Annex IV highlights include:

- Participation by member nation analysts;
- Collection and update of metadata forms;
- Broad dissemination of information;
- Convening and reporting on targeted workshops;
- Holding webinars and experts' forums;
- Progress towards the 2016 State of the Science report; and
- A partnership with a major international conference.

Progress towards each achievement is described in the following sections.

MEMBER NATION ANALYSTS

Phase 2 of Annex IV is characterized by the close involvement of an analyst from each of the member nations. Each analyst was nominated by his/her nation, and is committed to contributing 10 to 20 hours per quarter to Annex IV. Key tasks asked of each analyst include:

- Reporting progress in marine energy development and environmental effects work within their respective countries, updating existing Annex IV metadata forms and providing new ones as projects or research studies are initiated;
- Acting as an expert group for the Annex IV process on direction for webinar, expert forum, and workshop topics;
- Providing reviews of products, such as *Tethys* content and functionality;
- Engaging in identifying experts (or participating directly) in preparing a State of the Science report in 2016;
- Advising and participating in an international conference in 2015/2016; and
- Acting as an ambassador for Annex IV in their respective country.

COLLECTION AND UPDATE OF METADATA

Information is collected for ongoing marine energy sites and research projects in the form of metadata that describe the project or study, the methods and outcomes of environmental monitoring, and provide contact information for the owners or authors of the reports. Building on the collection of metadata from phase 1, Annex IV continued to collect information on new wave and tidal projects and for ongoing research studies. This information is subsequently

stored and can be accessed from *Tethys*. In addition, the program sought to update existing metadata forms by working through the country analysts and directly with developers and researchers. Over the course of 2014, 16 new project site forms and 9 research study forms have been added, while 47 project site forms and 11 research study forms have been updated. The total Annex IV metadata form collection on *Tethys* currently includes 82 project sites and 57 research studies. Those totals include project sites for which there is no longer gear in the water but where environmental data were collected; they are maintained in the collection to increase the overall lessons that can be learned.

DISSEMINATION OF INFORMATION ON ENVIRONMENTAL EFFECTS

Tethys, the online knowledge management system which supports Annex IV material, continues to expand and to increase user interactions. The publically available collection of scientific papers, reports, and other media increased by almost 500 papers in the last year, for a total of almost 1700 entries. The collection includes information on offshore wind effects as well, but over half the papers are exclusively about marine energy development. Over the past year, *Tethys* has seen a 106% increase in pageviews, with an increase in total visits to the site of 24%. During 2014, researchers, regulators, developers, and stakeholders, including seven of the Annex IV analysts, provided over a hundred peer review comments on the content and functionality of *Tethys;* the results of the peer review help guide improvements and changes to the system. A report summarizing results of the peer review is available at: http://Tethys.pnnl.gov/sites/default/files/attachments/Tethys%20FY14Q3%20Progress%20Report.pdf

ANNEX IV WORKSHOPS

Annex IV sponsored a one-day workshop in conjunction with the Environmental Impacts of Marine Renewables (EIMR) conference in Stornoway Scotland during spring 2014. The workshop was focused on identifying the best practices of environmental monitoring for specific key environmental interactions between marine animals and wave and tidal devices. The workshop was attended by 43 participants and 61 observers. Break out groups addressed four important interactions of marine energy devices with the environment: blade interaction; attraction; avoidance/ barrier effects; and mooring line interactions. The overall lessons from the workshop include: 1) In general, more research is needed to establish efficacy of monitoring methods and technologies; 2) Monitoring efforts around projects need to commensurate with risk to animals, and affordable; and 3) Integrated package of instruments to observe blade interactions are very costly and an independent research effort is needed to better develop these systems. A final workshop report has been written, reviewed, and distributed to the participants. Annex IV was also a major partner in the EIMR conference; all the EIMR presentations are archived on *Tethys*: http://tethys.pnnl.gov/conferences-and-workshops

Annex IV sponsored a one-day workshop in Wolfville Nova Scotia, bringing together regulators, marine energy researchers, and industry representatives, to determine what data are needed and what data can be collected, to assist with siting and permitting (consenting) of marine energy devices. The premise behind the workshop was that regulators in all nations need to assure that the deployment and operation of wave and tidal devices do not cause unacceptable harm to the marine environment and the animals that live there, particularly fish and marine mammals. New technologies and device components developed for marine energy create potential new interactions with animals and habitats for which there are no data; these interactions provide the greatest concerns and risk for regulatory approval. Baseline data on site characterization and use by animals is limited for sites where wave and tidal development is desirable. The scientific community is currently focused on adapting instruments and techniques to gather data in high-energy environments, including observations of animals in close proximity to devices. A workshop report is being prepared and will be disseminated early in 2015.

WEBINARS AND EXPERTS' FORUMS

Three webinars have been held by Annex IV in 2014, each bringing together between 55 and 140 people online to listen to recent research results and plans:

1. Summary of Instrumentation Workshop, January 23, 2014
This webinar summarized a workshop that was held in Seattle in June of 2013 focused on evaluating the gaps in available instrumentation for environmental monitoring and identifying possible solutions to address these gaps. Speakers for this webinar included: Brian Polagye, Northwest National Marine Renewable Energy Center; and Andrea Copping, Pacific Northwest National Laboratory.

2. Interactions of Marine Mammals and Birds around Marine Energy Devices, May 19, 2014
The second Annex IV webinar discussed the current understanding and new research efforts around interactions between marine mammals and birds and marine energy devices. Speakers for this webinar included: Ben Wilson, Scottish Association for Marine Sciences; Benjamin Williamson, University of Aberdeen; and Beth Scott, University of Aberdeen.

3. Tidal Energy Research in the Bay of Fundy, October 27, 2014
As a precursor to the International Conference on Ocean Energy (ICOE) held in Halifax, the third Annex IV webinar highlighted research activities pertaining to the environmental effects of marine renewable energy development in the Bay of Fundy. Speakers included: Graham Daborn, Anna Redden, and Richard Karsten, of Acadia University, as well as Greg Trowse, Fundy Tidal Inc.

The presentations and discussions are archived at: http://tethys.pnnl.gov/mhk-environmental-webinars

Two experts' forums were held in 2014, each lead by a prominent researcher in the field, with the intent of bringing together select experts to address specific challenges for monitoring potential effects of marine energy development:

1. Analyzing Acoustic Data around Marine Energy Devices was held on July 24, 2014
Discussions focused on the use of active acoustic instruments to measure interactions of marine animals and seabirds around marine energy devices and how to adequately address turbulence and other background signals that can interfere with acoustic data. Gayle Zydlewski from the University of Maine in the US led this discussion.

2. Risk of Collision between Marine Animals and Tidal Turbines was held on December 15, 2014
This forum was led by Carol Sparling of Sea Mammal Research Unit (SMRU) in the UK. Discussions focused on the challenge of observing collisions and near-turbine interactions for marine animals (marine mammals, birds, fish) in high-energy tidal areas, and the need for predictive models and conceptual frameworks for defining interactions to further our understanding.

The presentations and discussions are archived at: http://tethys.pnnl.gov/experts-forums

STATE OF THE SCIENCE REPORT

The culmination of Phase 2 of Annex IV will be the State of the Science report to be produced in 2016. Efforts have been initiated to develop an outline and assign primary authors for specific chapters of the report. The report will review all the major interactions that potentially place marine animals or habitats at risk from marine energy development. The three case study interactions developed for the Phase 1 Annex IV report (animal interactions with tidal blades; underwater noise effects from marine energy devices on animals; and changes to physical systems from energy removal) will be updated. In addition several more interactions will be explored that may include: effects of electromagnetic fields (EMF) on marine animals; effects on fish from reefing around devices; changes to benthic habitats; and potential spatial planning conflicts with fishing and conservation. Case studies that examine siting and permitting of marine energy devices may also be included. The first draft of the State of the Science report will be available for review in late 2015.

PARTNERING WITH AN INTERNATIONAL CONFERENCE

Annex IV will partner with the European Wave and Tidal Energy Conference (EWTEC) during September 2015 in Nantes, France. As the premier academic conference on marine energy development, every two years EWTEC brings together over 500 researchers from more than 20 countries. Although EWTEC has an environmental track,

the network of researchers involved with Annex IV can greatly enhance the participation and variety of papers on environmental effects. At the same time, EWTEC is an opportunity for Annex IV member nations and researchers to share environmental research with a broad audience.

FUTURE ACTIVITIES

The major focuses of Annex IV activities during 2015 will be organizing the environmental research sessions to be held at the EWTEC conference and developing the State of the Science report. EWTEC will be held during September 2015 and will require coordination among conference participants and speakers, reviewing papers, and organizing plenary and contributed talks. The writing and review period for the State of the Science report will occur during 2015, with a publication date in 2016.

Future efforts will continue to focus on creating a commons around Annex IV and *Tethys* including: the continuation of the Annex IV environmental webinars and expert forums; the use of social media to reach new users, and the regular addition of new content, metadata, blog posts, and *Tethys* Blasts to continue engaging the Tethys community. Regular communication and update calls will be held with Annex IV member nation analysts to keep them apprised of Annex IV progress and upcoming activities such as: webinars and expert forums; soliciting new and updated metadata forms; and continued planning for the EWTEC conference and the State of the Science report.

EXCHANGE AND ASSESSMENT OF OCEAN ENERGY DEVICE PROJECT INFORMATION AND EXPERIENCE (ANNEX V)

Project Duration
2012 - 2015

Operating Agent
Robert Thresher at the National Renewable Energy Laboratory on behalf of the Department of Energy (DOE), U.S.

Participating countries
All countries

Further information
www.ocean-energy-systems.org

OBJECTIVES

The mission of Annex V - The Exchange and Assessment of Ocean Energy Device Project Information and Experience - is to accelerate ocean energy device project development by promoting the sharing, interchange, evaluation, and compilation of information from participating member countries.

To this end, Annex V is sponsoring a series of workshops, bringing international experts together to contribute and exchange data that can be used to develop an assessment of the fundamental knowledge of ocean energy. Two workshops have been held; the first was on the site development and operations for open water testing and the second was on computational modeling and analysis of marine energy converters, with two additional workshops being planned.

ACCOMPLISHMENTS

Since 2012, Annex V has conducted two exchange workshops, in which participating members presented, collected, and reviewed project information, experience, and data. Annex V has facilitated the presentation of projects from participating member countries in the areas of open ocean testing methods and test center operation as well as the verification and validation of computational modeling methods.

WORKSHOP I: OPEN WATER TESTING

Dublin, Ireland, October 2012

The open water testing workshop brought together test site operators and wave device developers to exchange information and experience on all aspects of planning, development, operation, and usage of open-water test facilities to identify possible improvements in the capabilities of these facilities for the mutual benefit of the entire ocean energy industry. Workshop participants included 36 representatives from 12 different countries. The participants gave 16 presentations about open-water test facilities.

During workshop discussion sessions, a central theme emerged that focused on defining a business model for test centers in order for them to most effectively accelerate the development and commercialization of the industry. A second issue that emerged during the workshop was the clear preference of device developers to perform research and development (R&D) testing in open waters at or near full scale to validate stepwise device improvements and environmental effects over extended periods of time. A third issue that emerged was whether the test centers should provide some type of certificate attesting to the type and duration of testing that was accomplished during the open-water deployment of a device.

WORKSHOP II: COMPUTATIONAL MODELING AND ANALYSIS

Edinburgh, Scotland, November 2013

There are numerous worldwide organizations and individuals developing and applying computational analysis methods to analyze the performance and dynamic loading of wave, tidal, and ocean current devices. The goal of Workshop II was to bring together these expert analysts to exchange information and experience on all aspects of developing, using, verifying and validating these computational modeling tools to improve these capabilities for the mutual benefit of the global ocean energy industry.

Fifty participants from 12 different countries attended the two-day workshop. Twenty-seven presentations were given, 14 on the analysis and design of tidal and current converters, and 13 presentations on wave energy converter analysis and design. Workshop participants concluded that using computational benchmarking to rigorously validate wave and tidal codes for marine energy applications would be extremely useful for the global marine energy community. Workshop I and II reports are available online:
http://www.ocean-energy-systems.org/about-oes/work-programme/annex-v-project-information/

In response to the conclusion of this workshop, which stated the need for rigorous validation of wave and tidal computational codes, several Annex V participants held a planning meeting to develop and draft a new annex to undertake this validation assessment. As a result, the OES Executive Committee at its last meeting commissioned Annex VI – Ocean Energy Modeling Verification and Validation, to begin work in 2015.

FUTURE WORKSHOPS

During 2015, Annex V is planning to hold two workshops:

- The first workshop will focus on reliability of marine energy devices. As technology is developed in the ocean energy sector, an essential and necessary consideration for the design and cost-effective commercial operation of this technology is the reliability of the devices to operate for extended periods of time under harsh marine conditions. Reliability of the devices must be considered early in the design phase in order to significantly impact both the initial capital cost and the operation and maintenance costs for a long life. This workshop will share information and knowledge on device analysis and design methods for assuring survivability, structural integrity, and fully operational power generation between scheduled maintenance events, as well as the needed support mechanisms to develop the envisioned high reliability technology. The workshop will be hosted by WavEC Offshore Renewables in Lisbon, Portugal, and will be held at the WavEC premises on February 5th and 6th, 2015.

- The second planned workshop will focus on analysis of cost of energy for ocean energy systems. The assessment of the levelized cost of energy (LCOE) for ocean energy devices represents a critical element of understanding the path to commercialization of ocean energy. While the cost of existing prototype devices is high, there are significant opportunities for reduction in LCOE. This workshop will invite presentations that explore the factors contributing to energy capture and the cost of today's devices, as well as associated project costs contributing to the overall LCOE. In addition, the workshop will be open to presentations exploring how this LCOE might be reduced in the future through technology innovation, learning by doing, material and manufacturing advancements, and other means. This workshop is tentatively planned to be held in the fall of 2015 and the host will be the University of Edinburgh.

WORLDWIDE WEB GIS DATABASE FOR OCEAN ENERGY

Project Duration
Started in June 2013; annually updated

Project Coordinator
Jochen Bard, Fraunhofer Institute IWES, Germany

Further information
www.ocean-energy-systems.org

OBJECTIVE

The goal of this project is to develop an interactive web-based GIS mapping application 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 comprises ocean energy facilities, resources, relevant infrastructure and relevant general geopolitical and geographical information, altogether in conjunction with the respective location and distribution on a global map.

ACHIEVEMENTS

The web-based GIS tool was launched on the OES website in the first quarter of 2014 and a document has been prepared presenting the background/sources of the data utilized on the OES web-based GIS.

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.

COST OF ENERGY ASSESSMENT FOR WAVE, TIDAL AND OTEC

Project Duration
October 2014 – March 2015

Project Coordinator
Henry Jeffrey, The University of Edinburgh, UK

Project Partners
Alex Raventos, WavEC Offshore Renewables, Portugal
Julia Chozas, Julia F. Chozas, Consulting Engineer, Denmark
Mirko Previsic, Re Vision Consulting, USA

Project Advisors
Kim Nielsen, RAMBOLL Group A/S, Denmark
David Aderibigbe, FOT-K Consortium, Nigeria

Further information
www.ocean-energy-systems.org

OBJECTIVE

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 LCOE assessment for wave, tidal, and OTEC technologies, together with the identification of the routes to maximise rapid cost reduction through international collaboration and deployment effort.

The assessment of LCOE for ocean energy devices represents a critical element of understanding in the development of ocean energy array projects. While the cost of existing prototype devices is high, there is scope for significant reductions of the cost of energy. In order to unlock some of these cost savings, the deployment levels of ocean energy converters will need to ramp up and projects must progress into the construction and operation phases.

This project aims to provide an **authoritative view on which cost reductions are feasible at a global level, taking into account the experience from other technologies.** By undertaking a **bottom-up assessment of the cost components of leading wave, tidal, and OTEC systems**, this work will investigate the development and fabrication of leading devices or systems, and their integration into commercial arrays and large scale power plants. The assessment will include project development costs (including streamlining of environmental consenting) and operations and maintenance. The work will be informed by a series of in-depth interviews with technology developers, and will build upon work carried out in European funded projects, such as SI Ocean, DTOcean, Equimar or Waveplam.

05. CURRENT PERSPECTIVES ON OCEAN ENERGY FROM THREE LEADING PROJECT DEVELOPERS

DP ENERGY

SIMON DE PIETRO
Managing Director of DP Energy

The ocean energy sector needs the first pre-commercial projects in the water, and your organization has a leading role worldwide, could you give some information of your short to medium term plans given the actual conditions?

Simon De Pietro: It is critical firstly that the early arrays demonstrate performance in respect of both yield, and environmental compliance but secondly that there is a clear pathway beyond these deployments to significant cost reduction and increased reliability and operability. Both stages are critical to gaining investor confidence in the short to medium term. On their own, project sizes sub 10 MW are really not an attractive proposition to a major industrial, utility or pension fund. The deployed capital is simply not sufficient to warrant the attention and due diligence. For these small projects perceived risks are high and, even if theoretically bankable IRRs can be generated by high feed in tariffs and/or other support structures, getting investment is still difficult and to date debt from commercial lenders doubly difficult.

DP Energy is working on delivery of early stage small scale projects utilising competent technology supported by solid OEMs, and in parallel delivery of

longer term larger utility or industrial scale projects (100-200 MW+) which are de-risked (grid contract, consented etc) ready for conventional financing structures. The intent is that by supporting both, and planning the timing of delivery of these two project streams DP can help the sector make a relatively smooth transition to commercialisation. The objective being to give confidence to investors that tidal is a workable and valuable proposition and to provide certainty to the OEMs that there is sufficient market to warrant expenditure on R&D and cost reduction programmes.

DPs demonstration projects, which cover a range of technologies and OEMs, are planned for deployment in the 2017/2018 time frame – including the Fair Head project in Northern Ireland, and FORCE in Nova Scotia. Its lead industrial scale projects – including the build out of Fair Head, West Islay and Westray in Scotland are scheduled for 2020 - 2022 subject to grid and technology performance demonstration and a stable and supportive energy policy environment for investors.

Project development involves a wide variety of risks, including technical, regulatory and financial, could you describe which are the most critical ones you have encountered/are encountering and how could they be overcome?

Simon De Pietro:

The Fundamental Risk and Challenge

It is perhaps worth noting that DP Energy is an all round renewable, technology neutral, business and has interests in wind (where it started some 20 years ago), solar (PV in particular), and storage as well as in tidal energy. The first fundamental risk then for any sector is that the technology cannot achieve a competitive Cost of Energy (i.e. kWh price). Ultimately, as a renewable site developer, where the kWh comes from does not matter and the fall of costs for more mature renewable Wind and Solar PV in particular is a challenge for any new renewable technology. This challenge is compounded for Ocean Energy by the need to exist and operate in a harsh and energetic environment but of course that is also a mark of its great potential and why it is worth pursuing.

Technology Maturation/Commercialisation

Across the spread of Ocean Technologies, and whilst recognising the substantial potential in some of the other areas (Wave in particular), DPs view is that closest to maturity is the Tidal Energy Sector and as a commercial developer has chosen to focus its resources for the time being at least in this area. The maturity of the sector is also illustrated by the acquisition of the small innovative companies (MCT, TGL etc) by some large industrials. It needs these large industrials to substantially reduce costs and apply the rigours of value engineering that is a mark of their production background. The recent decision by Siemens to divest of MCT is clearly a concern for the sector but this is more likely a recognition of the potential size of the tidal sector which, whilst substantial, is more limited than for example the worldwide wave resource.

In order to achieve an acceptable Cost of Energy the sector needs to expand, savings need to be made not just on turbines and foundations, but also on installation and maintenance cost, and balance of plant (e.g. electrical marshalling). This requires ocean deployment and real sea experience not just tank testing and modeling and that is expensive. In order to facilitate these deployments then developers need to (and are) investing significant amounts of money and resources in putting projects in place based on the technology delivery plans in order to be ready for deployment in the first pre-commercial and commercial arrays.

As it does with its wind projects, DP Energy approaches development as a technology neutral Commercial developer and approaches sites from a "project comes first" not technology first perspective. However, National and EU funds such as NER 300 are very often linked to specific technologies and, if these change or fail to progress, the public investment in the sector is threatened and the development pathway is also compromised. The structure of the funds is sometimes also a challenge – funds based on generation including the NER300, which effectively supplement an enhanced Feed in Tariff still leave the entire technology risk with the site developer or the OEM if they are prepared to accept any risk.

Additional and ring fenced public support for the tidal energy industry recognizing the technology risks (and likely ability of the sector players to take those risks), coupled with a stable energy policy environment, would encourage continued investment in the sector.

Public/Private Finance – De-Risk Early Arrays

Whilst support from public funding is clearly recognized, and obviously welcomed, a significant amount of money has been invested by private companies in the industry, both in site and in technology development. However finance remains

one of the a major challenges to drive the sector forward. Until confidence is developed within the investor community and commercial debt is available to the sector this will remain the case, and that requires ocean deployment of early arrays.

While most of the leading markets are providing, or plan to provide reasonable revenue incentives, it will also be necessary for member states and the European Commission to provide direct capital support and/or underwrite the risk elements to encourage private debt and equity partners to engage at this early stage. Possible options which may be considered in this situation are co-investment and risk sharing including 'super-funds' and government backed guarantees to underwrite risk.

Linked to this is the need for cost reduction from technology providers, marine contractors and the wider supply chain. This cost reduction trajectory is likely to happen organically to some extent, but the projects will never reach a competitive levelised cost of energy (LCOE) unless there are significant cost reductions at all levels. Cost reductions traditionally occur through knowledge sharing, collaboration and joint ventures and this must happen in this sector to drive down costs.

Grid Issues

Like all renewable technologies, the resource is where the resource is, and particularly for Tidal energy the currently commercially exploitable resource is largely remote from the principal demand (e.g. Orkney and Pentland Firth, Bay of Fundy, Antrim Coast). Commercialisation of the technology through larger projects therefore requires close access to grid and potentially significant transmission reinforcement to facilitate dispatch of that energy to where it is needed.

As a site project developer, grid issues largely falls to DP to deliver and this is no different whether a wind, solar or tidal project. However, what is different is that commitment to grid securities and providing guarantees for potentially expensive grid solutions is significantly easier when the generation project is readily fundable (and bankable). For a tidal project the connections inevitably involve expensive offshore works and landfalls and long transmission upgrades. When this additional grid issue is combined with project financing challenges it becomes a significant hurdle.

In order for OEMs to make positive investment decisions in relation to the sector and delivery of technology they need to be convinced that there is a viable pipeline of projects. As a site developer the extreme time delays and capital costs associated with developing new infrastructure is a major deterrent and is an issue, which can be dealt with at least in part by energy policy makers.

DP Energy is working on delivery of early stage small scale projects utilising competent technology supported by solid OEMs, and in parallel delivery of longer term larger utility or industrial scale projects (100-200 MW+) which are de-risked (grid contract, consented etc) ready for conventional financing structures. The intent is that by supporting both, and planning the timing of delivery of these two project streams DP can help the sector make a relatively smooth transition to commercialisation.

Historically grid infrastructure was managed nationally and was not part of the initial capex of individual electricity generation projects. DP is supportive of deregulation and privatisation of the electricity sector as this has created opportunities for renewable energy developments and increased competition in general. It has however led to more of the costs associated with grid development and reinforcement being borne by individual generation projects, as opposed to being socialised, potentially making tidal energy projects unviable in many key site.

Grid infrastructure is an area where project developers and support organisations should work actively and vigorously together to lobby governments for change. Infrastructure is a national resource and it is therefore theoretically easier for public funding to be used for this purpose as it becomes a national asset rather than an asset of any individual project or promoter. There are many linked issues including the need to promote EU grid extensions and interconnection between countries and regions and to integrate tidal energy into short and medium term grid planning at EU and member state level.

Organisations like the OES have a key role in disseminating information and in working with national governments to provide timely and accurate information in relation to the industry.

If support measures are put in place in order to overcome those barriers, can you identify the responsible stakeholders for delivering solutions, such as, governments, supply chain, research sector, etc and what would be the expected improvement in terms of your project pipeline and cost reduction that could be achieved?

Simon De Pietro:

Technology – ultimately it is the responsibility of the OEMs to develop their technology in a way that is profitable in the long term and undertake whatever research is necessary to support that aspiration. In order to do that the OEMs need to concentrate on key technology challenges including energy yield/ performance, installation methodology, reliability and ability to maintain the devices at a reasonable cost. However, in order to build a new industry to enable the exploitation of a new energy resource it is necessary for the member states and the EU to provide R&D support for the OEMs directly or via the research sector to enable them to develop their devices to a stage that they are commercially ready for deployment and able to compete with more mature forms of renewable energy.

Finance – At this early stage it is critical that significant public funding remain available in the form of capital grants and risk sharing to enable the technology to be tested in real sea environments at a meaningful scale in arrays. Once confidence is established within the mainstream investment community that the technology works in these arrays, it will effectively de-risk future investments and will open the sector up to conventional finance mechanisms and private debt and equity deals.

Grid – Whilst DP is exploring a number of private wire solutions for its own projects, and in collaboration with others for multiple projects, at present the unlocking of grid infrastructure will require support from national governments and regulators. Provision of grid infrastructure is an area where public investment could be used in support of a large number of renewable projects.

Expected Improvements – The Billion Euro question. DP's objective is to see tidal competitive with other forms of renewable energy and in fact other generation based on direct cost of energy which is heading toward offshore wind (perhaps below), and its value of energy by virtue of its predictability. National and EU support should enable the industry to achieve this within a 2020-2025 timeframe

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

Simon De Pietro: DP Energy is a technology neutral renewable energy developer and operates internationally throughout these sectors. As such we have links with the majority of the main OEMs, utilities and a substantial number of the supply chain companies. This is useful in that it provides opportunities to learn from other regions in a number of areas - approaches to legislation, environment and other challenges.

Cross-border collaboration and cooperation are important as is competition.

It is important to not lose sight of development activities, research and field experiences (good and bad) across both Europe and the rest of the World. There appear to be some parallel research activities being undertaken independently and some better coordination to avoid duplication would be beneficial. This requires a multi-jurisdictional body to facilitate. Organisations like the OES have a key role in disseminating information and in working with national governments to provide timely and accurate information in relation to the industry.

We are keen to see learning captured and shared for the benefit of the industry in the early stages of its development. Investor confidence is not country based.

EMERA

NICHOLAS FYFFE
Site Development Manager

The ocean energy sector needs the first pre-commercial projects in the water, and your organization has a leading role worldwide, could you give some information of your short to medium term plans given the actual conditions?

Nicholas Fyffe: Emera Inc. is a geographically diverse energy and services company headquartered in Halifax, Nova Scotia with $9.07 billion in assets and 2013 revenues of $2.2 billion. The company invests in electricity generation, transmission and distribution, as well as gas transmission and utility energy services. Emera's strategy is focused on the transformation of the electricity industry to cleaner generation and the delivery of that clean energy to market. Emera has investments throughout north-eastern North America, and in four Caribbean countries.
Emera Inc. have partnered with OpenHydro to form Cape Sharp Tidal which will facilitate the development of tidal energy projects in the Bay of Fundy, NS. The group will initially deploy two grid connected 2 MW OpenHydro turbines at Berth D at the Fundy Ocean Research Centre for Energy (FORCE) in 2015, see Figure 1. Following those first deployments, the plan is for Cape Sharp Tidal to have developed 16 MW of tidal energy by 2017, 50 MW by 2019 and 300 MW after 2020; subject to obtaining the necessary regulatory approvals.

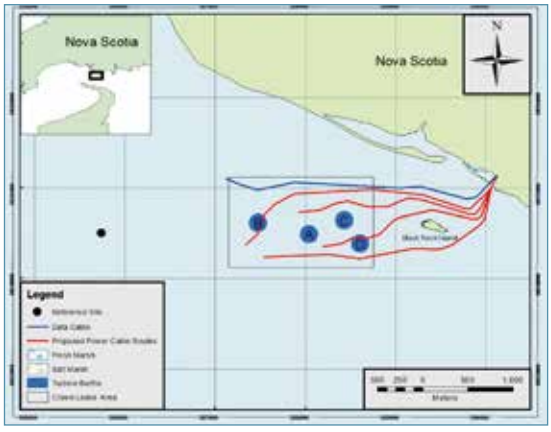


Figure 1 - FORCE Site and Berth Location (Source: Fundy Energy Resource Network)

Project development involve a wide variety of risks, including technical, regulatory and financial, could you describe which are the most critical ones you have encounter/are encountering and how could they be overcome?

Nicholas Fyffe: One of the biggest risks tidal energy project developers are facing in Canada is the uncertainty surrounding regulatory and permitting processes to secure sites for development of commercial scale tidal energy arrays. Currently the FORCE area is the only site in the Bay of Fundy with a Crown Lease for tidal energy development. This lease allows the four berth holders at FORCE to install turbines (up to 5MW in total for the site) and have them grid connected, however the path for building up to 50 MW and eventually 300 MW of tidal energy outside of the FORCE crown lease area in the Bay of Fundy has not yet been defined by the relevant regulatory and legislative bodies. This gives rise to uncertainty in the scheduling and financial aspects of project development and prevents any significant investment being made in a project site that is not licensed or does not have a clear path to being licensed. The Nova Scotia Department of Energy has recently begun developing legislation to provide a framework process by which project developers can propose to develop a tidal energy site and receive not only the rights to develop that site, but also the environmental consents, in conjunction with federal requirements, that are necessary to support development of large scale tidal energy arrays in the Bay of Fundy.

As tidal energy projects increase in size, the economies of scale obtained will reduce the resulting levelised cost of energy, however the additional infrastructure required to support construction, operation and maintenance of these larger projects will need to be carefully developed to ensure unnecessary cost is not re-introduced. The build-up of this supporting infrastructure is essential to the success of tidal power plants. Suitable port facilities providing loading

equipment, fuelling services, road access etc. in close proximity to tidal energy sites are essential as a base of operations for a tidal energy site. To enable the development of this infrastructure, the government at both a Provincial and Federal level should identify the needs of the industry and the infrastructure that can be developed. The government must build confidence and promote opportunities in the market to encourage private sector investment alongside grants and other funding opportunities that can be provided to support development. Providing certainty around the regulatory process will have a positive impact; if the government can establish a robust process and grant commercial licences for tidal energy sites then this will send a clear message to the market, enabling investment. Timeliness is of paramount importance. Realistic timelines for granting of licences and subsequent development of tidal energy sites are critical for investors to maintain confidence in the industry.

Technical challenges exist where there is a lack of operational experience in the harsh environments and high flows of a tidal energy site. The long term effect of exposure to subsea equipment, cables and connectors in these extreme environments is uncertain. Frequent and unplanned repair and maintenance of these components could escalate costs significantly, therefore it is essential that systems are robustly designed to ensure cables and equipment are adequately able to withstand damage from movement and vibration in high energy flows. There must also be careful consideration given on how to install, maintain and operate a subsea cabled grid connecting multiple turbines and other transmission equipment in a way that provides quality grid compliant power.

If support measures are put in place in order to overcome those barriers, can you identify the responsible stakeholders for delivering solutions, such as, governments, supply chain, research sector, etc and what would be the expected improvement in terms of your project pipeline and cost reduction that could be achieved?

Nicholas Fyffe: Certainly when looking at the uncertainty surrounding regulatory and permitting processes, the responsibility for leading a solution is borne by government and other regulatory bodies. The government must develop and provide a licensing system which reduces complexity in the development process by removing the need for multiple permits at a site and by providing a clear application and review process. The lack of a definite timeline or an overtly lengthy process for gaining a site license is also problematic and makes it difficult to build a business case for investing in the development of tidal energy in Nova Scotia. There is a wealth of experience available from offshore renewables in other jurisdictions such as Europe as well as offshore oil and gas in Canada and the USA, which can be used by the government to mold the licensing system into a robust platform for tidal energy development. There is also a responsibility for other stakeholders, such as project developers and service providers, to provide input into developing the regulatory process to ensure that the path for securing and developing sites is not encumbered by requirements that significantly delay or increase cost to a point where tidal energy projects are no longer feasible. On the other hand, it is also necessary to have environmental groups, local communities and local industry engaged in the regulatory process to ensure tidal energy sites are developed responsibly with regard to the environment and the interests of all stakeholders.

Figure 2 - Cable Laying at the FORCE Site (Source: FORCE)

The government can identify the supply chain needs of the industry and engage with suppliers to market their capabilities to project developers and other tidal energy participants which will aid in the development of the supply chain. Project developers also play an important role in engaging with existing local industry to establish the supply chain that will be required to support large scale tidal energy farms. To facilitate the ongoing operation of tidal power plants there is a distinct opportunity for communities in the area local to tidal energy resources to create turbine manufacturing and servicing plants and upgrade

Figure 3 - OpenHydro 16m Turbine (Source: OpenHydro)

existing local harbour infrastructure to support the offshore operations. Colleges and universities local to the area should also be engaged to provide opportunities for education and training in subjects and trades relevant to tidal energy to ensure skilled workers are available to support the industry. Overcoming these challenges will reduce uncertainty in tidal energy project development and help to stabilize project costs and timelines.

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

Nicholas Fyffe: In order for international collaboration to significantly accelerate the industry, it is imperative that the focus of collaborative efforts move from the energy converter itself to the more costly aspects of a tidal energy project, such as balance of plant, supporting infrastructure and operation and maintenance techniques. If more emphasis is placed on developing solutions in these areas, then costs can be reduced and industry growth can be more easily achieved.

Many of the challenges faced by the tidal energy industry are encountered regardless of jurisdiction. Internationally, tidal energy industry players are developing solutions and overcoming hurdles in a complementary manner, so that experience and knowledge can be shared for mutual benefit which will allow unnecessary costs and delays to project timelines to be avoided.

To give a specific example, Scotland is further advanced than Nova Scotia in its approach to regulatory and permitting of tidal energy sites with 600MW of tidal energy development rights being granted for the Pentland Firth and Orkney. The current efforts by the Nova Scotia Department of Energy to develop a licencing system in Nova Scotia would benefit from international collaboration and sharing of lessons learned from the Scottish experience. Conversely, tidal energy projects in Nova Scotia have the potential to offer to international collaborators opportunities for cost reductions, and efficiencies in installation, operation and maintenance of tidal energy devices and subsea grid infrastructure, if reliability for these techniques can be proven in the Bay of Fundy which is generally regarded as one of the harshest tidal energy environments in the world. OES could, of course, play an important role in facilitating this international collaboration through industry events, conferences, workshops and business to business matchmaking. By working with the offshore wind industry and other relevant industries to get better information and knowledge on deployment and retrieval techniques, operation and maintenance considerations, subsea cabling and infrastructure experience etc., OES could serve as a single source of information for the industry. It is important also that the wider ocean and offshore industry have significant involvement in developing ocean energy. Although tidal technology and project developers are fundamental to these efforts, research and development through collaboration with offshore industry, utilities, and government is required to provide solutions that will enable the success of tidal energy as an alternative source of renewable energy.

ESB

JAMES TEDD
Project Manager

ESB is developing the ESB Westwave project and is seeking to develop Ireland's first electricity from the Atlantic wave energy. ESB is investigating and developing a site near Doonbeg, Co Clare for 5 MW of wave energy devices - this is equivalent to the combined demand of nearby towns Doonbeg, Kilkee, and Kilrush. The ambitious project, which aims for operations to commence in 2018, is a first of its kind in Ireland. It is larger than anything developed to date, and is in line with a number of comparable projects under development in Europe.

The ocean energy sector needs the first pre-commercial projects in the water, and your organization has a leading role worldwide, could you give some information of your short to medium term plans given the actual conditions?

James Tedd: ESB is developing the ESB Westwave project and is seeking to develop Ireland's first electricity from the Atlantic wave energy. ESB is investigating and developing a site near Doonbeg, Co Clare for 5 MW of wave energy devices - this is equivalent to the combined demand of nearby towns Doonbeg, Kilkee, and Kilrush. The ambitious project, which aims for operations to commence in 2018, is a first of its kind in Ireland. It is larger than anything developed to date, and is in line with a number of comparable projects under development in Europe.

Successful development and delivery of the ESB Westwave project will support the aims of the Offshore Renewable Energy Development Plan through job creation, and communicating that Ireland is open for business. The development phase of the project is supported by SEAI (Sustainable Energy Authority of Ireland). EC NER300 funding of 23 M€ has been awarded to the project which, together with government capital and revenue will support the investment in the project.

The primary challenge for the project is the development of technology to a level at which ESB can proceed with sufficient confidence. We provided a thorough discussion on this in OES paper 2012 (http://www.ocean-energy-systems.org/documents/38361_oes_annual_report_2012_web_.pdf/).

Following successful operation of the ESB Westwave project and progressive development in wave technology, ESB intends to build out further wave energy project as part of ESB generation portfolio.

Project development involve a wide variety of risks, including technical, regulatory and financial, could you describe which are the most critical ones you have encounter/are encountering and how could they be overcome?

James Tedd: As a utility ESB is able to draw upon our experience in developing a range of generation project. ESB has implemented our in house Project Delivery Model to manage the ESB Westwave Project. This has allowed ESB to manage the project risks.

The key risk in developing the ESB Westwave project is the pace of development of the technology, as wave energy technology is novel with a number of companies testing prototype devices internationally. ESB has managed this through a Design Competition. ESB has established a design competition which will purchase the most competitive wave energy devices where prototype devices have proven their production and technical readiness for the extremes of the west of Ireland. The competition has been structured as a competitive dialogue announced on the OJEU.

The on-going information from this dialogue have been used to inform the development of the ESB Westwave project and mitigate the risks in the area of regulations, finances and public acceptance.

If support measures are put in place in order to overcome those barriers, can you identify the responsible stakeholders for delivering solutions, such as, governments, supply chain, research sector, etc and what would be the expected improvement in terms of your project pipeline and cost reduction that could be achieved?

James Tedd: The key requirement for the Ocean Energy sector is an increase in confidence in the technologies. The technology development has been characterised by SME led projects testing individual technologies. A number of these concepts have demonstrated devices with the capability to convert the energy into electricity. However very few devices have progressed into regular operation. This lack of development is hampering the development of the first array projects. Partnerships across industry and government agencies should focus on proving the operation of devices to the level where their performance can be well characterised and confidence can be gained.

Partnerships across industry and government agencies should focus on proving the operation of devices to the level where their performance can be well characterised and confidence can be gained.

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

James Tedd: Collaboration is key in innovative projects like ESB Westwave. The project has collaborated on wave resource data with Irish universities (UCC, UCD, NUIG), and with Infomar National Seabed Survey programme in terms of seabed data. ESB is collaborating with international partners to further the project including technology developers, and engineering experts. ESB is active in the development of IEC standards for Ocean Energy, which are important as the industry develops.

The role of the OES in publishing the international state of the art in Ocean Energy is valuable.

06. COUNTRY REPORTS

PORTUGAL

ANA BRITO E MELO
WavEC Offshore Renewables

OCEAN ENERGY POLICY

NATIONAL STRATEGY

The National Ocean Strategy 2013-2020 is the public policy instrument in Portugal for the sustainable development of the economic sectors related to the ocean, including the energy sector. The three key pillars of the maritime economy are: Knowledge, Spatial Planning, and Promotion of National Interests. The plan defines strategic actions, such as the support for new forms of technology applied to maritime activities, by creating conditions for the installation, testing and development of emerging forms of technology.

Available at:
http://www.dgpm.mam.gov.pt/Documents/ENM_Final_EN_V2.pdf

LEGISLATION AND REGULATORY ISSUES

In April 2014 the Portuguese Law 17/2014 on 'marine spatial planning and management' was created. This is seen as a Basic Law of the Planning and Management of the National Maritime Space complementing the existing maritime spatial planning called "POEM", published in late 2012. This legislation will clarify the licensing process in the sea for marine renewable energies projects.

The European Commission through DGMare has been funding the development of projects with the objective of promoting maritime spatial planning between different countries. Portugal was involved in coordinating the project "TPEA - Transboundary Planning in the European Atlantic" and developed a proposal for a Geoportal, for data sharing between Member States (Portugal-Spain and UK-Ireland) and further explored methodologies for cross border cooperation and coordination with the adjacent coastal zone. This project was completed in May 2014 and a guide of good practices was published.

A revision of the existing Environmental Impact Assessment (EIA) legislation was released in October 2013, creating a web-based "one-stop-shop" facility for the environmental licensing of projects, enabling the digital delivery of documents during the EIA process. According to this new legislation the timeline of the licensing procedures has been also clarified.

MARKET INCENTIVES

The existing support schemes (Feed-in Tariffs) for renewables have been under review. Portugal had in place a Feed-in Tariff for wave energy applicable for a certain time frame or until an upper limit of electricity produced is reached. It was one of the highest Feed-in Tariffs for wave energy demonstration projects. However this tariff has been suspended by the Portuguese Government pending the creation of new support mechanisms for wave energy.

PUBLIC FUNDING PROGRAMMES

In Portugal the Foundation for Science and Technology (FCT) is the main funding agency for research covering all fields of science, including ocean energy. FCT is part of OCEANERA-NET, a network of 16 European national and regional funders and managers of research and innovation programmes, from 9 countries, in the field of ocean energy, funded by the European Commission. The first join call for proposals was launched in October 2014.

Business-oriented research in Portugal is funded by "ANI – Agência Nacional de Inovação, S.A." (national innovation agency) former Innovation Agency (Adi), funded by the Ministry of Education and Science and the Ministry of Economy.

SEA TEST SITES

In Portugal, a specific site for wave energy development – offshore S. Pedro de Moel, between Figueira da Foz and Nazaré - with an area of 320 km2, was designated by the Portuguese State, in 2008.

In 2010, ENONDAS (a subsidiary of the Portuguese Grid Transmission System Operator) received from the Portuguese State a public concession for this site for 45 years. During 2014, three documents were published:

- Environmental Characterization
- Access Regulation
- Geophysical Characterization

These documents have been provisionally approved by the General Directorate for Energy and Geology (DGEG), after being in public discussion for a month until 12 October 2014 (available at: http://www.oceanplug.pt/en-GB/biblioteca/)

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

WavEC Offshore Renewables

WavEC is a private non-profit association, currently with 13 associates (industrial and public), and 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 20 specialists with a broad range of experience on ocean energy, including both the technical (numerical modelling, wave resource, monitoring, technology) and non-technical (economic models, environmental and licensing, public policies, dissemination) issues.

In 2014, WavEC was actively involved in the following European collaborative R&D projects:

- OCEANET (2013 – 2016), training network of young researchers coordinated by WavEC in the area of floating offshore wind and wave energy (Funded by EC 7th Framework Programme).
- DTOCEAN (2013 – 2016), providing shared access design tools for wave and tidal energy converter arrays (Funded by EC 7th Framework Programme).
- MaRINET (2011-2015), network of research facilities at all scales (from small models through to prototype scales; from laboratory through to open sea tests), allowing free access to facilities (Funded by EC 7th Framework Programme).
- PolyWEC (2012 – 2014), research on a new class of polymeric wave energy converters (PolyWECs), employing Electroactive Elastomer (EE) transducers (Funded by EC 7th Framework Programme).
- TROPOS (2012 - 2015), development of a floating modular multi-use platform system for use in deep waters (Funded by EC 7th Framework Programme).
- Waveport (2010 – 2014), construction and demonstration of the Powerbuoy unit (Funded by the EC 7th Framework Programme).
- SIOCEAN (2012 – 2014), dealing with barriers to large scale wave and tidal energy deployments, and aiming to deliver a common strategy for wave and tidal installed capacity by 2020 (Funded by Intelligent Energy Europe).
- Atlantic Power Cluster (2012 - 2014), built on the Marine Energy Working Group set up in the CPMR (Atlantic Arc Commission), with the intention to implement a transnational marine energy strategy (Funded by Interreg).

In 2014 WavEC was further involved in two business oriented projects in the framework of KIC InnoEnergy, a company funded by the EC European Institute of Technology (EIT), devoted to developing innovative industrial products:

- HiWave (High Efficiency Wave Power) - focused on the development of wave energy technology by the Swedish company Corpower, including tests at sea.
- KIC-OTS (Offshore Test Station) – aiming to develop a number of products and services directed at the current and future needs of the offshore renewable energy farms. In 2014 WavEC was involved in the development of a multi-parametric buoy that can monitor several environmental parameters, important to offshore energy parks.

WavEC has also participated in the 'Structural Design of Wave Energy Devices' project (SDWED) supported by the Danish Council for Strategic Research. It was a five-year project focused on the development of design tools for wave energy devices, concluded in 2014 under the coordination of Aalborg University in Denmark.

WavEc has been further developing internal capabilities on a number of key research areas:

- **Techno-economic Analysis:** development of detailed techno-economic tools for the analysis and optimization of ocean energy technologies, coupling hydrodynamic wave-to-wire models with engineering and economic models and data.
- **Supply-chain and Market Analysis:** development of an extensive database covering detailed information on several areas: technologies, projects, actors, components, costs, etc.
- **Underwater and Acoustic Monitoring** – development of methodologies for monitoring of underwater components using WavEC's Remotely Operated Vehicle (ROV); development of expertise on acoustic monitoring programmes covering field noise measurements and data processing and analysis.

Instituto Superior Técnico

Two groups were active on ocean energy at Instituto Superior Técnico (IST), University of Lisbon: Institute of Mechanical Engineering (IDMEC) with a decades-long history in wave energy conversion studies, and Centre for Marine Technology and Engineering (CENTEC) whose involvement in ocean energy is more recent.

Following previous years, the activity at IDMEC concentrated on wave energy conversion, especially the development of new types of oscillating water column converters and self-rectifying air turbines. Model testing of an OWC spar-buoy were carried out at the large wave tank of Plymouth University in June-July 2014, within the framework of the MARINET programme. The tests included extreme wave conditions and a triangular array with bottom and inter-body mooring connections (see figure). Data processing and analysis, from test results involving the air

turbine and the electrical equipment (generator and power electronics) carried out at Tecnalia's laboratory (Spain) within the framework of MARINET programme, were performed and submitted for publication. CFD modelling and optimization of a recently patented air turbine were performed, in collaboration with the Universities of Valladolid and Oviedo (Spain). Laboratory tests of moorings with imposed motion of the moored body were performed to validate numerical codes. Small-scale model tests of a patented new concept for a floating OWC were started at IST, in collaboration with LNEG, Lisbon. An important area of research at IDMEC is latching control of floating and fixed-structure OWC converters, taking advantage of the new types of air turbines fitted with fast valves; this included numerical modelling and model testing in wave flume.

Ocean energy is becoming a major area in the diversified activity of CENTEC. The activities at CENTEC in ocean energy involved a wide range of topics covering waves, tidal currents and offshore wind. The characterization, in European waters, of wave energy (and to a much lesser extent tidal and offshore wind energies) has been one of the dominant topics. The study of ocean energy conversion focussed mainly on wave energy converters, with numerical theoretical/modelling of several types of devices.
The First International Conference on Renewable Energies Offshore took place in Lisbon, at Instituto Superior Técnico, on 24-26 November 2015, organized by CENTEC. This was a successful conference, with more than one hundred papers from a wide range of countries presented in four parallel sessions. The proceedings will be published in 2015.

National Laboratory for Energy and Geology (LNEG)

LNEG has been involved in the technical/economical assessment of wave energy converters offshore the Portuguese coast. Two new wave energy devices are being developed. Together with Instituto Superior Técnico (IST), numerical and experimental testing is underway. Wave and wind Portuguese offshore resources have been studied. In the scope of the research project TESS – "Transition to an environmentally sustainable energy system: The role of technology-intensive firms in the commercialisation of emerging energy technologies", funded by FCT, research has also been conducted on the process of formation and early development of a wave energy "niche" in Portugal and its interactions with activities conducted at transnational and supra national levels. The research focused on the behaviour of actors and its impact on the dynamics of development and implementation of the technology.

Institute of Mechanical Engineering and Industrial Development (INEGI)

INEGI was the coordinator of the national project OTEO - "Offshore Energy Technology Observatory", in collaboration with WavEC and EnergyIN, concluded in 2013. The final outcome of this project was the edition of the book "*Offshore Renewable Energy - Current Status. Future Perspectives for Portugal*", published in 2014 by the project partners with invited international authors, available at:
http://oteo.inegi.up.pt/resources/363_1_livro.pdf

TECHNOLOGY DEMONSTRATION

Pico Plant

On the Island of Pico, Azores, WavEC runs an OWC (Oscillating Water Column); wave energy plant (www.pico-owc.net). Pico OWC is a unique structure, allowing testing commercially-sized turbines and auxiliary equipments (up to ~700 kW).

Pico plant continues to be used as land based real scale infrastructure for testing, research, training and dissemination. The plant has been permanently improved by WavEC with its own, minimal means. Regular presence and maintenance trips enabled to gradually improve the plant's performance and electricity production, and to demonstrate its operation to the professional community and the general public. It is included in the European Commission large scale infrastructure project MaRINET (http://www.fp7-marinet.eu/).

WaveRoller

The 100 kW grid connected WaveRoller demonstration device was in operation in Peniche, in theautumn of 2014. The aim of this campaign was to collect load data to validate the design load cases. This work was a continuation of previous campaigns from which performance data has been validated by DNV GL. The device was operating in fully exposed ocean environment with waves recorded in excess of 8 meters high. After the autumn campaign, the demonstration unit was brought to the harbour and has been thoroughly inspected by experts from Lloyd's Register, with the aim to get a certification for the WaveRoller technology in the near future. This project in Peniche has been carried out within the within the EC 7th Framework Programme Project SURGE and has had many successful campaigns since 2012.

AW-Energy Oy is building a full land scale test facility in Finland for testing commercial Power Take-Off (PTO) units. The Jarvenpaa facility creates operating conditions where PTOs are ran in a marine-like environment. Multiple improvements are expected on the second generation of PTOs currently under construction.

OTHER RELEVANT NATIONAL ACTIVITIES

WavEC Annual Seminar entitled "Fostering Transatlantic Growth of Marine Renewables" was organized in Lisbon on 9-10 October 2014 with the collaboration of the Embassy of the United States of America and the American Chamber of Commerce in Portugal, with invited speakers from USA.

The Seminar was organized around four panel sessions, each focusing on a specific theme: Associated challenges to harnessing marine energy and solutions; Logistic requirements for marine energy development; Partnering with the private sector and co-financing; United States – Portugal technical cooperation.

Following the Seminar, an International B2B networking event, promoted by the Enterprise Europe Network Portugal, through the Portuguese Innovation Agency (ADI) with the support of the Luso-American Foundation was held on October 10th, 2014. It brought together several companies, clusters, universities and R&D institutions and funding stakeholders, from Europe and the United States.

In 2015, WavEC Annual Seminar will be co-organised by the French Embassy in Portugal.

DENMARK

KIM NIELSEN
Ramboll

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

During 2014, the *Danish Partnership for Wave Power* worked on a roadmap project concerning prioritization of future research and demonstration activities. The roadmap will be published during the spring of 2015 and was supported by the Energy Technology Development and Demonstration Programme (EUDP) - €200.000.

LEGISLATION AND REGULATORY ISSUES

In relation to the development of DanWEC as a green lab and test site for wave energy converters, a dialogue concerning the use of the sea has taken place with the authorities. Shipping lanes close to shore as well as plans concerning a larger harbour in Hanstholm have shown the reality of the complexity concerning the legislation and regulations of the sea space. The DanWEC case has ended in such a way that the one stop practice continues and wave energy projects can apply on a project basis for a limited time testing. Two possible sites at about 20 – 30 meter water depth, as shown on the map below, have been considered possible.

MARKET INCENTIVE

At the moment, the market incentives concern the ForskVE project specific support model in which an upfront agreed performance curve provides the basis for funding release. This principle has been used in the case of WaveStar testing at DanWEC, Hanstholm, with the result that the energy production has been documented and the conversion efficiency has increased. WaveStar has supported the development of the standards IEC TC 114 PT102 "WEC assessment at a 2nd site" by sharing 1 year of measured electricity generation data with the PT 102 team.

PUBLIC FUNDING PROGRAMMES

Energinet.dk and EUDP are the two Danish funding agencies that support the development of renewable energy and also wave energy.

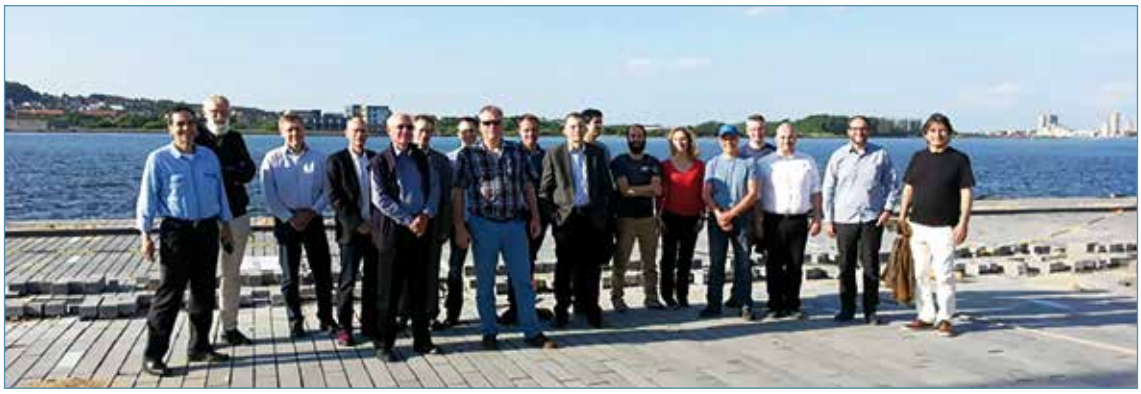
SEA TEST SITES

DanWEC has bought two wave rider buoys, with the Greenlab funding provided by the energy agency. The wave and current data collection from the new buoys started in march 2015. These wave data measurements will be used as reference for measured energy production of prototype tests at the site. Further DanWEC has included the 1:10 test site Nissum Bredning as part of its portfolio; this has been seen as a strategic investment in order to embrace also developers working in new developments at lower Technology Readiness Level (TRL) stages.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

The *Structural Design of Wave Energy Devices (SDWED)* project funded by the Danish Strategic Research Council coordinated by Aalborg University (AAU) has come to its end after 5 years of collaborative research including relevant Danish institutions such as DTU, DHI, Ramboll, as well as strategic partners from outside Denmark such as DNV, University of Edinburg, WavEC and the University of Bologna. The participant and invited partners were gathered at the 3rd SDWED Symposium in AAlborg in July 2014 and the publications and information from the project can be found at http://www.sdwed.civil.aau.dk. As part of the project, several PhD students have been educated and dedicated PhD courses with the focus on wave energy have been developed and given to more than 90 students during the project period.



SDWED partners and steering committee Aalborg 2014

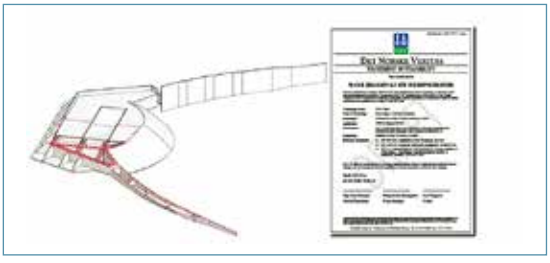
R&D PROJECTS

Digital Hydraulic Power Take Off (PTO) for Wave Energy funded by ForskEL (DK) coordinated by Aalborg University aiming at developing the WaveStar PTO technology further including digital control.

WaveSpring is an R&D project aimed at developing a "negative spring" technology for enhancing wave energy absorption. The project is supported by a EUDP (DK) co-funded project lead by Aalborg University, involving NTNU and WaveStar.

Mooring solutions for large wave energy converters – a EUDP (DK) co-funded project led by Aalborg University, involving 4 Danish Wave Energy developers, Chalmers University, and Tension Technology International. The objectives of the project are to design, test and develop cost efficient mooring solutions for large, slack moored, floating WECs, and to build national competences in design and modelling of mooring systems for WECs.

Wave Dragon 1.5 MW demonstrator project has been supported by EUDP (DK). The first phase of the project is now completed. This design phase includes a study investigating the feasibility of deploying the prototype for testing at DanWEC, Hanstholm. As part of the project, DNV GL has evaluated Wave Dragon in accordance with DNV RP-A203 Qualification of New Technology. Based on this assessment, Wave



Dragon has obtained a DNV GL Statement of Feasibility. DNV GL considers the technology conceptually feasible as defined in DNV-DSS-401 Technology Qualification Management and thereby suited for further development and qualification according to DNV GL RP-A203.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

In 2014, **Crestwing** was operational with a 1:10 scale project as shown below. The project concerns testing a mechanical PTO and a novel flexible mooring system design by Sea-flex.

PLANNED DEPLOYMENTS

During 2014, three Danish projects granted support from Energinet.dk (co-founding) for the design, building and testing of prototypes in the range of 15 – 100 kW. The projects are **Crestwing, Wave piston** and **Weptos**.

OTHER RELEVANT NATIONAL ACTIVITIES

The DanWEC Secretariat for the *Danish Partnership for Wave Power* will, during 2015, be taken over by the network organisation Offshoreenergy.dk. This will involve the Wave Energy Innovation Business conference (WEIB) where the second of its kind will take place on 28 April 2015, in Esbjerg. These events involve B2B meetings, technology exhibitions, presentations and discussions.

UNITED KINGDOM

KAREN DENNIS
Department of Energy & Climate Change

The Marine Energy sector has the potential to make a significant contribution in securing our electricity supply post 2030(50). Over the period 2000–2010, the sector made significant progress. There was a surge of innovative devices which attracted funding from Government bodies as well as private organisations. The sector attracted major players such as Alstom, Siemens, Atlantis and big utility companies. Some of these devices progressed upwards the technology readiness level (TRL) scale and were deployed throughout the UK for testing.

However the global economic downturn coupled with the risks and challenges associated with technology design problems and infrastructure issues, has had a negative impact on the sector. Investors, OEMs and utilities changed focus. The recent news of Pelamis going into administration, the restructuring at Aquamarine and Siemens selling Marine Current Turbines also presents additional challenges for the sector. Nonetheless the sector continues to forge ahead as in summer 2014, it was confirmed that MeyGen Limited had reached financial close on the project to deploy the world's first tidal array scheme in the Pentland Firth.

There is no doubt that the UK has world-class facilities (EMEC, Narec, WaveHub, FaBTest and the testing tanks at University of Edinburgh and Plymouth University) and a rich marine resource. These coupled together with the commitment across Government and Devolved Administrations to support the continuing development of the wave and tidal stream sectors (coordinated by the Low Carbon Innovation Coordination Group (LCICG)[1], and significant levels of secure revenue support in place, the UK remains an attractive location for the development of these technologies.

There has also been development on tidal range, with the proposal for a Swansea Bay tidal lagoon entering the planning process and as in the Autumn Statement 2014; the Government announcing that it has started its commitment to exploring the potential for a future tidal lagoon energy programme in the UK.

The Government recognises the potential of the untapped wave and tidal resource in the UK. More so, interest is buoyed by the fact that renewables are a global growth sector and therefore remains committed to its development for the future benefits to the UK economy.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

Work is on-going on meeting the objectives of the DECC 2013 Renewable Energy Roadmap which sets out scenarios for meeting our 2020 renewable energy targets. The latest review shows that the UK remains broadly on track to meet these. On marine energy, the focus has been working with the industry to overcome the barriers to deployment; more specifically in getting the first demonstration tidal array project off the ground. This work continues to be delivered via the **Marine Energy Programme Board** (MEPB), chaired annually by the lead minister for Energy and Climate Change with policy responsibility for wave and tidal stream energy. The work of the MEPB is

1 Core members of the LCICG are BIS, DECC, ETI, TSB, EPSRC, Carbon Trust, the Scottish Government and Scottish Enterprise. Associate members include Ofgem, DfT, the Crown Estate, UKTI, CLG, MoD, Defra and the Wales and NI Governments.

guided by a bi-monthly Programme Management Group which brings together Government and representatives of the sector. It manages a number of work-streams looking at issues critical to the progress of the sector.

Given the increasing divergence of progress towards commercial deployment of the wave and tidal stream sectors, DECC's Energy Innovation Policy team is overseeing delivery of an updated "Technology Innovation Needs Assessment" (TINA) for wave energy, on behalf of the LCICG. The TINAs provide a shared evidence base on the potential for cost reduction in each of eleven low carbon technologies and are a valuable tool in prioritising and coordinating innovation support. A TINA for marine energy was last published in 2012 [2].

The updated wave energy TINA will enable DECC and other government innovation funders to make effective decisions regarding how the wave sector should be supported in future, based on the potential of the technology in the coming years. A process of industry engagement on the wave energy TINA will start in early 2015. The final TINA is expected to be available later in the year.

A new roadmap developed by the UK Energy Research Centre (UKERC) and the Energy Technologies Institute (ETI) has identified the research and development areas that need to be addressed to make marine energy cost competitive with other energy technologies.

The Marine Energy Technology Roadmap recommends that the marine energy sector should target levelised cost reductions from 20-50p/kWh today to 10-20p/kWh by 2020 and 5-8p/kWh by 2050 in order to encourage continued deployment, and identifies the steps required to deliver these ambitions.

Following renewed interest in tidal range, and particularly tidal lagoons, from developers, the Government announced, in its 2014 Autumn Statement, that the Department of Energy and Climate Change would explore the potential for a future tidal lagoon programme in the UK. The government also announced the start of closer discussions with Tidal Lagoon Power Ltd to establish whether a potential tidal lagoon project at Swansea Bay is affordable and value for money for consumers (without prejudice to the planning decision on the project). Should the project progress, it could become the first tidal lagoon project in the world.

Tidal Lagoon Power ltd submitted an application for consent to the Planning Inspectorate at the start of the year for a tidal lagoon project located in Swansea Bay. The examination of the planning application is on-going. The development consent decision for the project is anticipated in 2015.

WALES

The energetic waters off the Welsh coast are ideal for marine renewable energy projects and the Welsh Government is encouraged by the growing interest in Welsh waters and the partnership approach taken to delivering projects.

The Welsh Government is working with developers to ensure that Wales can maximise the benefits and economic potential for our communities from all future operational projects. We are also working to ensure that Wales has the right skills base to support a marine industry in Wales.

Marine technology is still at a pre-commercial development phase and needs significant support from Government. The Welsh Government is working with the industry, the Crown Estate, Natural Resources Wales and key partners to overcome consenting risks and uncertainties. We also continue our work to streamline the planning system in Wales, which will benefit all future developments including those in the marine energy sector.

SCOTLAND

Work to progress and finalise Scotland's marine strategy remains on-going. The Scottish Government remains firmly committed to the continued development of a successful marine renewables energy industry in Scotland.

Scotland government bodies have invested over £20m in the MeyGen tidal project, the world's first tidal stream array, forming a significant part of the funding package (alongside DECC and The Crown Estate funding). Construction of the initial demonstration phase is planned to begin in the Pentland Firth in 2015. Once fully completed, the 269-turbine development could power almost 175,000 homes and support more than 100 jobs in the north of Scotland.

2 2012 - http://www.lowcarboninnovation.co.uk/working_together/technology_focus_areas/marine/

They have also invested £2.8 million the Marine Renewables Commercialisation Fund (MRCF) to support five innovation projects. These projects, which include a new cable mounted monitoring system and a rock anchor mooring system, will deliver new and better solutions to enable future arrays and reduce the associated costs and risks.

In order to encourage further innovation in wave energy development and in recognition of the need for a revised approach to supporting this emerging technology, the Scottish Government has announced the establishment of Wave Energy Scotland. Wave Energy Scotland will bring together the best engineering and academic minds to collaborate on projects that will accelerate the development of wave technologies.

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. Scotland also plays a vital role on the Ocean Energy Forum through its membership of the various steering groups and workstreams. This input is essential in identifying and addressing barriers that prevent the commercialisation of the ocean energy sector.

NORTHERN IRELAND

The two tidal projects in Northern Ireland waters, Tidal Ventures Limited and Fairhead Tidal, continue to work through the survey, research and stakeholder engagement as part of the Environmental Impact Assessment activity for the statutory consents and marine licences. They are also engaging with the NI Authority for Utility Regulation, NI Electricity and the System Operator for NI with regards to grid connection issues. It is expected that these projects will contribute to the Northern Ireland target of 40% renewable electricity consumption by 2020.

During 2014, the Department of the Environment continued work on the development of the first Marine Plan which will deliver better management of Northern Ireland's marine resources, including marine renewable resources, in a sustainable way. It will set clear objectives and priorities for the future development, management, conservation and use of the marine area.

LEGISLATION AND REGULATORY ISSUES

In July 2014 The Crown Estate (TCE) announced the outcome of its **wave and tidal stream leasing** process which was held in autumn 2013. Seabed rights were agreed for five new wave and tidal current sites with each having the potential to deliver projects of between 10 and 30 MW. TCE also implemented a new process whereby for the first time, locally based organisations will be able to manage and sub-let parts of the seabed to a range of wave and tidal stream developers. Under this arrangement, six new wave and tidal stream demonstration zones were allocated. The leasing outcomes are presented in the table below:

ORGANISATION	LOCATION	ZONE TYPE
Siemens MCT	Dorset, England	Portland Bill tidal stream project site
	Northern Ireland	Strangford Lough tidal stream project site
	Scotland	Mull of Galloway tidal stream project site
EMEC	Scotland	Stronsay Firth, tidal stream manages test facility project
MinestoWales	Wales	Holyhead Deep, tidal stream project site
WaveHub	North Cornwall, England	Wave demonstration zone
	South Pembrokeshire, Wales	Wave demonstration zone
	North Devon, England	Tidal demonstration zone
EMEC	Isle of Harris, Scotland	Wave demonstration zone
	Islay, Scotland	Tidal demonstration zone
Menter Môn	Wales	Tidal demonstration zone

In July 2014, the TCE confirmed plans to run a **leasing process for tidal range projects**. This follows an **industry engagement exercise** in December 2013 to understand the market interest in future tidal range and lagoon projects around the UK.

The Government is currently considering the process for planning for tidal range generating stations, including decommissioning. The framework for the UK marine licensing regime for activities carried out within the marine environment, such as offshore renewable energy installations is set out in the UK Marine and Coastal Access Act 2009. 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.

DECC recently has consulted on proposals to ensure that tidal range and tidal lagoons attached to land are decommissioned brought within the Energy Act 2004 decommissioning regime for offshore renewables satisfactorily. The consultation closed on 24th November 2014 and DECC and is currently considering the responses to the consultation.

WALES

Established in 2013, Natural Resources Wales (NRW) ensures that the natural resources of Wales are sustainably maintained, enhanced and used, now and in the future. The body brings together the work of the Countryside Council for Wales, Environment Agency Wales and Forestry Commission Wales, as well as some functions of Welsh Government.

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

MARKET INCENTIVES

The UK Government has implemented one of the most comprehensive systems of support for wave and tidal stream energy in the world through capital and revenue support and a number of research and development initiatives. 2014 saw the biggest change in the electricity market since privatisation with the implementation of the Electricity Market Reform (EMR). Wave and tidal stream technologies received a significant outcome under the EMR compared to other renewable technologies. They were the only technologies to receive a reserved allocation of 100 MW across both the Renewables Obligation (RO) and the contract for difference (CfD) schemes. This also comes with the highest strike price of any of the renewable technologies at £305/MWh. Both the reserved allocation and strike price are for the duration of the first Delivery Plan period which concludes in 2019.

NORTHERN IRELAND

Invest NI continues to work closely with companies active in the marine energy market to develop their capability to contribute to the supply chain. Invest NI is also supporting a number of collaborative network proposals aimed at the renewable supply chain, including marine energy.

Northern Ireland was the location for the very successful Renewable UK Wave & Tidal Exhibition & Conference in late February 2014, attracting 50 exhibiting companies an audience of over 400 industry delegates. The event was preceded by an MEPB meeting, SI Ocean project workshop and industry networking.

Through cooperation with colleagues in the Sustainable Energy Authority of Ireland (SEAI), Northern Ireland based businesses were supported in having a presence at the 5th International Conference on Ocean Energy in Nova Scotia in November 2014, hosted by Marine Renewables Canada in partnership with the governments of Canada and Nova Scotia and the offshore Energy Research Association. A number of Northern Ireland based businesses presented within the conference programme.

PUBLIC FUNDING PROGRAMMES

The main source for 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
- Innovate UK formerly 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

Other sources of public funding with scope to support research and development in the marine energy space are:

- The Regional Growth Fund: https://www.gov.uk/understanding-the-regional-growth-fund.
- The DECC Entrepreneurs Fund: https://www.gov.uk/government/publications/energy-entrepreneurs-fund-phase-3-documents and https://www.gov.uk/government/publications/energy-entrepreneurs-fund-phase-4-documents which awarded grants to three marine energy projects (Sustainable Marine Technologies' innovative deployment platform, PLAT-O, Marine South East's SAMED to validate novel anchoring technology for marine structures using helical screw piles and Minesto's Deep Green tidal kite ¼ scale trial.
- The DECC Marine Energy Array Demonstration Scheme (MEAD): £20M was allocated under the MEAD to support the deployment demonstration arrays. Following competition and subject to State Aid and financial close, £10m each was awarded to the MeyGen tidal array project in the Pentland Firth and the Siemens/MCT Skerries tidal array project in Wales in February 2013. In summer it was announced that only the MeyGen would be supported by the MEAD as the only project to reached financial close.

WALES

The Welsh Government invested £1M in developing the Marine Renewable Energy Strategic Framework (MRESF). MRESF, launched in 2011, assessed the available wave and tidal resource within Welsh waters within a sustainable framework and it provides developers with an online mapping tool.

Developers are able to use MRESF to obtain information on our key resource areas and potential development constraints. Unlike other marine spatial planning tools, the MRESF does not treat Natura 2000 sites (European designated sites of conservation importance) as hard constraints, and to ensure we understand the interactions between marine energy devices and the environment we adopt, where possible, a deploy and monitoring approach to marine licensing.

The Welsh Government is conducting a reviewing of MRESF to ensure the baseline data used, and the evidence it provides to developers, continues to be fit for purpose.

SEA TEST SITES

The European Marine Energy Centre (EMEC)

The European Marine Energy Centre (EMEC) is still 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.

In 2014, 12 developers tested devices at EMEC. Several wave and tidal developers continued

their grid-connected test programmes on EMEC's Billia Croo and Fall of Warness sites. Nautricity successfully deployed their CoRMaT tidal turbine at EMEC's non grid-connected Shapinsay Sound site in May, and Magallanes (funded by the EU MaRINET project) deployed their floating tidal turbine on the same site in November.

In addition to EMEC's establish test sites, EMEC was awarded further rights to areas of seabed in Harris, Islay and Orkney by The Crown Estate. Awarding rights to these zones will enable EMEC to manage the seabed in conjunction with its local partners and sub-let areas of seabed for developers to progress projects. EMEC has also been awarded seabed rights to progress a tidal stream project in the Stronsay Firth in Orkney.

To start the journey towards development in these areas, EMEC has signed Memoranda of Understanding with the West Harris Trust alongside Comhairle nan Eilean Siar, and the Islay Energy Trust. The respective organisations will collaborate to manage the Harris Wave Demonstration Zone and Islay Tidal Demonstration Zone in consortia acting as 'Third Party Managers' for their individual sites.

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 been approved as an assessor under the EU's Environmental Technology Verification (ETV) scheme and will be checking claims about the performance of innovative environmental technologies. It has expanded its scope of accreditation attaining the International Standard ISO/IEC 17020 for verification of new environmental technologies.

The Scottish Government awarded a share of the Marine Renewables Commercialisation Fund (MRCF) to EMEC to support further development of an Integrated Measurement Platform – a seabed 'pod' designed to measure a variety of parameters in tidal flows, such as at EMEC's Fall of Warness tidal test site, off the island of Eday, in Orkney. Following development in 2014, the EMEC-IMP will be deployed in early 2015.

In March, EMEC hosted a workshop to review the existing suite of marine renewable energy standards and identify areas where new standards require to be developed. The report from the workshop produced in collaboration with the Offshore Renewable Energy Catapult is available to read online: http://www.emec.org.uk/review-of-standards-for-marine-renewables/.

Funded by The Crown Estate, EMEC has been reviewing the reliability of our subsea cables throughout the year to help inform on the performance of subsea cabling in high energy environments. The report will be published in early 2015.

The Orkney Vessel Trials project, which has been facilitated by Orkney consultancy Aquatera Ltd, in association with the European Marine Energy Centre (EMEC), demonstrated the potential for considerable cost savings using the capabilities of smaller support vessels in the marine renewables industry. The report is available to download here (Press release: Orkney vessel trials demonstrate cost savings for marine energy).

On 3 June 2014 EMEC hosted the first EU Energy Day dedicated to ocean energy in partnership with Ocean Energy Europe, the trade association for ocean renewables in Europe. At the Orkney Ocean Energy Day, as part of the EU's Sustainable Energy Week calendar of events, representatives from the European Commission, technology companies from across Europe, and local residents visited sites around Orkney to share understanding of how the industry has developed to this point and what is required to take it further.

Photos and videos: http://www.emec.org.uk/blog-video-and-photos-from-orkney-ocean-energy-day-2014/

Bringing together operational and planned test sites from around the world for the second time, the EMEC and FORCE (the Fundy Ocean Research Centre for Energy) jointly hosted a discussion forum for international open-water test centres in Halifax, Canada, in association with the International Conference on Ocean Energy (ICOE). The event built on EMEC's Global Ocean Energy symposium held in Orkney, Scotland, in 2013, which created a global network focused on collaborative opportunities for test centres in support of the developing ocean energy 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 kms2 of seabed divided into four separate berths. Wave Hub is owned

by the UK Government Department of Business, Innovation and Skills (BIS) and operated by Wave Hub Limited on its behalf.
The priority in 2014 has been to secure customers for all four of the Wave Hub berths. The three successful wave energy developers are UK based Seatricity Ltd, the Finnish utility company Fortum Oyj and the Australian wave energy developer Carnegie Wave Energy. Seatricity installed the first wave device at the site during the summer. The Finnish multi-national utilities firm Fortum signed an agreement to secure a berth to test and evaluate wave devices for a wave energy array project and Carnegie Wave Energy secured the final berth to deploy a 3 MW array of its next generation 1 MW CETO 6 technology in 2016, with the option to expand to 10 MW.
Work is progressing with the Energy Technologies Institute (ETI) and Glosten Associates to enable deployment of the PelaStar 6MW floating offshore wind platform.
Further, the substation upgrade to enable operation at both 11 kV and 33 kV was successfully completed, a new connection agreement from Western Power Distribution was secured and the Environmental Statement was reviewed. Finally, a new five year business plan has been prepared, which includes plans for taking forward the three Demonstration Zone seabed leases secured from The Crown Estate in Pembrokeshire (wave), North Devon (tidal) and North Cornwall (wave).

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 site is leased from The Crown Estate and has a Marine Consent for testing, subject to permits issued by Falmouth Harbour Commissioners. Operational support for the site, as well as on-going monitoring and world leading research, is provided by the Renewable Energy Group from the University of Exeter, based on the nearby Penryn campus.
The University contribution is made possible in part thanks to an investment of Regional Growth Fund money. The RGF investment of £549,000 into FaBTest was approved by the Cornwall and Isles of Scilly Local Enterprise Partnership (LEP). The LEP recognised FaBTest as a key investment priority and a unique asset which can create economic benefits and market opportunities. The Regional Growth Fund is managed locally by Cornwall Development Company on behalf of the LEP and Cornwall Council.
The University of Exeter uses the site for on-going work around resource characterisation and environmental monitoring, as well as using it to contribute to pioneering research into reliability engineering, which is focussed 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.
The Fred Olsen Lifesaver device was deployed and tested between March 2012 and June 2014, before undergoing a refit ahead of a grid connected deployment elsewhere. There are further deployments expected in 2015/16 and a plug and play data communication system will be in place for these devices to access, further reducing cost to early stage developers.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Energy Technologies Institute (ETI)

The Energy Technologies Institute (ETI) is a public-private partnership between global energy and engineering companies – BP, Caterpillar, EDF, Rolls-Royce and Shell – and the UK Government. Public sector representation is through the Department for Business, Innovation and Skills, with funding channelled through Innovate UK and

the Engineering and Physical Sciences Research Council. The Department of Energy and Climate Change are observers on the Board. The major ETI projects are:

Tidal Energy Converter Phase 2: The ETI launched the Tidal Energy Converter Phase 2 in May 2014 to design, build and test a multi-turbine foundation structure. Two 1.5 MW turbines will be installed on the structure at the Atlantis owned MeyGen tidal stream array in Pentland Firth, Scotland, increasing the rated capacity of the tidal array from 6 MW to 9 MW (enough to power 4,500 local homes). Atlantis are developing a patent-pending innovative and cost effective turbine foundation design, commencing with the detailed design, fabrication and installation of the structure and its associated technologies. Atlantis will be responsible for the turbine supply and electrical connection to the local grid.

ReDAPT: The ETI's ReDAPT (Reliable Data Acquisition Platform for Tidal) has been successfully installed and is running at EMEC. The 1 MW turbine has reached the full nominal power and has generated over 1000 MWh of electricity to the grid. Testing and collection of operational data will continue until the end of 2014. With an ETI investment of £12.6m, the project involves Alstom, E.ON, EDF, DNV GL, Plymouth Marine Laboratory (PML), EMEC and the University of Edinburgh.

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 released array design tools Tidal Farmer and Wave farmer in 2014. This project also informs work within the DTOcean collaborative programme on array designs.

- 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 (http://www.hrwallingford.com/projects/smarttide)

- The **Wave Energy Converter** (WEC) System Demonstrator Project finished in 2014, and aimed to accelerate the development and commercialisation of WEC systems.

Innovate UK

Innovate UK is the new name for the Technology Strategy Board, it is the UK's innovate agency. It funds, supports and connects innovative businesses to accelerate sustainable economic growth.

In collaboration with the Offshore Energy Research Association of Nova Scotia, Innovate UK has developed a funding competition for the in-stream tidal energy sector to encourage joined up research focus, reduce duplication of effort and provide opportunity in new markets for UK companies. The two organisations are jointly investing approximately £750,000 on collaborative R&D projects to develop enhanced sensing technologies for tidal stream energy applications. The funding is aimed at projects which advance tidal technologies by improving data analysis, collection methods and acquisition of better data to facilitate in the reduction of risk, uncertainty and cost. The first stage application closed in November 2014 with projects expected to start in the summer of 2015.

Innovate UK is a delivery partner and consortium member of the Ocean Energy ERA-NET (OceanERA-NET), which is a network of 16 national and regional funders and managers of research and innovation programmes from 9 European countries. The objective of OceanERA-NET is to coordinate funding programmes among European countries and regions to support research and innovation in the ocean energy sector, which covers tidal, wave, ocean thermal and salinity gradient technologies. The OceanERA-NET project has launched its first funding call in 2014, which closes for applications in December 2014. Innovate UK is a funding partner on this call.

Innovate UK also continued with dissemination of its 2012 *Marine Energy: Supporting Array Technologies (MESAT)* programme with an event held in November 2014 to update the industry on the progress of the projects. Innovate UK and Scottish Enterprise invested about £6m in 6 projects aiming to develop technologies to support wave and tidal arrays under its MESAT programme. Presentations from this event are available here.

The Offshore Renewable Energy Catapult (ORE Catapult)

The Offshore Renewable Energy (ORE) Catapult became operational in 2013. It was established by Innovate UK (at the time 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 May 2014 the ORE Catapult merged with the National Renewable Energy Centre (Narec). The ORE Catapult now offers an integrated engineering, research and testing capability for the offshore renewable energy sector. Facilities include powertrain testing, still water docks, simulated seabed, component testing, high voltage laboratory and wind turbine blade testing. The major ORE Catapult projects are:

Tidal Projects

Marine Farm Accelerator (MFA):
Established by the ORE Catapult with project management services provided by the Carbon Trust. The MFA is built around a steering group of tidal project developers and has established Technical Working Groups on Yield and Electrical Systems as well as a Device Advisory Group (DAG) of fourteen wave and tidal device developers who provide advice and guidance into MFA projects. Six work streams have now been identified covering Energy Yield, O&M, Site Characterisation, Electrical Systems, Installation and Insurance.

Tidal Energy Converter Cost Reduction via Power Take-Off Optimisation (TIDAL-EC):
ORE Catapult is the project coordinator of a €1.3million EU FP7 funded project involving seven consortium partners from five European countries. Partners include Minesto, Sintef, Fibersensing, University of Edinburgh, Tocardo, and Ocean Flow Energy. The two year project which commenced in September 2014 will conduct vital research and design evaluation activities to determine the optimum design of a tidal energy converter power take-off system and permanent magnet generator - two of the largest and most critical components of any mainstream tidal energy device. The project proposes to develop an optimised system that will improve reliability, increase power conversion efficiency and facilitate reduction in the cost of tidal power.

Testing and demonstration - MCT 1MW powertrain test:
In June 2014, ORE Catapult completed a multi-axis onshore endurance test programme on Siemens-owned Marine Current Turbines' (MCT) first 1 MW powertrain (gearbox, generator and power conditioning equipment) using the 3 MW tidal turbine nacelle testing facility in Blyth, Northumberland. During the 11 month test programme the 1 MW turbine was exposed to the full range of power output and aggressive loadings the device would experience subsea, securing performance data equivalent to over 18 years of operation in some of the world's harshest tidal cycles.

Scottish Enterprise Tidal Energy Array Cabling Solution Development Project:
ORE Catapult in collaboration with IHC Engineering Business, Tekmar and OceanFlow Energy undertook an exercise funded by Scottish Enterprise with the aim of overcoming the technical challenges experienced with subsea inter-array cabling, such as, securing, protecting and recovering the electrical cables required to take the power generated from a number of tidal energy devices deployed in high tidal flow areas to shore based infrastructure. This project was an important step in the path to commercialisation for the marine energy industry in Scotland, a sub-sector that has been prioritised by Scottish Enterprise in its efforts to realise the economic potential of the renewables industry.

Wave Projects

Wave Technology Assessment:
The ORE Catapult has developed a wave technology assessment process that ensures winning technologies can be identified early and poor concepts can be confidently ruled out. The technology assessment process which will continue to be refined in 2015 can be used to make assessments at concept, scale prototype and full scale stages. The process considers power performance, structural design, operations and maintenance (O&M) strategy and economic feasibility. Marine Farm Accelerator Device Advisory Group: This forum brings together the UKs leading wave device developers to identify collaborative projects to address generic technical innovation problems and identify solutions to cross cutting issues such as support vessels, foundation, connectors, and cabling.

Cross cutting Projects

Local Enterprise Partnerships (LEPs): The ORE Catapult is working with nine LEPs across England to explore marine energy strategic economic priorities and identify where collaboration with the ORE Catapult would add value to each region.

Marine Energy Supply Chain Model: Delivery in mid-2015 of a publically accessible model of the UK marine energy supply chain, linking up regional data bases to provide knowledge and support diversification into the marine sector.

Use of composites in Marine Energy: A collaborative project with the National Composite Centre, part of the High value Manufacturing Catapult to look at alternatives materials for offshore wind, wave and tidal structures and devices reporting in late 2015.

Environmental Monitoring: A portfolio of projects initiated in 2015 to reduce the risk in Environmental Impact Assessment and monitoring through development of proven sensor technology and standardised deployment, integration and data analysis techniques.

Knowledge Management

Wave & Tidal Knowledge Network (WTKN): On-going development of the WTKN established by The Crown Estate to encourage and grow industry knowledge sharing.

WALES

The Welsh European Funding Office is the Managing Authority for Structural Funds in Wales. The European Commission recently approved the £1.1 billion European Regional Development Fund (ERDF) programmes. The fund will help drive research and innovation, SME competitiveness and business finance, renewable energy and energy efficiency infrastructure.

Two marine energy projects have already been identified for support, namely the wave demonstration zone off Pembrokeshire, and the tidal demonstration zone off the coast of Anglesey. It is likely that ERDF support will be used to ensure that a complete, generic Environmental Impact Assessment is undertaken for each zone, as well as the installation of relevant infrastructure for the connection solution from the zone to the grid, as The Crown Estate's leases are already in place. By doing this, developers are being attracted to the zones as the costs and risks to them as individual operations are being vastly reduced. There continues to be a very healthy pipeline of marine energy proposals for Welsh waters looking for ERDF support.

NORTHERN IRELAND

The Centre for Advanced Sustainable Energy (CASE)

CASE celebrated its first year of Invest Northern Ireland funding through the Competence Centre programme. This industry-led enterprise – the latest in a series of new Competence Centres funded by Invest NI to rapidly transform research into commercial success - has been drawing upon the research capabilities of Queens University Belfast (QUB), Ulster University and the Agri-Food Biosciences Institute (AFBI).

2014 saw the completion of the first project in wave and tidal technologies under the CASE umbrella; testing of 1/10th scale tidal turbines in tandem formation in Montgomery Lake and Strangford Lough with 5 companies collaborating on this project. This is the first time that testing of more than one turbine at this scale has happened anywhere in the world and results will be used to inform the development of larger scale commercial arrays of turbines, such as those proposed off the North Antrim coast.

Two further projects currently underway in this area are a Tension Pile Foundations project led by McLaughlin and Harvey which involves detailed data analysis and testing of a scaled version of the foundation prototype and Triple T2, a follow on to the tidal turbine project referred to above using a single Schottel turbine with four work packages covering guidelines for data analysis, the effect of turbulence on turbine performance, facilitation of comparative analysis between lake, tank and real sea tests and dissemination.

Other Support – R&D Projects Funded by the European Union.

In October 2014, marine energy companies Minesto and Atlantis Resources Ltd were awarded €750,000 from the Eurostars Programme, funded by the European Union. The funding was awarded to reduce the cost of tidal energy and is a unique collaboration between two different marine energy developers. The funds will be used to reduce the cost of tidal power plants by creating cost effective high reliability tidal turbine blades and wings of composite materials.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

Installations at EMEC:

WAVE SITE			
Developer	**Device**	**Rated capacity**	**Location**
Aquamarine Power Ltd	Oyster 800	800 kW	EMEC
Pelamis Wave Power	P2-001	750 kW	EMEC
ScottishPower Renewables	P2-002	750 kW	EMEC
Seatricity	Oceanus	800 kW	EMEC
Wello Oy	Penguin	500 kW	EMEC

TIDAL SITE			
Developer	**Device**	**Rated capacity**	**Location**
TGL (a wholly owned Alstom Company)	DeepGen	1 MW	EMEC
ANDRITZ HYDRO Hammerfest	HS1000	1 MW	EMEC
OpenHydro	Open Centre Turbine	0.25 MW	EMEC
Scotrenewables Tidal Power Ltd	SR250	0.25 MW	EMEC
Voith	Hy-Tide	1 MW	EMEC
Nautricity	Cormat	Non grid connected	EMEC
Magallanes	ATIR	Non grid connected	EMEC

Installations at other test sites:

- WaveHub: Seatricity completed deployment of its 0.16 MW Oceanus2 device in September 2014.
- Falmouth Bay Test Site (FaBTest): The Fred Olsen Lifesaver device until June 2014.

Non Test Centre-based In-Sea Device Test:

- Tidal Energy Limited (TEL), 0.4 MW DeltaStream device unveiled soon to be installed in the Ramsey Sound, Wales.
- Siemens/MCT, 1.2 MW SeaGen device – Strangford Lough, Northern Ireland, since 2008.
- Minesto, Deep Green 0.50 MW device in the Strangford Lough.

PLANNED DEPLOYMENTS

Pre-commercial demonstration array projects being planned are:

Tidal Stream Schemes:

- The World's first Tidal Array Scheme, MeyGen Limited, 7 MW tidal array project in the Pentland Firth in Scotland. This is the first phased of a planned 380 MW project.
- Pending a 12-month trial of the DeltaStream device in the Ramsey Sound, TEL will join forces with majority shareholder Eco2 to install up to nine DeltaStream machines off St Davids Head in Pembrokeshire to create a 10 MW commercial array.

Wave Schemes (at Wavehub):

- Seatricity Limited, Oceanus2 device, 10 MW wave array planned for deployment around 2015.
- Carnegie Wave Energy Limited, CETO device, 10 MW wave array planned for deployment in 2016.
- Forum, testing of wave devices to deploy a 10 MW array scheme in the future.

Tidal Range schemes:

- The Swansea Bay Lagoon: In January 2014 the Planning Inspectorate accepted for examination a privately funded 320 MW tidal lagoon project in Swansea Bay by Tidal Lagoon Power (TLP). The Examination of the application closed on 10 December 2014.

Demonstration Facility:

- Perpetuus Tidal Energy Centre: Plans are underway for the development of a 30 MW pre-consented commercial tidal array demonstration facility in the Isle of Wight. It is anticipated that the facility will be fully operational around 2017/18.

OTHER RELEVANT NATIONAL ACTIVITIES

- 25-26th February 2015: **Wave & Tidal 2015**, Conference & Exhibition, EICC, Edinburgh, UK.
- 6-8th October 2015: **RenewableUK 2015**, Annual Conference & Exhibition, Liverpool, UK.
- 6-7th May 2015: **All Energy 2015**, Annual Exhibition & Conference, Glasgow, UK

IRELAND

PROF. TONY LEWIS . ***Marine Renewable Energy Ireland Centre (MaREI)*** and the staff in the Ocean Energy Development Unit at the Sustainable Energy Authority of Ireland

Significant steps were taken by Ireland in support of the Ocean Energy Sector in 2014. Of particular note the following was achieved:

- *The Irish Government launched the Offshore Renewable Energy Development Plan (OREDP). This plan secures a budget for the sector until end 2016 and makes provisions for development until 2018.*
- *Significant work was undertaken to update Ocean Energy research facilities in Cork.*
- *Support structures in the form of an online information portal and grant levels were improved.*
- *Finally updates to test site infrastructure was significantly funded and the outcome of this investment will be delivered in 2015.*

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The Offshore Renewable Energy Development Plan (OREDP)

The Irish Government's Department of Communications, Energy and Natural Resources (DCENR) published the Offshore Renewable Energy Development Plan (OREDP) in February 2014 (http://www.dcenr.gov.ie/Energy/Sustainable+and+Renewable+Energy+Division/OREDP.htm)

The OREDP sets out key principles, specific actions and enablers needed to deliver Ireland's significant potential in the ocean energy sector. The OREDP highlights the potential opportunities for Ireland in relation to marine energy at low, medium and high levels of development. Accordingly the OREDP is seen as providing a framework for the development of this sector. The over-arching vision of the Plan is Ireland's "offshore renewable energy resource contributing to economic development and sustainable growth, generating jobs for citizens, supported by coherent policy, planning and regulation, and managed in an integrated manner" (DCENR, 2014). A comprehensive Strategic Environmental Assessment was undertaken to inform the plan.

The Plan is divided into two parts. The first part deals with the opportunities, policy context and next steps, including ten key enabling actions for the development of the sector. The second part focuses on the Strategic Environmental and Appropriate Assessment of the Plan and includes plan level mitigation measures as well as public consultation on the Plan itself.

The implementation of the OREDP is being led by the DCENR who has formed an Offshore Renewable Energy Steering Group (ORESG) to oversee implementation. This consists of the main Government departments and agencies with roles and responsibilities that relate to energy and the marine environment, developers and broader

interest and user groups when necessary. The Group reports directly to the Minister and the Plan will be reviewed before the end of 2017.
The work of the ORESG, and hence the implementation of the OREDP, is organised according to three work-streams: Environment, Infrastructure and Job Creation. The Job Creation working group has responsibility across several actions, including identifying additional exchequer support requirements, supply chain development and communicating the message that 'Ireland is Open for Business'. Under the Environment work-stream the Group will ensure the needs of the marine energy industry are reflected in the on-going reform of the foreshore and marine consenting process. The actions deriving from the SEA and AA of the OREDP will also be taken forward under this work-stream to ensure that future marine energy development takes place in an environmentally sustainable manner. The Infrastructure working group will concentrate on supporting and delivering objectives of other policies such as the National Ports Policy (DTTAS, 2013) and Grid 25 (EirGrid, 2010) so as to expedite integrated infrastructure development which will facilitate the offshore renewable energy sector.

Ocean Energy Portal

The Ocean energy Portal was launched at the International Conference for Ocean Energy (ICOE) in Halifax, November 2014. This Portal facilitates access to all information related to ocean energy activity in Ireland and is intended to become the "first stop shop" to which all developers can engage with relevant support sectors in Ireland and from where they can obtain the most relevant and up to date information. (www.oceanenergyireland.ie)

MARKET INCENTIVES

Under the Job Creation work-stream of the OREDP, one of the key actions is the introduction of Initial Market Support Tariff for Ocean Energy. This is currently under design by Department of Communications Energy and Natural Resources and proposed for introduction in 2016. It will be equivalent to €260/MWh and strictly limited to 30MW for ocean (wave and tidal), focusing on pre-commercial trials and experiments.

PUBLIC FUNDING PROGRAMMES

SEAI Prototype Development Fund

The OREDP reiterates the focus on stimulating industry-led projects for the development and deployment of ocean energy devices and systems through the support of the Sustainable Energy Authority of Ireland's (SEAI) Prototype Development Fund. The objectives of this programme are to accelerate and enhance support for the research, development, testing and deployment of wave and tidal energy devices through the following indicative types of activities:
SEAI supported eighteen projects through this programme in 2014, ranging from scaled testing of wave and tidal energy device concepts, research into innovative enabling components and the site development for ESB's WestWave proposed 5MW array project near Killard, Co. Clare. The Prototype Development Fund has recently been re-launched, with a new provision for increased grant levels for projects displaying a high level of collaboration.

OCEANERA-NET

The ERA-NET scheme is an innovative component of the European Union's Framework Programme, which supports co-operation of national/regional research funding programmes to strengthen the European Research Area (ERA). The EU does not provide financial support for the research activities themselves, for which the ERA-NET members' Funding Organisations are expected to use their own national/regional resources. OCEANERA-NET (http://www.oceaneranet.eu), aims to coordinate and support research, innovation and knowledge exchange in the Ocean Energy sector amongst European countries and regions, by launching transnational competitive joint calls for funding collaborative RTDI projects. SEAI is a participant in the OCEANERA-NET and joined 18 funding Agencies in 7 European countries in a joint call for collaborative research pre-proposals which closed in December 2014. A second joint call is due to be launched in Autumn 2015.

SEA TEST SITES

Galway Bay Quarter Scale Test Site

Ireland's ¼ scale marine test site is located 1.5 km offshore in water depths ranging from 20m – 23m within Galway Bay. The license for the site has been held by the Marine Institute since 2006. The site has provided test and validation facilities for a number of devices to date. Extensive historical wave and weather data is available for the site. This data has been gathered and collated since 2008. Testing continued in Galway in 2014.

In 2015 work at the test site will be focussed on installation of a cable and floating power system. The Sustainable Energy Authority of Ireland, the Marine Institute, the Hydraulics and Maritime Research Centre (UCC) and SmartBay Ireland will be working together on this project which is being funded by Science Foundation Ireland.

The project consists of three components:

1. A standard telecommunications cable from a shore station to the wave energy test site providing power and data connectivity
2. Subsea test and monitoring devices
3. Floating 'Sea Station' platform

The proposed new infrastructure will support wave energy converters by providing them with systems power and safely dissipating any wave energy they generate. Access to the test facility will be open to all wave energy developers wishing to test at ¼ scale (TRL 5-6) and will be coordinated by SmartBay Ireland Ltd.

Atlantic Marine Energy Test Site (AMETS)

The Atlantic Marine Energy Test Site (AMETS) is being developed by Sustainable Energy Authority of Ireland (SEAI) to facilitate testing of full scale wave energy converters in an open ocean environment.

AMETS will be located off Annagh Head, west of Belmullet in County Mayo and will be connected to the national grid.

The test site is an integral component of Ireland's Ocean Energy Strategy and is being developed in accordance with the national Offshore Renewable Energy Development Plan (OREDP).

At the site there will be two test areas:

- Test Area A will be at 100 m water depth and will be located some 16 km out from Belderra Strand; Test Area A will be 6.9 km^2 (2.02 nautical square miles).
- Test Area B will be at 50 m water depth and will be located 6 km from the strand. Test Area B will be 1.5 km^2 (0.44 nautical square miles).

In 2015 SEAI will work with the industry to review requirements at the site and will commence onshore elements of the test site (e.g. substation and grid connection currently planned for completion in 2016).

RESEARCH & DEVELOPMENT

GOVERNMENT FUNDED R&D

Marine Renewable Energy Ireland (MaREI)

MaREI is a research centre of excellence funded by Science Foundation Ireland. This is a virtual Centre with the Administration and Organisational Resources hosted within University College Cork but with associated research activities in the University of Limerick, National University of Ireland, Maynooth, University College Dublin, National University of Ireland, Galway and Cork Institute of Technology. The overall funding is €28 million for a period of 6 years and involves 42 industry partners who provide 30% of the funding. Prof. Conchur O'Bradaigh is the Director of this Centre and is also Professor of Energy Engineering within UCC. The research activities in MaREI are divided into a number of Spoke Projects which address specific problems relevant to the partner companies and Platform Projects which relate to underpinning research of a more general nature.

Beaufort

The Beaufort Building will house a range of research activities in University College Cork related to ocean energy, energy systems and maritime topics. The €14 million building is funded by the Government Departments of Energy, Marine and Education together with external support from Bord Gais Eireann and the Industrial Development

Authority. The construction commenced in early 2014 and is expected to open in July of 2015. The building will house the National Ocean Test Facility with large scale wave test tanks together with ancillary power take-off system simulators and supporting sustainable energy research facilities.
The Beaufort Building will represent the UCC presence within the Irish Maritime and Energy Resource Cluster (IMERC). This is a grouping with the National Maritime College of Ireland and the Irish Naval Service on the large campus in Ringaskiddy, Cork. The overall campus will contain innovation and other buildings in a Technology Park related to maritime and energy commercial developments.

Beaufort Building – University College Cork (Oct 2014)

Science Foundation Ireland (SFI)
SFI have awarded Professor John Ringwood of the Wave Energy Group within the National University of Ireland, Maynooth, a grant of €1.5 million for "innovative research into wave energy development". The research will work toward the development of the next generation of controllers for wave energy devices. Prof Ringwood is a Co-PI within the SFI funded MaREI Centre.

PARTICIPATION IN COLLABORATIVE INTERNATIONAL PROJECTS

UCC (Beaufort-HMRC) co-ordinates the MaRINET (Marine Renewables Infrastructure Network for Energy Technologies) project . The initiative was reported last year and runs for four years until 2015, with at least six 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
This 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.

DTOcean . This is an EU project coordinated by Edinburgh University with 18 partners from 11 countries (Ireland, Spain, United Kingdom, Germany, Portugal, France, Norway, Denmark, Sweden, Belgium and United States of America) with the goal to develop open-source Optimal Design Tools for Ocean Energy Arrays aimed at accelerating the industrial development of ocean energy power generation knowledge, and providing design tools for deploying the first generation of wave and tidal energy converter arrays. Beaufort-HMRC is a partner in this project providing database support and technical input to all of the Work Packages.

IEC TC114 . Ireland has a mirror committee (TC18) and contributes experts to TC114 development of standards and guidelines in ocean energy. Ireland has expert participation in all of the Work Programmes except those related to OTEC.

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 started in 2013.

Lean Wind . The Beaufort-HMRC is also the co-ordinator of the European Commission funded FP7 Lean Wind project, designed to reduce costs of offshore wind technology and operations.
Ireland, through HMRC, also participates in the European research network, EERA

MERIKA (Marine Energy Research Innovation and Knowledge Accelerator) is an ambitious initiative by UHI (University of the Highlands and the Islands), located in Scotland and the UK's outermost region. The project revolves around the concept of turning the UHI Faculty of Science, Health and Engineering into a reference research and innovation hub for all of Europe on the theme of marine energy. Funded by the EU Seventh Framework Programme, the MERIKA Project runs from 2014-2017. Prof. Mike Hartnett from the National University of Ireland, Galway is a partner in this project and will contribute to the networking and business development activities. Prof. Hartnett is a Co-PI within the SFI MaREI Centre.

OceaNet . This is a four year Initial Training Network funded under the European Commission FP7 Marie Curie programme coordinated by the WavEC in Portugal. The grant aid funds 12 early stage researchers (ESR) distributed around the 9 partners. Beaufort-HMRC is a partner and hosts one of the ESRs working with Prof. Tony Lewis towards a PhD in combined wind/ocean energy platform systems.

ERC Proof of Concept Grant . This prestigious award has been made to Professor Frederic Dias, School of Mathematical Sciences, University College Dublin: Measuring 'rogue waves' in extreme sea conditions. The European Research Council - Proof-of-Concept grant is to support testing of a measurement system, combining research on the physics of extreme waves with the recent developments in buoy design, in order to optimise the new technology for waves of high amplitude and steepness. Commercial applications, if successful, would include marine renewable energies, shipping, marine forecasting, and ocean observation.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

Technology From Ideas successfully installed and tested their elastomeric mooring tethers on a Mobilis 8000 databuoy at the Galway Bay Quarter Scale Test Site, as part of a project supported by SEAI.

OTHER RELEVANT NATIONAL ACTIVITIES

The annual plenary meeting of IEC Technical Committee TC114 on Marine Energy Standardisation will be held in Dublin Castle from April 27th to May 1st 2015. The Ocean Energy Europe Annual Conference will also take place in Dublin in October 2015 (Dates TBC).

CANADA

ELISA OBERMANN *(Marine Renewables Canada)*
TRACEY KUTNEY *(Natural Resources Canada)*

2014 was a year of a number of marine energy achievements in Canada. These achievements include: Fundy Ocean Research Centre for Energy (FORCE) laid the 4 subsea electrical cables in the fall; a number of river current technologies have been and are currently being tested at the Canadian Hydrokinetic Test Centre; and the West Coast Wave Initiative continues to gain recognition for their activities in wave energy forecasting.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

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

On the Atlantic coast, the province of Nova Scotia is where many tidal activities are taking place in Canada, particularly in the Bay of Fundy. 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 goals to develop marine renewable energy legislation, implement a research and development plan and has a target of having 300 MW of in-stream tidal electricity generation grid connected by 2030.

LEGISLATION AND REGULATORY ISSUES

At the federal level, the Department of Natural Resources Canada, under the Marine Renewable Energy Enabling Measures program, is taking a lead role towards the development of a policy framework for administering marine renewable energy activities in the federal offshore. This policy framework will provide direction to the federal government on the potential development of a comprehensive legal framework for administering marine renewable energy in the federal offshore.

In early 2014, the Government of Nova Scotia amended the *Renewable Electricity Regulations* under the *Electricity Act* to establish the feed-in tariff (FIT) approval process for larger-scale developmental tidal projects. The regulations and FIT are intended to help ensure the industry can invest in projects and install 15 to 20 MW of tidal-power capacity in Nova Scotia over the next 5-6 years.

The Government of Nova Scotia continues to work on developing legislation specific to marine renewable energy. It is anticipated that legislation will be tabled in fall 2015.

The *Statement of Best Practices for In-Stream Tidal Energy Development & Operation* was developed by the Nova Scotia Department of Energy and Marine Renewables Canada. It provides guidance for the development and operations of in-stream tidal energy. The Statement is a tool that can be used by industry, government, and other key stakeholders to harmonize development with environmental interests and ensure that the industry grows in an environmentally

and socially responsible manner. It follows a sequence of essential steps in planning, deployment, operation, and decommissioning of an in-stream tidal energy project.

As part of Nova Scotia's strategy for marine renewable energy development, the province continues to initiate and lead strategic environmental assessments (SEA). The Offshore Energy Research Association of Nova Scotia (OERA) led an update to the Bay of Fundy SEA (previously conducted in 2007-2008) and the report was released in 2014. The OERA also managed a SEA for the Cape Breton Island Region, which was also released in 2014.

MARKET INCENTIVES

In 2013, the Nova Scotia Utility and Review Board (UARB) 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 project plans, turbine designs, and to support the build-out to multiple-device projects. The Test Path - Phase 1 is limited to single-device deployments at FORCE for a 3-year period. At the end of the 3 years, the rates transition to the Test Path - Phase 2, and the developer may deploy additional devices. The entire project would then be subject to the Test Path – Phase 2 rates for the following 15-years. The Developmental Path allows for the deployment of multiple devices for a period of 15 years, and is not limited to deployments at FORCE. 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. The net present value (NPV) of both the Testing and the Developmental FIT paths are intended to be the same over the contract period.

Test Path – Phase 1		Test Path – Phase 2		Developmental Path	
≤ 3,330 MWh	> 3,330 MWh	≤ 16,640 MWh	>16,640 MWh	≤ 16,640 MWh	>16,640 MWh
$575	$455	$495	$375	$530	$420

The Fundy Ocean Research Centre for Energy (FORCE) is Canada's research centre for in-stream tidal energy, located in the Bay of Fundy, Nova Scotia. FORCE provides four berths (project sites) to host technology developers, with electrical infrastructure to deliver power to the grid. In December 2014, four developers with projects at FORCE received Developmental FIT approvals, totalling 17.5 MW to be developed at the FORCE site:

- Minas Energy (4 MW)
- Black Rock Tidal Power (5 MW)
- Atlantis Operations Canada (4.5 MW)
- Cape Sharp Tidal Venture (4 MW)

These developers have received approval for the Developmental FIT path, which allows them to enter into a 15-year power purchase agreement with Nova Scotia Power. The first turbines are expected to operate in the Bay of Fundy in 2015.

The Government of Nova Scotia also has the Community Feed-in-Tariff (COMFIT) program, which was launched in September 2011. Under the COMFIT program, Nova 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. To-date, one entity has received COMFIT approvals for five in-stream tidal energy projects. Fundy Tidal Inc. is in the process of finalizing deployment plans for small-scale projects with its financial partner, International Marine Energy, and device developers Clean Current, Tocardo, and Nautricity.

PUBLIC FUNDING PROGRAMMES

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.

At a provincial level, Nova Scotia has directly invested in the FORCE development initiative and, through the 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.

To further activity under the Canada-United Kingdom Joint Declaration, a memorandum of understanding between Nova Scotia, the OERA, and the United Kingdom's Technology Strategy Board (TSB, now InnovateUK) was signed in March 2014 to encourage joint research to develop new and innovative technology for high-flow tidal environments. As a first action in support of this MOU, the OERA and InnovateUK launched a call for collaborative R&D projects focused on advancing environmental monitoring, sensing, and instrumentation in August 2014 (www.oera.ca/news/requests-for-proposals-funding/current-opportunities/). The two jurisdictions are jointly investing $1.4 million. The deadline for expressions of interest was November 28, 2014, and the successful projects will be announced in 2015.

SEA TEST SITES

Over the course of 2014, FORCE has been working on completing aspects of the shared infrastructure it provides for tidal energy developers. In late 2013, FORCE successfully installed a data cable designed to connect a recoverable research platform – the Fundy Advanced Sensor Technology platform (FAST). This was the first subsea cable ever installed in the Minas Passage. The cable installation is part of an $8 million research project to build the FAST platform which is designed to monitor and characterize the FORCE site. The data cable allows for continuous, real-time data transmission from the platform to shore.

Building on the data cable deployment experience, FORCE successfully installed four subsea power cables, one dedicated to each of its 4 turbine test berths, at its site in the fall, giving it the largest transmission capacity for any tidal energy site in the world at 64 MW.

FORCE cable deployment

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

The Canadian Hydrokinetic Turbine Test Centre (CHTTC) in Manitoba is operating, using its dedicated infrastructure on the Winnipeg River to test river current technologies. Since September 2014, 7 turbines, supplied by 4 technology developers, have been tested at the site. CHTTC will work towards facilitating the deployment of systems in rivers, and developing the required expertise for all aspects of these projects. These activities will allow rural communities to benefit from hydrokinetic river resources to help serve their energy needs.

Interest in wave energy in Canada continues to focus on the West Coast Wave Initiative (WCWI) out of University of Victoria's Institute for Integrated Energy Systems (IESVic). The WCWI has developed a high resolution wave model of the British Columbia coast that was validated against the wave energy data for BC over the past 11 years. The model can forecast wave conditions up to 48 hrs into the future. Hourly power production estimates for future wave energy converter farms off the BC coast, created by combining the detailed wave resource and device performance characteristics, are then simulated into the BC Hydro electrical grid. This allows for the identification of wave energy converter farm locations which maximise utilization of the produced power. With a suite of data buoys gathering new wave data (www.uvic.ca/research/projects/wcwi/research/buoy-information/index.php), a new target is to develop the ability to generate high resolution forecasts of the energy output from wave farms, an essential input to system operators.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

In 2014, Clean Current continued to operate the company's 1.5 m turbine at the Canadian Hydrokinetic Turbine Test Centre (CHTTC) in Manitoba. The unit was retrieved for inspection and retrofitted with a new heightened foundation to better capture the peak river flows. The turbine power was delivered to an onshore resistive load, because the device was tested before CHTTC was grid connected. Clean Current's onshore control system also successfully varied the load to optimize energy extraction based on the constantly varying river conditions.

Clean Current deployment at CHTTC

New Energy Corp. installed their 5 kW enCurrent vertical axis turbine in Ringmo, Dolpa, Nepal, in the spring of 2014. The site is very remote – it is 3 days to the nearest road, and all components needed to be carried in by hand. The system operated for four solid months at capacity. Ringmo closes down in the fall, but will be opened again in the spring at which time the unit will be restarted.

New Energy at remote site in Nepal

New Energy Corp. installed their 5 kW enCurrent vertical-axis turbine at the CHTTC in September, primarily to test a patented fully submersible bearing. The test was a resounding success, and this bearing design has already been incorporated into the

commercial product design. Testing will continue in 2015 on various aspects of the mechanical design as well as control system enhancements for both stand-alone and grid connected applications.
Mavi tested the Mi1-20 kW floating ducted cross-flow turbine at the CHTTC in November, 2014. Due to severe winter conditions, turbine operation was limited to short interval testing. Mavi will return to the CHTTC in Spring/Summer 2015 to complete a longer term test program.

Jupiter Hydro tested their Delta unit (36" diameter) helical screws turbine at the CHTTC in the second quarter of 2014. In the fourth quarter of 2014, Jupiter Hydro tested their 3EC42 unit (42" diameter) helical screws turbine at the CHTTC. The 3EC42 unit has remote monitoring and control capabilities.

Idénergie conducted a public demonstration of the installation and electricity generation of their small scale (<5 kW) river current turbine. The turbine was installed in a river near Montréal and linked it to a cabin 300 m away to power the basic home appliances (fridge, tv, lighting, cooking stove, internet, water pump).
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.

Mavi prepares Mi1 Turbine for deployment at CHTTC

Jupiter Hydro model 3EC42 deployment at CHTTC

PLANNED DEPLOYMENTS

In March 2014, the Government of Nova Scotia announced two new berth holders at FORCE, to join the two existing berth holders. Cape Sharp Tidal Venture, comprised of OpenHydro/DCNS with partner Emera were awarded a berth after a 1 MW OpenHydro device was deployed in 2009 and recovered in 2010 by Nova Scotia Power Inc. Black Rock Tidal Power, with parent company, SCHOTTEL, also secured a berth. As part of their new plans, Minas Energy and partner Marine Current Turbines (MCT) have added Bluewater Energy Services as partner and they have jointly agreed to develop a two x 2 MW floating tidal current turbine platforms. Atlantis Resources, with partners Lockheed Martin and Irving Shipbuilding remains the fourth berth holder at the FORCE site. To support these deployments and the first 20 MW of development at the FORCE site, the Government of Nova Scotia committed more than $4 million in funding to increase the electrical capacity at FORCE.
In November 2014, the Government of Nova Scotia announced plans for a fifth berth holder at FORCE. The province is in discussions with Ireland-based renewable energy development company, DP Marine Energy, about installing a 4.5 MW tidal stream demonstration power plant at the FORCE site.
Working with a consortium of industry and academic partners, Fundy Tidal has continued to advance COMFIT small-scale tidal energy projects in Grand Passage, Petit Passage, and Digby Gut toward deployment of turbines in late 2015 and/or early 2016. Fundy Tidal recently partnered with International Marine Energy (IME) with agreements to develop current and future projects in Atlantic Canada, Quebec, and Nunavut. IME also holds interests in Western Tidal Holdings (active in British Columbia) and Quemar Grand Nord Inc. (active in Quebec). The partnership provides opportunities to expand project development opportunities beyond Nova Scotia.

New Energy Corp. plans on installing two of their 5 kW enCurrent turbines in Myanmar in order to provide year round power for a school. The two floating demonstration systems are to be installed in a river adjacent to the school. Installation is scheduled for early 2015.

New Energy Corp. continues to advance with their Canoe Pass, British Columbia project. Canoe Pass is a 500 kW Tidal demonstration on Vancouver Island. All permitting and regulatory approvals are in place for the project. Part of the causeway between two islands will be removed to install two 250 kW turbines. The site construction is underway and the turbine installation is scheduled for late 2015/early 2016.

Once performance testing is complete at the CHTTC, the Mavi Mi1 turbine will be shipped back to BC and deployed at an off grid tidal site to demonstrate the feasibility of using tidal turbines to power remote communities. Concurrently, Mavi will be developing a lighter version of the Mi1 designed for river applications.

Idénergie is planning 5 to 10 installations in Quebec and the surrounding provinces/states with owners of cabins, regional natural park managers, universities and others. Idénergie has a demonstration project planned for 3 turbines in the Amazonian region.

OTHER RELEVANT NATIONAL ACTIVITIES

INTERNATIONAL COLLABORATION

Canada has been working with other international bodies to collaborate on the development of best practices, standards, and procedures. FORCE and EMEC jointly hosted a discussion forum for international open-water test centres in Halifax, Nova Scotia, this fall. Discussions among the centres were focused on key issues for test sites, such as environmental monitoring, standards development, and operational procedures. As a result, these centres have committed to coordinate procedures and standards to ensure consistency in testing marine energy converters across the globe.

5TH INTERNATIONAL CONFERENCE ON OCEAN ENERGY

ICOE 2014 was held in Halifax, Nova Scotia in November, marking the first time ICOE was held outside of Europe. The conference attracted participants from over 25 countries to Halifax, Nova Scotia which includes 650 delegates, 121 exhibitors, and 220 presenters. The participant profile was comprised of utilities, tidal/wave/river energy device developers, multinational corporations, government, project developers, academia, and supply chain companies and service providers with marine, energy, hydro, offshore oil and gas, and/or ocean technology expertise.

The conference included a full week of activities including three full days of speaker and poster presentations, a tradeshow and exhibition, site visits to the FORCE and Annapolis Tidal Power Station, Welcome Reception, Gala Dinner, and over ten side events hosted by various organizations.

OTHER CONFERENCES

Marine Renewables Canada Annual Conference will be held in fall 2015.

UNITED STATES OF AMERICA

ALISON LABONTE
U.S. Department of Energy (DOE)

Marine and Hydrokinetic Technologies (MHK) capture the energy of waves and currents (e.g., tides, ocean currents, or in-stream river flows). With more than 50% of the U.S. population living within 50 miles of U.S. coastlines, MHK technologies hold significant potential to supply renewable electricity to these consumers, particularly in areas with high costs of electricity. U.S. MHK resource assessments identify a technical resource potential of up to 1,285-1,846 terawatt-hours (TWh) of generation per year. For context, approximately 90,000 homes can be powered by 1 TWh of electricity generation each year. A cost-effective MHK industry could provide a substantial amount of electricity for the United States due in large part to its unique advantages as a source of energy, including its vast resource potential, its close proximity to major coastal load centers and its predictability.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The mission of the U.S. Department of Energy's (DOE) Water Power Program is to research, test, evaluate, develop and demonstrate innovative technologies capable of generating renewable, environmentally responsible and cost-effective electricity from water resources. The Program has established a national MHK cost goal of 12-15 cents per kilowatt hour (kWh) by 2030. To accomplish this goal, the Program has a strategic focus on the following four major focus areas:

1. Technology Advancement and Demonstration
2. Testing Infrastructure and Instrumentation Development
3. Resource Characterization
4. Market Acceleration and Deployment

To facilitate this work, the Water Power Program supports a strong research, development and demonstration (RD&D) project portfolio. The Program also leverages capabilities at the U.S. Department of Energy's national laboratories to spur innovation in promising research areas and identify cost reduction pathways, and has built coordinated partnerships with other government agencies that are breaking new ground for the industry.

LEGISLATION AND REGULATORY ISSUES

Several key pieces of U.S. federal legislation that would benefit the advancement of the MHK industry are currently under consideration:

- The Marine and Hydrokinetic Renewable Energy Act of 2013 (S. 1419) was introduced in August 2013 and has been recommended by the Senate Energy and Natural Resources Committee for full consideration by the Senate.

Sponsored by Senator Ron Wyden and co-sponsored by Senators Lisa Murkowski and Angus King, this bill would promote research, development, and demonstration of MHK renewable energy technologies.

- The Renewable Electricity Standard Act of 2013 (S.1595) and the American Renewable Energy and Efficiency Act (S.1627), both pending in the Senate Energy and Natural Resources Committee, would each create a renewable electricity standard that would apply to all renewable energy sources.
- 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, and loan guarantees. This bill is sponsored by Senator Bernie Sanders and is under consideration by the Committee on Environment and Public Works.
- The 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. It would also 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. Sponsored by Representative Jan Schakowsky and 22 other cosponsors, this bill is currently under consideration by the House Committee on Ways and Means.
- The Advancing Offshore Wind Production Act (H.R.1398), sponsored by Representative Rob Wittman, would set a 30-day timeline for the Secretary of the Interior to act on permits for all weather testing and monitoring projects in the U.S. Outer Continental Shelf. This bill includes a provision that would apply this timeline to tidal and ocean current energy projects. This bill has been referred to the House Natural Resources Committee.

While significant progress has been made to expedite the permitting process for MHK technologies in the United States, especially for pilot scale and research projects, the amount of time, finances and other resources required to navigate the permitting process remains a challenge for many MHK projects. To help ensure that the regulatory community has access to the most recent, amalgamated information regarding MHK systems and environmental research, the Water Power Program sponsored a MHK regulator training workshop in September 2014. A second workshop will be held in the spring of 2015.

In addition to the Water Power Program's work, the National Ocean Council continues to promote regional ocean planning efforts in the United States, notably with a group of regional planning bodies that coordinate ocean activities and develop marine spatial plans for their regions. Similarly, the Bureau of Ocean Energy Management has established a series of state task forces to lead planning efforts for marine renewable energy in a number of states with MHK resources, including Oregon and Hawaii.

MARKET INCENTIVES

Currently, there are limited federal market incentives to support the development of MHK. The Federal Production Tax Credit of 1.1 cents per kWh for a number of renewable energy technologies, including MHK technologies, has now expired. Even when it was in place, it served a limited number of MHK projects due to a provision that required projects to have at least 150 kW in capacity under construction by December 31, 2013. In addition to the Production Tax Credit, tidal projects are eligible for a tax credit equal to 10% of expenditures under the Investment Tax Credit. There is no Investment Tax Credit for MHK technologies other than tidal.

At the state level, MHK technologies are an eligible energy resource under 20 states' renewable portfolio standards and voluntary renewable energy goals. MHK technologies also benefit from state funding opportunities, such as the Alaska Energy Authority's Emerging Technology Fund and Renewable Energy Fund.

PUBLIC FUNDING PROGRAMS

Because MHK energy is an early stage market and there are currently limited incentives for investment, the Water Power Program has a clear role in expediting the development and deployment of innovative MHK technologies. The Water Power Program focuses on investing in technologies with a credible potential for lowering the levelized cost of energy (LCOE) below the local hurdle price at which MHK can compete with other regional generation sources. The Program makes investments that mitigate risks, support key technology innovations, and assist the private sector in creating a robust U.S. MHK industry by providing funding and technical assistance. The completion

of national assessments of U.S. wave, tidal, ocean current, river in-stream, and ocean thermal energy resources has resulted in an emphasis in technology development efforts of the abundant national wave energy resource.
The Water Power Program's annual budget for MHK RD&D climbed from $31.6 million in 2013 to $41.3 million in 2014. In late 2014, the fiscal year 2015 budget was announced, and the funding for MHK RD&D will be maintained at $41.3 million. Most of the funding in 2014 was directed toward Focus Area 1: Technology Advancement and Demonstration.

FUNDING OPPORTUNITY ANNOUNCEMENTS

Through competitive award funding solicitations, or Funding Opportunity Announcements (FOAs), the Water Power Program identifies and funds qualified projects within specific topic areas and subtopics that support program objectives, depending on available funds. In evaluating all proposals for new energy developments or new adaptations of existing technology, the Program rigorously assesses whether individual applications clearly demonstrate that the proposed advances can reasonably lead to a reduction in the total cost of energy produced when compared to other technologies.
In fiscal year 2014, the Water Power Program allocated $23.7 million of the $41.3 million to new FOAs for MHK RD&D projects that aim to address key technical and market barriers to deployment in the United States. Together, these projects will increase the power production and reliability of MHK devices and help gather valuable data on how deployed devices interact with the surrounding environment. Of this total amount, the Water Power Program made the following awards to a variety of recipient types, including private industry, and universities:

- $3.2 million to aid in the development of advanced instrumentation for environmental monitoring and data collection (five projects), and wave resource characterization (one project).
- $4 million to three universities that will work together to accelerate the development of cost-effective MHK technologies.
- $6.5 million for the development and execution of a Wave Energy Prize competition.
- $10 million for two projects that will test innovative wave energy conversion (WEC) devices for one year in new deep water test berths at the Navy's Wave Energy Test Site off the waters of the Kaneohe Marine Corps Base Hawaii.

Wave Energy Prize: The Wave Energy Prize is designed to help reduce the cost of WEC devices, generate enthusiasm and interest from new developers, and leverage the best ideas to promote a clean energy future. Scheduled to be launched in 2015, the Prize is an 18 month design-build-test competition in which participants will develop new and next generation WEC devices. Since comparing the performance of WEC devices can be difficult, the Wave Energy Prize will use the world-class wave-making capabilities of the Naval Surface Warfare Center's Carderock Division's MASK Basin, which will generate consistent waves to test each device. Since October 2014, the Prize Administration Team, consisting of Ricardo Inc., JZ Consulting and Polaris Strategic Communications, have been developing prize rules, testing timelines, and evaluation metrics that will ensure exciting Wave Energy Prize outcomes. The wave states to be tested and the technical criteria for winning the prize are being set by Ricardo with the assistance of experts at DOE's Sandia National Laboratories and the National Renewable Energy Laboratory. Once the Prize is launched in Spring 2015, the Prize Administration Team will be reviewing what the Water Power Program hopes will be dozens of novel WEC device concepts for official entry into the competition.

Demonstrations at the Navy's Wave Energy Test Site (WETS): Ocean Energy USA and Northwest Energy Innovations will conduct in-water tests to collect important performance, reliability and cost data from innovative WEC devices that are in the late stages of technology development. As the nation's only grid-connected open-water test site, testing at the Navy's WETS is a critical step to gathering data that will accelerate the commercialization and deployment of MHK technologies. Ocean Energy USA will leverage lessons learned from previous quarter-scale test deployments that have led to design improvements for a full-scale deployment of their Ocean Energy Buoy at WETS. Research objectives include validating the mooring design and device durability in the open ocean environment, measuring power output at full scale, and evaluating the device's LCOE. Northwest Energy Innovations will build and test a full-scale model of its Azura WEC device. Azura extracts power from both the vertical and horizontal motions of waves to maximize energy capture. NWEI is incorporating lessons learned from their half-scale prototype testing in 2012 to modify and improve the full-scale device design.

Under DOE's Small Business Innovation Research (SBIR) and Technology Transfer (STTR) programs, $150,000 in funding will help small businesses develop prognostic and health monitoring systems for MHK devices. Commercial-scale MHK energy converters are large, often highly complex devices operating in a harsh marine environment, and servicing these devices at sea is a difficult and costly operation. Advanced prognostic and health monitoring systems promise to anticipate and identify relevant changes to device health, minimizing the maintenance and failure frequency of these devices, and potentially reducing MHK's LCOE. 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 DOE's Technology Readiness Level chain. Small businesses that win awards in these programs keep the rights to any technology developed and are encouraged to commercialize the technology.

Additional funding was available from state-level non-profit organizations in 2014. For example, the Oregon Wave Energy Trust committed a total of $535,500 to assist companies testing MHK devices along the west coast of the United States.

SEA TEST SITES

Testing infrastructure represents one of the four major focus areas for the Water Power Program. Test facilities are intended to offer a wide range of testing services that address both technical and nontechnical barriers of MHK systems. Prototype testing is essential to maturing existing wave technologies, validating performance against analytic models, and demonstrating compliance with applicable design standards. Testing mitigates the technical and financial risk of developing and deploying mass-produced wave energy devices, plants, technologies, and related products. By spearheading the development of a testing infrastructure, the Program ensures that many more prototypes from a diverse set of technology developers can be tested than if each had to carry the cost of developing, permitting and installing their own test facility. As a result, superior technologies that could have failed due to insufficient funds have a chance to succeed.

Navy's Wave Energy Test Site: The U.S. Naval Facilities Engineering Command (NAVFAC) operates an open ocean wave energy test site facility located at Marine Corps Base 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 feet) depth test site, 1.2 kilometers (3,900 feet) offshore. The Navy has completed the permitting process and has begun construction of two additional grid-connected test berths at the Kaneohe Bay site at 80 meter and 60 meter depths for 100 to 1,000 kW WEC devices.

Pacific Marine Energy Center - South Energy Test Site (PMEC-SETS) and the California Wave Energy Test Center (CalWave) – Wave and Tidal Test Facilities under development: In early 2014, with $1.5 million in funding from the Water Power Program, NNMREC and California Polytechnic State University began developing preliminary designs and cost estimates for full-scale, open-ocean, grid-connected wave energy test facilities, PMEC-SETS and CalWave. The Water Power Program will use the results of these projects for planning and budgeting of a domestic wave energy test facility. PMEC-SETS is located off the coast of Oregon. Researchers at OSU are conducting site characterization and a cable routing study is in process. Following construction, PMEC-SETS will serve as the utility-scale, grid-connected wave energy test facility for evaluating WEC device performance, environmental interactions, and survivability. CalWave has investigated and characterized two wave energy sites five miles off the coast of California (Santa Barbara County and Humboldt Bay). The site in Santa Barbara County near Vandenberg Air Force Base has been selected by the project team and has advanced to the preliminary design and cost estimate phase.

National Marine Renewable Energy Centers (NMRECs): In 2014, the Water Power Program continued to support the NMRECs, which provide domestic expertise in MHK device testing and the evaluation of environmental performance data, ultimately providing the necessary level of confidence to enable the private financing of commercial generation plants:

▸ **Pacific Marine Energy Center (PMEC) – Wave, and River Test Facility:** Pacific Marine Energy Center or PMEC is the marine energy converter testing facilities arm of the Northwest National Marine Renewable Energy Center (NNMREC). 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. For wave energy testing, PMEC supports two operational test sites, the North Energy Test Site (NETS) and Lake Washington. The north test site has a mobile Ocean Sentinel test buoy that facilitates open-ocean, stand-alone testing of WEC devices with average power outputs up to 100 kW. The Lake Washington site is operated by the University of Washington in Seattle, and tested Oscilla Power's wave energy technology in 2013. In 2014, NNMREC was joined by University of Alaska Fairbanks and PMEC now includes the Tanana River Hydrokinetic Test Site. An ocean energy company tested their turbine technology at the Tanana River site in 2014.

▸ **Southeast National Marine Renewable Energy Center (SNMREC) – Ocean Current Test Facility:** SNMREC is working to advance research in open-ocean current systems by building the capability, infrastructure, and strategic partnerships necessary to support technology developers on the path to commercialization. In 2014, SNMREC signed a five-year lease agreement with the U.S. Department of the Interior's Bureau of Ocean Energy Management, and will continue to develop a test site for small-scale ocean current turbines.

▸ **Hawaii National Marine Renewable Energy Center (HINMREC) – Wave and Ocean Thermal Energy Conversion (OTEC) Test Facility:** HINMREC's mission is to facilitate the development and commercialization of WEC devices and to assist the private sector with moving ocean thermal energy conversion systems beyond proof-of-concept to pre-commercialization. Beginning in 2015, HINMREC plans to support the Navy in testing WEC devices at the Navy's two new test berths at its WETS at Kaneohe Bay, Hawaii. HINMREC will assess the power performance of WEC devices, including but not limited to Ocean Energy USA's and Northwest Energy Innovations' FOA R&D projects. HINMREC will also determine acoustic and electromagnetic field outputs at the WETS, which will contribute to the environmental impact assessment of WEC devices and other MHK technologies.

RESEARCH & DEVELOPMENT

ABOUT NATIONAL LABORATORIES

In addition to NMRECs, DOE's national laboratories possess unique instruments and facilities and address large scale, complex R&D challenges with an approach that emphasizes translating basic science to innovation. The Water Power Program partners with several of these important R&D institutions to support R&D in MHK technologies.

Sandia National Laboratories (SNL): Through a partnership with several national laboratories and academic institutions, SNL is leading efforts in technology development, market acceleration, and reference model developments. 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 and development requirements for deep tank testing
- Wave environment characterization and measurements in tidal flows
- Wave and tidal energy modeling to predict environmental effects of energy removal and inform optimal device spacing

National Renewable Energy Laboratory (NREL): NREL's research supports the Water Power Program'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 Program 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
- Strategic long-term vision and roadmap development for water power in the United States

Pacific Northwest National Laboratory (PNNL): PNNL supports the Water Power Program through research, engineering, information aggregation and disseminations, resource characterization and forecasting, market analysis, planning and coordination to overcome barriers for water power. PNNL's specific efforts include:

- MHK environmental impacts research, international collaboration and information sharing
- 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

Oak Ridge National Laboratory (ORNL): ORNL is involved in a number of R&D activities supporting the Water Power Program's mission. These activities and products help all stakeholders understand and resolve the environmental effects of MHK technologies and help developers advance MHK technologies to commercialization. ORNL scientists are currently conducting laboratory and field experiments to evaluate the effects of noise and electromagnetic fields on marine organisms.

2014 MHK R&D HIGHLIGHTS

LCOE Modeling: To normalize competing claims of LCOE, the Water Power Program and national laboratory partners have developed, for the Program's own use, a standardized cost and performance data reporting process to facilitate uniform calculation of LCOE from MHK device developers. This standardization framework is a working version in what is anticipated to be an iterative process that involves industry and the broader Water Power Program stakeholder community. The LCOE reporting process references a generalized Cost Breakdown Structure (CBS) for MHK projects that is being developed by the Water Power Program and NREL. 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 pertain to one project but not others.

Advanced Design Tools: To help advance the survivability, availability and cost-effectiveness of high performance WEC devices, in 2014, the Water Power Program and national laboratory partners advanced control strategies, open source simulation tools, and modelling and design methodologies for the industry.

- The Water Power Program's Advanced Controls project is demonstrating the potential of nonlinear controls to ultimately enable WEC developers to select the best control strategies for their devices.
- The WEC Simulation project has resulted in an open source code and will make a validation data set available at the end of 2015 that meets the needs of both existing and new WEC developers.
- In fiscal year 2015, NREL and SNL will develop and validate a methodology for modelling WECs in extreme conditions to advance the state of the art in Extreme Conditions Modeling of WECs.

Reliability Framework: To help reduce the risks of industry failures and advance the development of current and new technologies at a lower cost and faster pace, the Water Power Program and NREL have developed an MHK technology reliability and survivability risk assessment framework. This framework provides a risk management methodology to identify and reduce risks during all stages of technology development, particularly prior to demonstration activities. The framework will be released in August 2015.

Wave Resource Modeling: To accurately characterize the wave energy resource at resolutions sufficient for siting and deployment purposes, the Water Power Program is working with SNL and PNNL to deliver a wave modelling system that can simulate near-shore wave dynamics with high spatial resolution over the entire West Coast. The modelling system uses an unstructured grid modelling framework and will incorporate wave-device interactions and effects to better plan, site and deploy WEC arrays.

NNMREC's Advanced Laboratory and Field Arrays Project (ALFA): NNMREC is a multi-institution entity with a diverse funding base that focuses on R&D for marine renewables. The ALFA project conducted by NNMREC works to reduce the LCOE of MHK energy by leveraging research, development and testing capabilities at Oregon State University, University of Washington, and the University of Alaska, Fairbanks. ALFA will accelerate the development of next-generation arrays of WEC and tidal energy conversion devices through a suite of field-focused R&D activities spanning a three year performance period.

Environmental R&D: To help address the technological limitations associated with environmental monitoring of MHK devices, the Water Power Program awarded $2.75 million to five new projects in 2014 to improve existing or develop new environmental monitoring technologies. These projects will focus on the detection and classification of marine animals in the vicinity of MHK devices, measuring noise produced by devices, automating optical data processing and developing integrated instrumentation packages to monitor MHK devices more efficiently. In 2014, nine projects that focus on furthering understanding of potential environmental effects from the deployment and operation of MHK devices got underway. The projects include research by universities, industry, non-profits, and national laboratories on device-generated noise and its subsequent effects on marine mega fauna, understanding interactions between fish and tidal turbines, developing and using models to predict strike occurrence and assessing the potential effects that electromagnetic fields may have on marine species. The Water Power Program awarded $2.4 million in 2013 to support these projects.

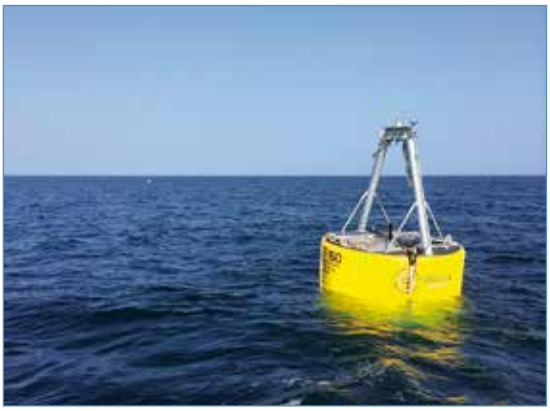
TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS IN 2014

M3 Wave: M3 Wave's project explored the commercial viability of the submerged Delos-Reyes Morrow Pressure Device, which uses a unique method of harnessing the up and down motion of waves by inflating and deflating bags–to convert wave energy into electricity. DOE provided funding to advance the technology from the concept definition stage and prove its feasibility with analysis and small-scale experimental testing. The project resulted in estimates for power output and cost of electricity of a full-scale system. NNMREC provided M3 with an analysis of near-shore wave conditions and a detailed system response model while Pacific Energy Ventures and M3 Wave worked with industry experts to estimate full-scale system and operating costs. This project created new tools and techniques for modelling and testing submerged near-shore devices. Following the completion of the DOE-funded portion of the project, M3 Wave tested their device off the coast of Oregon in September 2014.

M3 Wave's Delos-Reyes Morrow Pressure Device project

Oscilla Power: With funding from DOE's SBIR/STTR program, Oscilla Power designed and constructed a modular, scalable WEC device based on reverse magnetostrictive generator technology. This unique technology transforms the energy from changes in tension and strain into electricity, using inexpensive alloys, and has no moving parts. Although this technology is being developed for wave energy, it can be applied to capture energy from any structure that experiences changes in tension and strain. For example, Oscilla has licensed the technology to provide downhole power during drilling for the oil and gas industry. Oscilla tested their TDU2 system off the coast of New Hampshire at Isle of Shoals in August 2014 and has demonstrated functionality and reliability of a full-scale core, buoy and mooring.



Oscilla tested its WEC device off the coast of New Hampshire

Ocean Renewable Power Company (ORPC): ORPC successfully deployed the RivGen Power System in Summer 2014. The RivGen Power System harvests energy from river and tidal currents, generating electricity either with direct power grid connection or in remote communities with isolated power grids. Its core component, the turbine generator unit, utilizes innovative control systems to drive advanced turbines that efficiently provide reliable energy even within highly turbulent flow environments. The deployment validated simulations and successfully demonstrated the "self-deploying/self-retrieving" capabilities of the device. ORPC's advanced control systems are being developed in collaboration with the University of Washington, Maine Technology Institute and NREL with support from the DOE Water Power Program.

Ocean Renewable Power Company's RivGen turbine prior to being lowered into the Kvichak River in Alaska

PLANNED DEPLOYMENTS

Northwest Energy Innovations (NWEI): With funding from the DOE Water Power Program, NWEI will deploy an improved Azura device at the U.S. Navy's WETS in Hawaii and conduct open-ocean grid-connected testing for one year, starting in winter 2014/2015. Since commencing operations in 2010, NWEI and its partners have successfully completed pilot scale projects in New Zealand and Oregon. The primary objectives of this upcoming test are to utilize the data collected to optimize energy capture, validate existing cost and performance models and further refine the models.

Resolute Marine Energy: The Water Power Program is supporting Resolute Marine Energy to develop an intelligent feedback control algorithm for their next generation device, SurgeWEC™. The control system will be validated in Resolute's Development Center on a full-scale SurgeWEC™ and, upon completion, will be integrated into Resolute's 720 kW wave power project in Alaska.

Fred Olsen: Fred Olsen's Lifesaver WEC device will be deployed at WETS early next year with the support of U.S. Navy funding. The Lifesaver features up to five independently operating power take-off units, an all-electric power

conversion system, and a patented drive train. Its hull design provides buoyancy and water displacement and enables controlled movements, which reduces the impact of sea forces during more aggressive sea states.

Columbia Power Technologies: Columbia Power Technologies will conduct an open-water demonstration of a utility-scale StingRAY at WETS in 2016. With funding from the Water Power Program, the StingRAY includes a direct drive train, which reduces the number of moving parts, permanent magnet generators, which are an efficient way to generate electricity, and a composite structure, which helps to increase the strength and longevity of the device. The deployment at WETS, supported by the U.S. Navy, will include StingRAY utility-scale design and design certification, performance and efficiency validation and design and testing of the structural components.

OTHER RELEVANT NATIONAL ACTIVITIES

The National Hydropower Association (NHA) became the national trade association for the U.S. marine renewable energy (MRE) industry in 2014, assuming the role that had formerly been held by the Ocean Renewable Energy Coalition (OREC). A Joint Working Group, comprised of industry representatives, OREC and the NHA, led the transition effort. The U.S. MRE industry had been assessing ways to unify and strengthen its voice and, accordingly, a varied and diverse group of industry representatives including technology developers, academic institutions, component suppliers and service professionals from the wave/tidal/ocean current/riverine sectors participated in the Joint Working Group.

In November 2014, both the NHA Board of Directors and the OREC Board of Directors voted unanimously to accept and act on the Joint Working Group's recommendations and proposal. The result was that the NHA's former Ocean, Tidal and New Technologies Council was renamed the Marine Energy Council. The Marine Energy Council will operate as a semi-autonomous group within the NHA, and it will choose and elect its own leadership in early 2015. One of the first actions taken by the Marine Energy Council was to begin making plans for an annual conference to replace the former Global Marine Renewable Energy Conference, and to continue supporting the annual Water Power Program-sponsored Marine Energy Technology Symposium. (The Symposium has historically run concurrently with the Global Marine Renewable Energy Conference.) A new conference, called the International Marine Renewable Energy Conference, is scheduled to take place in Washington, D.C. on April 27-29, 2015.

BELGIUM

JULIEN DE ROUCK
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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. 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 ± 2400 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.

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 450 MW wind and 20 MW wave energy (rated power). This hybrid park has a water depth of 35-40 m 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 4.4 m diameter, 5 m height and 25 tonnes weight was commissioned outside the Harbour of Ostend in July 2013. The sea test ended in December 2013. Results are being analysed within PhD scholarships and master thesis. The plans and intentions for FlanSea II are currently under development.

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

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

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.
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).

PLANNED DEPLOYMENTS

Depending on the results of the FlanSea I project a possible continuation is under investigation. In this FlanSea II project the emphasis is on the development, which involves deployment of one or multiple wave energy convertors of bigger scale and/or alternative for the Power Take Off.

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 is in the long term believed to be approximately €50-55/MWh. A total income in this range 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.

Innovation Norway runs 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 runs an energy research programme called ENERGIX. This programme supports R&D within all renewable energy technologies.

For 2014, these three institutions had a combined budget of approximately €110 million.

NATIONAL SEA TEST FACILITIES

Runde Environmental Centre (REC) is located on Runde Island, off the Norwegian west coast, as a research centre with activities within marine biology, oceanography and ocean energy. REC has developed leading in-house competence on environmental monitoring, and offers Remotely Operated Vehicle (ROV) surveys, 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 (e.g. 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, licenses to build offshore wind, wave and tidal farms in certain far shore geographical areas cannot be given without a prior governmental process in which 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" were finalized in late 2012.

The licensing body NVE continues to prioritize small scale demonstration projects located nearshore according to the existing Ocean 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 European Union MARINET research network.

TECHNOLOGY DEMONSTRATION

OPERATIONAL OCEAN ENERGY PROJECTS

Havkraft AS: This Norwegian technology company is 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. In 2014, Havkraft deployed a demonstration converter with an installed capacity of 200 kW.

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 €20,7 million from NER300 for the proposed Sound of Islay project.

PLANNED DEPLOYMENTS

STRAUM: 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 redeploy the Morild II tidal prototype that at the moment is at a shipyard for repair and maintenance. For this technology STRAUM is currently performing a small scale testing programme both for the wave chamber and the air turbine (www.straumgroup.com).

Langlee Wave Power: The wave energy converter, named Langlee Robusto, is a semi-submerged, floating steel structure anchored to the seabed with four chains. 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. Langlee is planning to install a full scale prototype on Canary Islands in 2015.

Flumill: The company 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. Flumill plans to build and install a full scale grid connected demonstration system in Rystraumen. 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: has developed a “plug and go” power plant for utilization of tidal, ocean, and river currents. A demonstration version with an installed capacity of 250 kW will be tested in a tidal current and river stream in 2015. The Deep River concept builds the turbine and generator in container solutions. Using standard container size as a base makes it easy to transport and install. The power plant is fully scalable, both in amount of turbines and in size and can deliver both electricity and hydrogen.

Tidal Sails: develops and constructs 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. The company 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 the same in any scale.

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. The project is supported by Innovation Norway and Ocean Energy plans to install a demonstration at Runde (www.ocean-energy.no).

MEXICO

CARLOS ORTIZ GOMEZ
SENER

OCEAN ENERGY POLICY

Mexico has experimented relevant policy changes during this year lined up with its interest in building a sustainable future. The most important of these changes is the Energy Reform which was approved by the Congress in December 2013 and whose legal framework was promulgated on 11 August 2014. These new laws have fully opened the power sector to a free electricity market by letting private companies participate in the generation, transmission and distribution stages, making the energy industry more competitive, efficient and inclusive.
The Energy Reform also emphasizes a major inclusion of renewable energies in the electricity generation. Prove of this is the recently published Law of Geothermal Energy, and the Law of Electrical Industry which replaces the old Law of the Public Service of Electrical Energy and lays the foundations for a more sustainable industry through the acquisition of Clean Energy Certificates.
Therefore, the country has been building the accurate environment for a complete sustainable energy transition in which clean technologies like those of ocean energy will be crucial for achieving such an ambitious goal.

NATIONAL STRATEGY AND TARGETS

Although Mexico has not a specific national strategy for developing ocean energy, it has several dispositions for developing renewable energies as part of a green energy policy integrated by the National Strategy of Energy 2013-2027, which is a legal instrument that sets out the challenges for the energy sector and establishes the further actions to address them; the National Strategy for Energy Transition and Sustainable Use of Energy 2013, which is the mechanism that encourages and promotes the use of non-fossil energy sources; the Use of Renewable Energies Special Programme 2014-2018 and the Climate Change Special Programme 2014-2018.
The 10th Strategic Topic of the first governmental mechanisms mentioned before stresses the need of diversifying the energetic matrix with the purpose of reaching the 35% of the total electrical generation by 2024 with clean energy sources; a national goal that has been established in the Law of the Use of Renewable Energies and Energy Transition Funding since its promulgation in 2008 by determining a maximum participation of fossil fuels of the 65% and reinforced in the 3rd transitional article of the General Law of Climate Change promulgated in 2012.
Likewise the other documents set out the targets, guidelines and actions to boost and optimize the Mexican energy sector by disseminating the advantages of clean energy sources and encouraging public and private projects with the objective of developing a clean technology, in order to harness these resources and contribute to the Nation's sustainable development.

LEGISLATION AND REGULATORY ISSUES

There is not a specific regulation for ocean energy currently in Mexico. However, there is a law applicable to all renewable energies, the Law of the Use of Renewable Energies and Energy Transition Funding. This law regulates the renewable energies and clean technologies harnessing to generate electricity with private purposes. Likewise, it establishes the national strategy for energy transition funding. However, in case some institution or private company wanted to develop an ocean energy project, it would be necessary to review other applicable dispositions related to all factors that intervene in matters of the sea and energy.

MARKET INCENTIVES

The new regulation that was promulgated on 11 August 2014 as a result of the Energy Reform has set up a new incentive called Clean Energy Certificates (CELs). These certificates will be granted by the Energy Regulatory

Commission (CRE) and will be given to those producers that generate electricity from clean energy sources. The owners of the certificates will be able to negotiate and commercialize them as a commodity in order to potentiate its benefits. Since this is a new initiative, the operation rules have not been established, however this regulation is expected to be promulgated during the first three months of next year.

The Clean Energy Certificates were lay down by the Mexican Government as a mechanism of control and promotion of the renewables industry growth. Therefore, ocean energy developers will be suitable candidates to receive CELs because of the great potential of the Mexican territory that can be harnessed and the particular advantages of this resource.

PUBLIC FUNDING PROGRAMMES

There are three major funding sources in Mexico created to support and promote the development of renewable energies and energy efficiency projects carried on by higher education institutions, research centres and private companies with technological basis in order to encourage interesting synergies between the academy and the industry for the Nation's development and economic growth.

Energy Sustainability Fund (Fondo Sectorial Conacyt-Secretaría de Energía-Sustentabilidad Energética)

Authority: Secretariat of Energy (SENER) and National Council of Science and Technology (CONACYT)

Programme: There are several programmes with different purposes derived from this fund. The most significant are:

- Laboratory of Innovation in Energy Sustainability.
- Institutional Strengthening for Energy Sustainability.
- Mexican Innovation Centre in Ocean Energy (CEMIE Océano).

This fund was created to solve the main problem areas of the energy sector and to boost the scientific research as well as the technological development of energy sustainability. Therefore, it offers public mechanisms to encourage the academia and the industry to present proposals whose objectives match with the purpose of the fund. In this sense, in September 2014, the CONACYT and SENER made a call to research centres, higher education institutions and private companies interested in developing ocean energy technologies to integrate a consortium and form the Mexican Innovation Centre in Ocean Energy (CEMIE Océano). This call will end on 9 February 2015 and the results will be published during the next three months.

Fund: Energy Transition and its Sustainable Use Fund (Fondo para la Transición Energética y el Aprovechamiento Sustentable de la Energía FOTEASE)

Authority: Secretariat of Energy (SENER)

Program: There are not public calls to present proposals. This fund was created because of the 27th article of the Law of the Use of Renewable Energies and Energy Transition Funding with the purpose of financing integral projects that impact the energy sector and promote continuous income to renew the financial resources established for the fund.

Fund: Energy Research and Technological Development Fund (Fondo Sectorial para Investigación y Desarrollo Tecnológico en Energía)

Authority: Federal Commission of Electricity (CFE) and National Council of Science and Technology

Program: This year, CFE has published a public call through CONACYT about the design and construction of different marine energy converters technologies (CFE-CONACYT 2014 call). This fund was created to solve the main problem areas of the power sector through scientific research, technological development and innovation. Therefore, in June 2014, the CFE convened higher education institutes, research centres and private companies, through the CONACYT, to present proposals for 13 demands. There is not a winning proposal yet.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

There are several institutions and private companies interested in ocean energy technologies that have made some studies, published papers and who are designing marine energy converters and planning ocean energy projects for

the integration of the Mexican Innovation Centre in Ocean Energy (CEMIE Oceáno), the most significant public initiative for developing ocean energy in Mexico.

These institutions and research centres are:

- Instituto de Ingeniería (II-UNAM),
- Instituto Mexicano de Tecnología del Agua (IMTA),
- Centro de Investigación y de Estudios Avanzados del Instituto Politécnico Nacional - Mérida (CINVESTAV),
- Instituto de Investigaciones Eléctricas (IIE),
- Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE),
- Instituto de Ecología (IEAC),
- Instituto de Energías Renovables (IER-UNAM), and
- Centro de Ingeniería y Desarrollo Industrial (CIDESI).

Likewise, there are some private companies with technological basis that have been working in designing ocean energy systems: AXIS Ingeniería, RDZ Renewables, Sexto Sol, Energy Forever, and Grupo ENAL. Their ideas and projects are not public yet. Some of these are expected to be part of the strategic and operative plan of the Mexican Innovation Centre in Ocean Energy (CEMIE Océano), the governmental initiative that seeks to unite all the research, development and innovation in ocean energy technologies done in Mexico.

TECHNOLOGY DEMONSTRATION

PLANNED PROJECTS

There are some private companies working on different stages of the development of marine energy prototype devices. During the Workshop "Towards Marine Renewable Energy, Achievements, Challenges and Networks", organized by CICESE (Centro de Investigación Científica y de Educación Superior de Ensenada) last October, the company Energy Forever presented a wave power plant project, which consists in the design, construction and commercialization of a buoy system that converts wave power to electricity. In fact, they have already started the corresponding procedures to deploy the first prototype at the Sauzal Port of Ensenada, Baja California, in association with the Federal Commission of Electricity (CFE).

OTHER RELEVANT NATIONAL ACTIVITIES

In 2014 the following major national events related with ocean energy topics have been organized:

Event	Date & Place	Institutions	Main Objective
Towards Marine Renewable Energy, Achievements, Challenges and Networks (TMRE 14)	14 August 2014 Centro de Investigación Científica y de Educación Superior de Ensenada (CICESE), Ensenada, Baja California.	CICESE, UNAM, Universidad Autónoma de Baja California (UABC) Energy Forever, RDZ Renewables, Grupo ENAL and others.	To present and disseminate what institutions and private companies are doing towards ocean energy development in order to create possible strategic synergies.
Workshop: Opportunities for ocean energy development in Mexico, lessons learned from the European Union	8-10 October 2014 Secretariat of Energy	UK Energy Research Centre (UKERC), University of Edinburgh, WavEC Offshore Renewables, British Embassy in Mexico, CFE, CONACYT, ENAL.	To promote information exchange and discussion of collaboration opportunities.
Clarification Workshop for the Mexican Innovation Centre in Ocean Energy	2 December 2014 National Council of Science and Technology (CONACYT), Mexico City.	CONACYT, SENER and all institutions, research centres and private companies interested in being part of the CEMIE Océano.	To present the objective of the CEMIE Océano and to clarify all doubts of the interested participants.

SPAIN

JOSÉ LUIS VILLATE
TECNALIA

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

Despite the lack of financial support to all renewables in Spain, big Spanish companies such as IBERDROLA, SENER or ABENGOA and research centres such as TECNALIA continue active in the ocean energy sector. There are also some enthusiastic small companies developing and testing wave and tidal current concepts. At a regional level, there is some support mainly from the two regional governments of the Basque Country and Canary Islands. Their respective open sea test facilities, bimep and PLOCAN, are now fully prepared to install and test wave energy devices. Mutriku OWC plant in the Basque Country has now more than three years of continuous operation. There is further some initial interest in this field growing in other regions such as Andalucía and Galicia.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

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 due to the lack of support to all renewables and no specific strategic plans for ocean 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 60 MW by 2020.

LEGISLATION AND REGULATORY ISSUES

In Spain no dedicated consenting process exists for ocean energy technologies but in December 2013 a new Law on Environmental Impact Assessment was approved (Law 21/2013, of 9 December). According to it, all projects devoted to the production of energy on the marine environment are subject to be evaluated through a simplified process. In addition to this environmental law, the consenting process in Spain is based on two more legal instruments that are briefly outlined here:

- Royal Decree 1028/2007 establishes the administrative procedure for processing applications for electricity generating facilities in territorial waters. Although it focuses on offshore wind, it also includes electricity generation from other marine renewable technologies. This Decree foresees a simplified procedure governed by Royal Decree 1955/2000 regulating energy transport, distribution, commercialisation, supply and the authorisation procedure for electrical power plants.
- Law 2/2013, of 29 May, for protection and sustainable use of coastal and amending the previous Coastal Law of 1988. It provides the legal framework for occupation of the territorial sea, as well as governing issues affecting the fishing sector and safety conditions for maritime navigation.

SEA TEST SITES

The Biscay Marine Energy Platform **(bimep)**, an open sea test facility promoted by EVE in the Basque Country, has already obtained all the administrative permits for developing trials in Armintza related to waves and has started the licensing procedure for offshore wind testing. bimep is actually facing the final implementation phase. With onshore substation and the offices already finished, the test site is now ready to operate. The other test site, Mutriku Wave Power Plant, is by now ready to host testings related to new concepts of air turbines, electrical generators or control systems.

bimep test site layout

In July 2014, **IH Cantabria** and bimep signed a collaboration agreement with the aim of combining the expertise of both institutions and promoting synergies between both centres. The main objective will be the establishment of a joint and complementary scientific and technological offer, which will be focused on the technological development and the acceleration of the implementation of the marine energy in deep and very deep waters, as well as contribute to the economic development of the surrounding society.

PLOCAN offers a marine test site for ocean energy converter prototypes. The submarine electrical infrastructure is still in the design stage. It will be ready by the end of 2015 offering the required grid connection. The initial capacity is set at 15 MW with a future extension planned up to 50 MW by 2020. Main technologies under testing will be related with waves and offshore wind conversion. The PLOCAN test site was authorized by the Environmental Body of the Regional Government of the Canary Islands in April 2013 with the corresponding Environmental Statement. The authorization to reserve the marine space area to establish the test site was adopted during the Cabinet of Ministers in March 2014. The test site is extended over 23 km^2 from coast to 600 m depth.

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 has been working on several R&D projects for 10 years covering areas such as modelling and analysis of floating structures and mooring systems; hydrodynamic characterisation; structural analysis and optimisation; electric transmission and grid connection solutions; power quality and grid code compliance; materials testing and failure analysis; corrosion monitoring; O&M strategies definition; installation, commissioning and decommissioning simulations; resource and environmental impact assessment. TECNALIA applies this knowledge using a coordinated, holistic approach, focusing on the deployment of cost effective marine energy farms throughout their life cycle.

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.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

Mutriku Oscillating Water Column (MOWC) plant is an onshore testing facility. The power plant consists of 16 air chambers and 16 sets of "Wells turbines plus generator" of 18,5 kW each. The air chamber dimensions are 4.5 m wide, 3.1 m deep and 10 m high (over the Maximum Equinoctial Spring Tide Low Water). The diameter of the hole at the top is 0.75 m. The turbine gallery dimensions are 100 m long, 6.1 m wide and 5.4 m high. The plant is able to host new concepts of air turbines, electrical generators or control systems to be tested without grid-connection. Mutriku Wave Power Plant, promoted by EVE, is integrated within the breakwater of Mutriku (Basque Country) and started its operation in July 2011. Since then, it has produced more than 650 MWh.

Mutriku break water and OWC wave power plant

Wedge Global is leading UNDIGEN Project based on the industrial scale W1 device. The W1 system is an axisymmetric resonant point absorber with direct drive (linear generator) power take-off and incorporates nine years of technology development and testing. During 2014, the W1 system has been under open ocean test for five months in the Atlantic Ocean at **PLOCAN** site and additional 6 months testing at the harbour on the Canary Islands. 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**. After completion of the planned tests during 2014, and due to the outstanding performance of the system, additional tests are planned for 2015.

Installation of the Wedge Global "W1 device"

Waveport, the 4-year European funded project for demonstration of the Powerbuoy device from North American company, **Ocean Power Technologies**, was concluded in October 2014 but the device has not been tested as planned. It was built by the Spanish company **Degima** and shipped to USA.

PLANNED DEPLOYMENTS

In 2014, **OCEANTEC** made a second programme of task testing at CEHIPAR and then designed a low power prototype (40 kW) of its OWC floating device. The prototype has the main elements of the actual device with possibilities to optimize their performance in later designs. OCEANTEC plans to conduct sea trials in the years 2016-2017 to ensure the validity of the selected concept and optimize its design before having a full scale prototype (500 kW) to be tested at sea in the years 2018-2019.

Other Spanish projects under development:

- In Galicia, an experimental prototype of a wave energy device is being tested by **Norvento**.
- **PIPO Systems** is planning to install an autonomous observation and maritime surveillance device with a 5 kW wave power generator. This concept satisfies an existing demand and its development will be very useful for the optimisation of higher power systems.
- **Metalurgica Marina** is still working on the Kostalde project to develop and install a 100 kW wave energy device.
- The **Magallanes Project** aims to develop a high stability floating platform to support a 1 MW tidal turbine with currents over 1,5m/s. In 20014, the company successfully finished a test programme at EMEC.
- The PROCODAC-GESMEY consortium (the **Naval School of the Polytechnic University of Madrid, Soermar and Astilleros Balenciaga**) plans to test a 1 MW prototype of its floating tidal turbine concept designed to operate in areas of 40 meters depth.

INDUSTRIAL INVOLVEMENT

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. In Spain, IBERDROLA is partner with TECNALIA in OCEANTEC Energías Marinas.

Abengoa Seapower continues 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 mainly focused on grid and performance of marine energy devices.

SENER is an engineering and construction company backed more than 50 years' experience with capabilities in "Turnkey" Projects, and in the Design and Construction of Offshore Infrastructures and Marine Renewable Energy devices such as Wave Energy Converters and Floating Platforms for offshore Wind. SENER is in charge of the Engineering Property and Construction Management of bimep and it has also been an active partner in the OceanLider Project and other Projects related to the design of auxiliary vessels for supporting offshore Marine Farms.

OTHER RELEVANT NATIONAL ACTIVITIES

The second edition of southern Europe's largest marine energy conference will be held in Bilbao on 20 - 24 April 2015. **Bilbao Marine Energy Week,** organized by EVE, TECNALIA and the Bilbao Exhibition Centre, will attract leading agents, companies, researchers and decision-makers involved in the development of marine energy sources.

Since 2005, Bilbao has hosted a range of different international symposia on marine and offshore wind energy. Now, after almost a decade of development, these separate events have come together to form the Bilbao Marine Energy Week conference and exhibition – a week where the debate is centred on the development and future of marine energy.

Bilbao Marine Energy Week 2015

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 both in Government initiatives (e.g. one of the highest incentive for such sources worldwide) and in the research and development activities carried out by public and private players. Mainly universities and companies specialized in research and innovation are involved in R&D in this field; thanks to those efforts Italy is indeed at the forefront of research, development and demonstration at a prototypal level. Such leadership has been recently recognized by Chilean Government's economic development organization CORFO (Corporación de Fomento de la Producción); Enel Green Power (EGP) from Italy and DCNS from France have been selected to set up a groundbreaking global centre of marine energy R&D excellence in Chile, named Marine Energy Research and Innovation Centre (MERIC). MERIC's applied research and development work will focus on key sources of marine renewable energy such as tidal power and wave power.

LEGISLATION AND REGULATORY ISSUES – MARKET INCENTIVES

The Ministerial Decree on renewable energy sources (DM 6 July 2012) reviews the support schemes (until 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 source 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 not requests to enrol to the register, while in 2014 a single initiative, with capacity of 99 kW, was admitted 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	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

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Key players involved in research regarding the exploitation of marine energy to produce energy are universities. Among these, the University of Naples "Federico II" is distinguished for its GEM project started in 2003. In fact, the public/private consortium SEAPOWER Scarl (www.seapowerscrl.com), formed by a private company and the University of Naples, thanks to the collaboration between ADAG applied research group of the Department of Industrial Engineering - Aerospace Division, University of Naples "Federico II" and Eng. Nicola Giorgio Morrone, developed one of the most attractive project of the last period in the field of renewable energy production using marine sources, GEM, *The Ocean's Kite* (http://www.seapowerscrl.com/ocean-and-river-system/gem). The SEAPOWER public/private consortium is waiting for the final permit to set up and manage a real test field laboratory in the Strait of Messina opened to Italian and to foreign companies for testing their tidal current devices in the Strait of Messina. 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 a 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 tests 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 as well as shape optimization procedure in order to maximize the power output given the sea state. A 60 kW prototype is being designed to be deployed on the Italian coast in order to verify its performance in real field.

Wave tank test on 1:5 model scale of the Seapower system

R&D PROJECTS

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 the Ministry of Economic Development on the National Energy Research Set Plan, a special contract was signed (2011-2012). The partnership is formed by POLITO and ENEA aiming at the evaluation of the effective productivity of floating system for sea wave energy conversion.
▸ **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 the 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 conversion. 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.
▸ **Regional project REMOTO - Produzione di Energia da Moto Ondoso - Regione Siciliana (2013-2015):** In the frame of regional research plan (Regione Sicilia), Wave for Energy and other partners have received a grant for deployment and grid connection of a full scale device for sea wave energy conversion.

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 is studying the possible integration of wave energy production in various applications to grid connected renewable energy generation.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

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 current. 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 had already been measured on the 1:5 model during the test campaign in the naval towing tank.
A full scale prototype of 200 kW at 2.5 m/s water current speed is being designed and will be deployed in the Strait of Messina to definitively assess all the performances of the system.

GEM: Artist impression

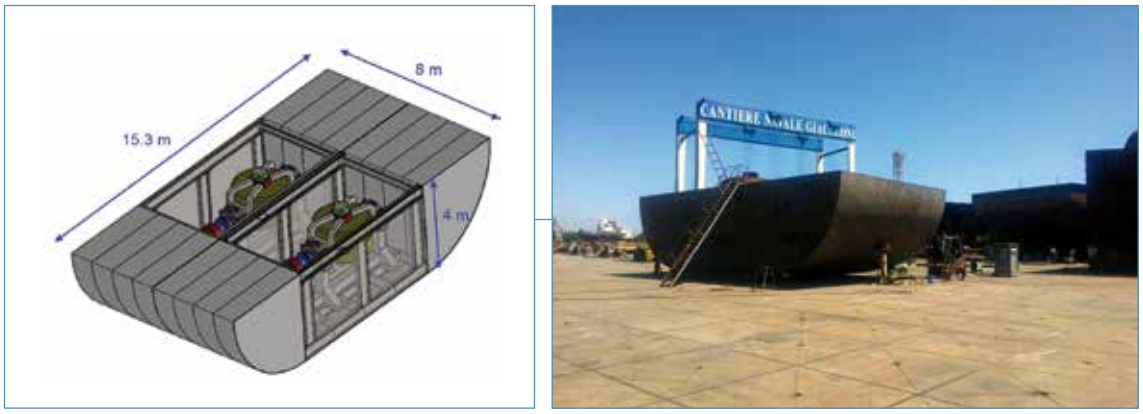
Real scale prototype

THE KOBOLD TURBINE

The "Kobold Turbine" has been developed since 1998 by ADAG Group of the Department of Industrial Engineering, 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 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.
A prototype is being built and will placed on the Lomboc Island (the island immediately at east of Bali), where it could feed energy to a small village. The Indonesian plant will have blades with 7 m length (chord 0,4 m) and 5 m diameter (intercepted area 35 m^2); the power could be about 120-150 kW.
The Ponte di Archimede company has now transferred its assets to the Horcynus Orca Foundation with the aim to leverage on the experiences gained with Kobold and the local workforce in the area to create a centre of excellence in the marine energy space.

ISWEC Project

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, 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.



Full scale ISWEC drawing (CAD) with two gyros (left) and the hull (rigth)

Trials at various levels has 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 2015.

PLANNED DEPLOYMENTS

Last june, 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 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 converter 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.
40South Energy has handled the installation and commissioning of the machine, which began to produce the first electricity. Partners will continue assessing the performance of the system in the marine environment during 2015 in light of installing the machine and connecting to the network on the Elba Island during second half of the year. 40South Energy, in its continuous efforts to strive for utilizing the marine energy resources, is also developing a 50 kW solution to install near shore and depth of 8 m within 200 m from the costal line.

OTHER RELEVANT NATIONAL ACTIVITIES

In Italy, in the year 2014 there were two workshops on Ocean energy:

- European workshop on Ocean Energy Satellite Data (OESD), organized in Rome on 30 June 2014 by the Italian Association OWEMES (Offshore Wind and Other Marine Renewable Energies in Mediterranean and European Seas) in the frame of EUSEW 2014;
- Second national workshop on the marine energies, "Energies from the sea – The new technologies for the Italian seas", organized in Rome on 1-2 July 2014 by ENEA, the Italian National Agency for New Technologies, Energy and Sustainable Economic Development.

NEW ZEALAND

CRAIG STEVENS
Aotearoa Wave and Tidal Energy Association

With a population of 4.4 million people and the world's 5th largest Exclusive Economic Zone (EEZ), New Zealand/Aotearoa is essentially a maritime nation. It also has a high proportion of renewable electricity supply already but it is highly dependent on imported transport energy. There is also limited demand for energy at present.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The NZ Government has the goal of 90% renewable electricity supply by 2025. Beyond this, the Government's overarching goal is to grow New Zealand's economy and deliver greater prosperity, security and opportunities for all New Zealanders. The Government has set four key priorities in this regard, with the Government's principal economic goal, and second key priority, being to build a more competitive and productive economy.

- The 2011-2021 NZ Energy Strategy places priority on diverse resource development, with particular focus on adoption of new renewable energy technologies under which, inter alia, the Government has a role in encouraging the swift uptake of these technologies in New Zealand and supporting the deployment of home grown energy technologies domestically and overseas.
- Commercialisation and deployment of marine energy will help meet the goal of 90% renewable electricity supply by 2025.
- The Government's foreign investment policy encourages permitted Greenfields investment.
- New Zealand Aid Programme Strategic Plan 2012-2015 focuses on sustainable economic development in the Pacific, and a more targeted approach in Asia with renewable energy as a key enabler.

LEGISLATION AND REGULATORY ISSUES

The NZ Environmental Protection Authority handle applications for marine activity offshore of the 12 nm limit under the Resource Management Act.

A recent landmark case for resource exploitation went against the applicants serving notice on the high levels of certainty required around impacts (e.g. http://www.epa.govt.nz/EEZ/trans_tasman). In shore of 12 nm exploitation applications are heard by regional authorities.

PUBLIC FUNDING PROGRAMMES

There are limited opportunities for funding specifically for marine renewable energies since the closure of the Marine Energy Deployment Fund in 2012. The energy portfolio in the Government R&D funding ministry MBIE (Ministry for Business, Innovation and Employment) has in the past funded wave energy device development projects and tidal array resource and design projects. There is a current project funded by the investigator-led Marsden Fund on large array scaling and design (PI Ross Vennell, Univ. Otago).

SEA TEST SITES

NZ-MEC is a proposed R&D and test site off the Wellington coast. It presently sits as a business case before the MBIE (Ministry for Business, Innovation and Employment). The establishment of NZ-MEC will be a catalyst to launching New Zealand's marine energy supply chain into the fast growing global marine energy fabrication and servicing industry, creating prototypes and eventually export-oriented commercial device production opportunities for New Zealand companies.

NZ-MEC will play a key facilitation role, connecting its device developer clients and their service needs with local marine energy supply chain participants such as design engineering firms, fabricators, offshore services and equipment suppliers. Identifying and exploiting niche opportunities by NZ-MEC and New Zealand's marine energy supply chain will be key to achieving this outcome.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

- NIWA – National Institute for Water and Atmospheric Research – Government-owned environmental research agency with a focus on atmospheric and aquatic environments that operates ocean-going vessels (www.niwa.co.nz).
- HERA – Heavy Engineering Research Association http://www.hera.org.nz/MainMenu
- GNS - Government-owned research agency with a focus on Earth, geoscience and isotope research and consultancy services (www.gns.cri.nz).
- Univ. Otago, Department of Marine Science http://www.otago.ac.nz/marinescience
- WELTEC https://www.weltec.ac.nz/
- AUT www.aut.ac.nz/study-at-aut/study-areas/engineering/undergraduate/maritime-majors
- Callaghan Innovation http://www.callaghaninnovation.govt.nz/

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

The big story in the technology space was the success of AzuraWave. http://azurawave.com/ The initial technology development, called Wave Energy Technology New Zealand or WET-NZ, was conducted by Callaghan Innovation (formerly Industrial Research Limited), which is a New Zealand Crown Research Institute. Since development began in 2006, the technology has advanced from initial concept to open ocean pilot testing. Recognizing the potential of the US market, NWEI began collaborating with Callaghan to further develop and optimize the technology.

Since commencing operations in 2010, NWEI and its partners have successfully completed pilot scale projects in New Zealand and Oregon, and NWEI is now preparing for a grid connected demonstration project at the US Navy's wave energy test site at the Marine Corps Base Hawaii.

Unlike other wave energy technologies, AzuraWave extracts energy from both the heave (vertical) and surge (horizontal) motion of the wave, producing power from the relative rotational motion between the hull and float. The Power Take-Off (PTO) system is based on high pressure hydraulics and is located within the PowerPod.

AZURAWAVE

OTHER RELEVANT NATIONAL ACTIVITIES

AWATEA – AOTEAROA (NEW ZEALAND)

Wave and Tidal Energy Association (www.awatea.org.nz) is relatively active for the size of the local industry. It was established in April 2006 to advocate for, assist and accelerate the development of the marine energy industry. It acts as an industry association with the following mission: "AWATEA will promote, aid and foster a vibrant and viable marine energy industry in New Zealand". The association has the following objectives:

- Promote the marine energy industry in New Zealand, including research, energy generation, marine fabrication and marine services;
- Increase recognition and utilization of marine energy as another energy source in New Zealand's supply portfolio;
- Act as a centre for advocacy of marine energy, including lobbying, drawing up submissions to Government and representing the views of the marine energy industry;
- Become an exchange for information platform about the marine energy sector, to provide and publish statistics and informed commentary on issues affecting the uptake of marine energy in New Zealand;
- Be a meeting place for marine energy industry participants;
- Represent the New Zealand marine energy industry to national bodies, including Government agencies, non -governmental organizations and other industry bodies and liaise with other international bodies.

AWATEA produced a white paper in early 2014 laying out some ideas for future development.
http://www.awatea.org.nz/information/white-paper/

SUSTAINABLE SEAS – A NEW GOVERNMENT FUNDING INITIATIVE

www.sustainableseaschallenge.co.nz/

The aim of the Sustainable Seas National Science Challenge is to enhance use of New Zealand's vast marine resources, while ensuring that our marine environment is understood, cared for, and used wisely for the benefit of all, now and in the future.

This requires a new way of managing the many uses of our marine resources that combines the aspirations and experience of Māori, communities, and industry with the evidence of scientific research to transform New Zealand into a world leader in sustainable marine economic development.

SWEDEN

MARIA OLSSON
Swedish Energy Agency

During 2014, the Sotenäs project, which is planned to become one of the largest wave energy parks in the world, progressed. The first 10 generators were put into the ocean and around 20 more are expected to be installed soon. During 2014, the Swedish Energy Agency also started a national ocean energy programme that will run for four years. The aim is to strengthen the research and development being done in the area and increase the cooperation between and within academia and industry. A first call has recently opened for academia, institutes and industry to apply.

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 20-20-20-targets, the following national target for renewable energy, reduction of carbon emission and efficient use of energy in Sweden by 2020 has 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 40 percent reduction in greenhouse gas emissions from 1990 levels;
- 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 2014 is that in 2020 the first three goals will be achieved with margin, while the last goal concerning efficient energy use is more uncertain.

In 2014, the Ministry of Enterprises, Energy and Communications continued the work on a national maritime strategy that will present actions, aiming at a sustainable development of industries related to the sea, which includes ocean energy.

In parallel, the Swedish Agency for Marine and Water Management is preparing the forthcoming national marine spatial plans. New Swedish legislation on marine spatial planning came into force on 1 September 2014. The marine spatial plans will be directional (non-binding) during the consenting process.

LEGISLATION AND REGULATORY ISSUES

The Swedish Water Law is now under review. It has been suggested that more water related activities should be made subject only to notification and not a full-permit process but nothing has been decided yet.

MARKET INCENTIVES

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 has 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 relative to production in 2012.

PUBLIC FUNDING PROGRAMMES

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 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 of 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.

The Swedish Energy Agency has currently started a national ocean energy programme that will run for four years. The aim is to strengthen the research and development being done in the area and increase the cooperation between and within academia and industry. Before forming a programme, an extensive mapping of the Swedish ocean energy sector and their needs has been carried out.

SEA TEST SITES

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.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Uppsala University

The Division of Electricity at Uppsala University conducts research on wave energy technology and hydrokinetic energy conversion from tidal, ocean currents and rivers. At the moment, the wave power research group at the Division of Electricity consists of 16 PhD students and 13 senior researchers. 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 verify research results, Uppsala University operates two research sites: Lysekil wave power research site and Söderfors marine current research site. The Swedish Energy Agency is supporting theoretical and experimental works related to the Lysekil project as well as theoretical work behind the Söderfors project.

The Lysekil project: The Division of Electricity continued the activities on real sea testing at the Lysekil research site in 2014. Preparations have been made for a 140 kVA grid connection via a 1 kV/11 kV substation near the measuring station on Härmanö. This is planned to be finished in January 2015. One wave energy converter and one low-voltage marine substation have been assembled and are waiting to be deployed at the test site when the weather allows. At the same time, three to five installed wave energy converters are planned to be connected to the substation and fitted with buoys and put into operation. The produced electricity will be consumed by loads in the measuring station on Hermanö until grid connection (including permits) is established. In November, the permission for the Lysekil test site was prolonged for 20 years. The new permission includes a large increase of the area of the test site, now covering 0.5 km^2. The new permission allows up to 20 wave energy converters, two substations and two sea cables. One of the reasons for this expansion is to further enable external actors to utilize the test site for research and testing of wave energy, and related marine technology. There is interest from both national and international organizations and companies.

Picture from the Lysekil project. WECs to the left are deployed. Substation to the right will be deployed early 2015.

The Söderfors project: The Söderfors marine currents research site is located in Dalälven River. The site has been 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 at the site consists of a fixed pitch vertical axis turbine connected to a directly driven permanent generator. During 2014 most of the work focused on the control system and the future grid connection of the energy converter.

Picture from March 2013 when the marine current energy converter was being deployed in Dalälven river

Chalmers University of Technology

At Chalmers University of Technology, Department of Shipping and Marine Technology, a research project with the title "Durability analysis of cables and moorings used in systems for harvesting of renewable ocean energy" is being carried out. The project is funded by the Swedish Energy Agency and focuses on tidal and wave energy converters and the durability analysis of moorings and cables.

The department is also involved in the VINNOVA funded project Offshore Väst. The project was initiated primarily together with the research institute SP. Offshore Väst brings together industry, research organisations and public authorities in the offshore field. One of the work packages in the project (WP2: Marine renewable energy) engages several researchers and lecturers in the department; hence work is being done both through education and research. Chalmers is responsible for work package WP4 – Offshore Academy.

SP Technical Research Institute of Sweden

SP applies its 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 commercialisation. 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 aims 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 was the project manager and coordinator.
- Strategic Innovation Agenda for Marine Electricity Production. This was conducted during 2014 and SP put together an agenda for ocean energy together with Uppsala University and Fortum.
- During 2014, SP was also involved in a project assigned by the Swedish Energy Agency, which included a mapping of Swedish ocean energy sector and their visions and needs.

SSPA Sweden

SSPA Sweden has performed development in ship design and operations within the maritime sector, in close cooperation with industry and society, over the past 75 years. SSPA is working in several areas related to ocean energy such as risk analyses before establishment, bio-fouling and countermeasures, reliable measurement methodology, wave measurement, system and hydrodynamic calculations and simulations. SSPA has three major test facilities that are well suited for marine energy testing. To carry out full scale tests at sea is often a very extensive work and involves significant costs. Before testing, the prototype stage may be performed in model scale under controlled conditions. At SSPA facilities, the generated waves and flowing water are utilized to test wave power plants, other marine energy technologies and the development of turbines.

With the help of simulation studies, SSPA has investigated the function and performance conditions for the WaveTube wave power plant. Another project involved the company Minesto, in which their underwater kite Deep Green was tested in several steps in the SSPA Towing Tank. The technique was refined and adjusted before real tests in ocean water using prototypes.

Other relevant universities are **Blekinge Institute of Technology** that has supported the company Ocean Harvesting Technologies AB with development of simulation models and facilities for the test rig as well as **KTH Royal Institute of Technology** that has supported the company CorPower Ocean AB.

TECHNOLOGY DEMONSTRATION

OPERATIONAL 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. The installed capacity is 180 kW but with a new permission to install 20 more wave energy converters which open up for external actors to test their technique. 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 the largest wave energy plant in the world. The project is in two stages, with a first 1 MW being commissioned in the first phase. 10 generators have already been put into the ocean and around 20 more are expected to be installed soon. The second, 9 MW, stage will be launched subsequent to the evaluation of the first 1 MW. 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 Agency, the power company Fortum and by Seabased Industry AB.
Seabased also signed contracts for a large wave energy plant in Ghana, totaling 14 MW and the first equipment deliveries have already been shipped.

OTHER RELEVANT DEVELOPMENT COMPANIES

There are several Swedish development companies that are progressing and are testing or will be testing their technology primarily outside Sweden. Among them are CorPower Ocean AB, Ocean Harvesting Technology AB, Minesto, Wavetube, Vigor Wave Energy AB and Waves4Power.

Minesto develops a marine current technology, Deep Green, which resembles an underwater kite with a wing and a turbine. It moves swiftly in an 8-shaped trajectory in the current. A ¼ scale prototype was deployed in 2013 in Strangford Lough, Northern Ireland, and is currently undergoing extensive long-time sea trials. The next step for Deep Green is the installation of the first commercial scale installation, a 0.5 MW power plant off the coast, in Wales, in 2017. The installation in Wales will be successively extended to a 10 MW (20 power plants) array which will eventually deliver power to over 8000 Welsh households. The proposed installation site is located off the Holyhead Island in Anglesey, Wales.

Waves4Power is a developer of buoy based OWEC (Offshore Wave Energy Converter) systems. There are plans to install a demonstration plant in 2015 at Runde test site (Norway). This will be connected via subsea cable to the shore based power grid.

CorPower Ocean AB has developed a Wave Energy Converter, inspired by the pumping principles of the human heart. Together with the Spanish power company Iberdrola and WavEC, CorPower is planning for a demonstration project in scale 1:2 during 2015.

Ocean Harvesting Technologies AB (OHT) was founded in 2007 in Karlskrona, Sweden. OHT develops a collector hub system with a patented gravity accumulator technology to smooth power captured from multiple wave power buoys connected to the hub before electricity is generated.
In 2014, new simulation models were developed and integrated with simulation models from Waves4Power and CorPower, in order to evaluate the technical fit and potential performance advantages from combining these different technologies. This project is supported by the Swedish Energy Agency and OffshoreVäst. The next planned activities are focusing on design and test of the power take-off design including the gravity weight accumulator in a test rig.

Wavetube is a Swedish wave power startup that was founded in 2012 in collaboration between Chalmers University of Technology and Encubator AB in Gothenburg. The wave power solution is based on a completely sealed system with three interconnected compartments that float on the ocean sea surface. The system is filled with freshwater that flows back and forth as the system moves. On its way it passes turbines that are coupled to generators that produce electricity. Wavetube has performed a wave basin trial at Aalborg University and a second round is currently being performed at Queen's University Belfast and their marine laboratory facility in Portaferry, Northern Ireland. The next planned activities are more wave tank trials followed by sea trials for a scale model.

Vigor Wave Energy AB is in the process of developing its wave energy technology. The company has its own 50m wave tank where the technology has been tested. The next planned activities are to take the technology from the lab to the marine environment and generate results that can verify the simulations.

OTHER RELEVANT NATIONAL ACTIVITIES

The former ocean energy centre, OEC, which was a network between ocean energy companies and R&D institutions, has almost faded out. However there are plans to establish a similar one again and also include offshore wind in it. Offshore Väst, which has been mentioned before, gathers several companies, universities, institutes and authorities in projects supporting the offshore sector in Sweden.
Relevant conferences taking place in Sweden are the Swedish Maritime Day and StandUp for Energy. Swedish Maritime Day gathers stakeholders from academy, industry and the public sector. The conference is not only focused on offshore energy but also in areas like shipping, biotechnology, marine environment etc. StandUp for Energy is a research alliance between Uppsala University, KTH, Swedish University of Agricultural Sciences and Luleå University of Technology, focusing on areas such as renewable energy production (marine energy included), electricity grid, electric and hybrid vehicles and energy system. Conferences are held every year and are attended by companies and policy makers.

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.

REPUBLIC OF KOREA

KEYYONG HONG, HOYOON KIM
Korea Research Institute of Ships and Ocean Engineering

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The strategic plan of ocean energy development of the Republic of Korea (ROK) used to be based on "The 3rd National Plan for Technology Development, Use and Diffusion of New and Renewable Energy," which includes the national vision, long term goal, strategy, and action plan for new and renewable energy development for the period of 2009 to 2030. The goal for ocean energy distribution was forecasted to reach 4.7% in 2030, but the newly updated "The 4th New and Renewable Energy Master Plan 2014-2035", released in September 2014, has significantly lowered the goal to 1.6% until 2025, and 1.3% in 2035. Although the distribution goal for ocean energy was lowered down to 1.6%, the 2nd National Energy Master Plan states that the overall distribution goal for new and renewable energy increases. It was pointed out that ocean energy had difficulty in reaching its original goal due to stronger restriction towards environmental protection and reluctance of local residents.
The Ministry of Oceans and Fisheries (MOF) has published the "Mid-Term and Long-Term Clean Ocean Energy Development Plan 2016-2025" in order to review the ocean energy development technology area of ROK. Its main purpose is to set up a relevant R&D support plan based on the observation and seek more efficient roads towards renewable energy distribution. Meanwhile, MOF is updating the ocean energy R&D roadmap, which is to be released in 2015, where they plan to:

- Enhance the infrastructures and accelerate commercial development;
- Plan open sea testing facilities for wave and current devices;
- Collaboration with South Pacific islands for OTEC.

LEGISLATION AND REGULATORY ISSUES

Currently, there is no explicit legislation and regulation dedicated to ocean energy alone, but there are national acts for renewable energy development overall. There is the "Framework Act on Low Carbon, Green Growth", and the "Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy." Also there is the "Energy Act" for national acts on energy and various regulatory measures for marine environment protection such as the "Framework Act on Marine Fishery Development" and the "Marine Environment Management Act."
However, based on the "Act on the Promotion of the Development, Use and Diffusion of New and Renewable Energy", the Ministry of Trade, Industry and Energy (MOTIE) can enforce obligatory appliance of renewable energy resources for public buildings. As ocean thermal energy for air conditioning is approved to be one of the renewable energy resources, it is currently under the process of testing the actual use of ocean thermal energy powered air conditioning before its actual utilization. Public buildings are called up for the test until January 2015.

MARKET INCENTIVES

The Renewable Portfolio Standard, or the RPS, was initiated in 2012 and was enforced in 13 utility companies with capacity over 500 MW. According to the regulation, 3% of the total electricity production was from renewable energy in 2014.

The tradable Renewable Energy Certificate (REC) is a policy that supplements the RPS policy. The value of REC policy varies depending on the type of generated resource and other factors such as distance from coastline, capacity or installation method. For instance, the REC of a tidal barrage with embankment is 1.0, while the one without embankment is 2.0. REC has not been determined for other ocean energies yet. However, the ocean thermal energy for air conditioning purposes is currently under the process of becoming an obligatory method for public buildings.

PUBLIC FUNDING PROGRAMMES

The main funding institutions are MOF and MOTIE. The public funding for renewable ocean energy is led by the combination of the two government ministries above mentioned, which operate the national RD&D programme for ocean energy. MOF funds mainly demonstration projects under the "Practical Ocean Energy Technology Development Programme," while MOTIE is in charge of the fundamental R&D projects under the "New and Renewable Technology Development Programme". Participation of private sectors has been continuously increasing in ocean energy development sector recently as well.

The education programme for training professional human resources in the ocean energy development sector is soon to be launched in ROK. It is the second step of Ocean Energy Human Resources Development Research carried out by the Korean Institute of Marine Science & Technology Promotion (KIMST). After the first phase of the project was carried out from 2009 to 2013, the project entered its second phase from 2014 to 2018. While the first phase concentrated solely on the field of ocean energy, the second phase expanded the realm to include the study of offshore plants, or the field of ocean energy infrastructures. Two institutes of Inha University and Korea Maritime and Ocean University have been selected as recipients of the programme and will carry out specialized education courses, R&D, and scholarship programmes for students, each concentrating on ocean energy and offshore plants.

SEA TEST SITES

The sea test sites are currently being planned, but there is no active sea test site that is open for use in ROK. However, a feasibility study for the construction of test beds for wave and tidal energy devices has been carried out, and also there are plans to utilize the newly built demonstration ocean energy plant sites as possible sea test sites. The areas that are suggested to be used as test beds include the Uldolmok tidal power plant, Yongsoo OWC wave energy plant on Jeju Island, and Goseong ocean thermal energy plant.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Tidal energy RD&D institutions and projects

Project (Charged by, Funded by)	Type of Converter	Structure	Power Capacity	Project Period	Remarks
MW Class Tidal Current Device (HHI, MOTIE)	Pitch Control	Pile	>2X500 kW	2010-2015	Sea Test in 2014
Hydraulic Turbine for Tidal Barrage (HHI, MOTIE)	Bulb	Caisson	7 MW(Develop) 30 MW(Design)	2011-2014	Applicable to Hydraulic Dam
Flexible Turbine for Tidal Current (KIOST, MOTIE)	Oscillating Hydrofoil	Pile	10 kW	2011-2014	Efficiency > 26%

Active Control Tidal Current System (KIOST, MOF)	HAT with Pitch Control	Varying by Water Depth	200 kW	2011-2017	Sea Test in 2016
Semi-active Flow Control Turbine (Inha Univ., MOTIE)	HAT with Flow Control	Moored Submersible	10 kW	2013-2016	Based on CFD
Active Impeller Tidal Turbine System (Daum Eng., MOTIE)	Vertical Impeller with Flow Control	Pre-cast Concrete	50 kW	2013-2016	Sea Test in 2016

MOF: Ministry of Oceans and Fisheries
MOTIE: Ministry of Trade, Industry and Energy
HHI: Hyundai Heavy Industry Co., Ltd.
KISOT: Korea Institute of Ocean Science and Technology

Wave energy RD&D institutions and projects

Project (Charged by, Funded by)	Type of Converter	Structure	Power Capacity	Project Period	Remarks
Yongsoo OWC with Dual System (KRISO, MOF)	OWC with Impulse Turbines	Gravity Caisson	2X250 kW	2003-2015	Pilot Plant in 2014
Resonant Vertical Oscillator (Gyeongju Univ., MOTIE)	Point Absorber	Single Point Moored Buoy	-	2010-2014	Prototype Test in 2013
Pendulum WEC Utilizing Standing Waves (KRISO, MOF)	Oscillating Surge	Floating Twin Hull	300 kW	2010-2016	Sea Test of Pilot Plant in 2015
Cross-flow Hydraulic Turbine (KMOU, MOTIE)	Wave Induced Flow	Moored Floating Hull	-	2011-2014	Sea Test in 2014
Swinging Semi-Sphere with Hinged Arm (Hwa Jin Co., MOTIE)	Floating Point Absorber	Jack-up Platform	Expandable 15 kW Units	2013-2016	Sea Test in 2016
Controllable Resonant WEC with Yoyo Oscillator (iKR, MOTIE)	Point Absorber with Variable Spring Stiffness	Moored Array of Cylinders	10 kW	2013-2016	Sea Test in 2016
WEC for Navigational Lighting Buoy (KPM, MOTIE)	Point Absorber with Solenoid	Single Point Moored Buoy	50 W	2013-2016	Sea Test in 2016

iKR: Innovation KR
KPM: Korea Plant Management Company
MOF: Ministry of Oceans and Fisheries
MOTIE: Ministry of Trade, Industry and Energy
KMOU: Korea Maritime and Ocean University
KRISO: Korea Research Institute of Ships & Ocean Engineering

OTEC, salinity gradient & other ocean energy RD&D projects

Project (Charged by, Funded by)	Project Period	Remarks
Promotion Programme for Ocean Energy Education (KIMST, MOF)	2009-2018	MOF programme promoting ocean energy education, research and development in universities
OTEC Using Deep Ocean Water (KRISO, 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
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
Hybrid OTEC Using Plant Array (KEPRI, MOTIE)	2011-2015	Use of cooling water discharged from power plant Pilot plant of 10kW in 2015
Establishment of Infra System for Ocean Energy (KAIST, MOTIE)	2011-2016	Education programme for ocean energy experts in graduate school
Standardization of OTEC (KR, MOTIE)	2012-2014	Development of international standards for design and evaluation of ocean thermal energy utilization system
Low Temperature Working Fluid and Radial Flow Turbine for OTEC (KMOU, MOTIE)	2013-2016	Design of organic Rankine cycle radial flow turbine for 200kW OTEC using low temperature working fluid
Key Technologies of RED Stack for salinity gradient utilization (KERI, MOTIE)	2014-2017	Development of reverse electro dialysis stack and optimized ion exchange membrane for kW-class salinity gradient power generation
Education Programme for Training Professional Human resources in Ocean Energy Devices and Offshore Plants (Inha Univ. KAIST)	2014-2018	Reformation of the education process for training top level technical professionals in ocean energy department

MOF: Ministry of Oceans and Fisheries
MOTIE: Ministry of Trade, Industry and Energy
KIMST: Korea Institute of Marine Science & Technology Promotion
KAIST: Korea Advanced Institute of Science and Technology
KEPRI: Korea Electric Power Research Institute
KERI: Korea Energy Research Institute
KMOU: Korea Maritime and Ocean University
KR: Korea Register of Shipping
KRISO: Korea Research Institute of Ships & Ocean Engineering

TECHNOLOGY DEMONSTRATION

OPERATIONAL OCEAN ENERGY PROJECTS

The 500 kW Oscillating Water Column (OWC) plant in Yongsoo, Jeju Island, is being installed in Jeju since 2012. The plant, which is developed by KRISO and funded by MOF, is equipped with a couple of turbines and generators of 250 kW capacity and is located 1km away from the coastline. It is currently going through an on-going inspection for grid connection by the 22.9 kV AC underwater cable. The construction of the demonstration OWC plant has recently been completed, in November 2014, and will start operating in March 2015.

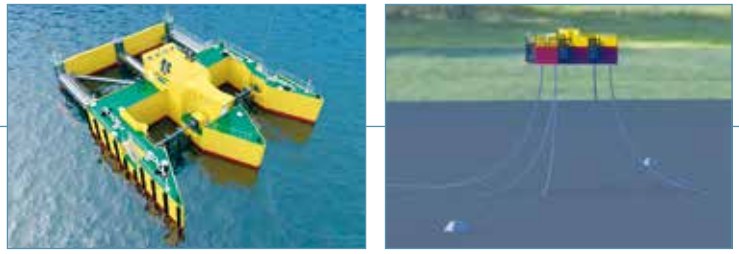
500 kW OWC plant of Jeju Island

The 200 kW High Temperature-Difference Ocean Thermal Energy Conversion (H-OTEC) by KRISO in Goseong was completed in December 2014 and is expected to be utilized within 1~2 years. Unlike the previous OTEC which used the temperature difference between surface water of 20~35°C and deep sea water that maintains 2°C, the H-OTEC utilizes heat source generated from other power generation facilities, reaching up to 75°C. This allowed the newly installed H-OTEC to be highly efficient and it is expected to generate 1,580,000 kW a year for 70 households, saving 339 TOE of oil, and 742 tons of CO2.

200 kW H-OTEC in Goseong

PLANNED DEPLOYMENTS

The project targeted technical development and demonstration of a pendulum-activated, high-efficiency and high-persistence 300 kW floating wave energy converter (WEC) with an operating capacity applicable to deep sea conditions. The process of actualizing the 300 kW pendulum wave energy converter is being continued by KRISO and MOF, and has currently secured its source technology and completed its detail design in 2014. The development project started in 2010 and is expected to end by 2016.



300 kW floating wave energy converter of KRISO

OTHER RELEVANT NATIONAL ACTIVITIES

Solar, Wind & Earth Energy Trade Fair (SWEET) is a specialized fair on new and renewable energy. This annual fair was first held in 2006 and has grown in size and number of participants, as it held 194 companies from 14 countries in 2014. The main focus of the fair is to support the investment plan for new and renewable energy industry of ROK and provide opportunity for participants of worldwide companies and experts specialized in new and renewable energy, where they can exchange ideas and information. Among various classifications of new and renewable energy, the exhibition contains tidal power generation, wave power generation, and OTEC.

CHINA

DENGWEN XIA
National Ocean Technology Centre

In 2014, the Chinese Government released the Strategic Action Plan for Energy Development (2014-2020), providing details on a set of measures that will enable China to meet its 2020 target, that is, to build a clean, efficient, safe and sustainable energy supply system. As a promising Renewable Energy (RE), the development of Marine Renewable Energy (MRE) was emphasized to contribute to the optimization of energy structure. The Ministry of Science and Technology (MOST) of the People's Republic of China began to develop the RE technology development strategy (to 2020), considering three key missions for MRE. The State Oceanic Administration (SOA) released the Outline of Marine Renewable Energy Development (2013-2016), in December 2013, focusing on the design and building of two demonstration bases in rich MRE resources areas and national test sites for MRE by 2016. The new round of Special Funding Programme for MRE (SFPMRE) sponsored by the Ministry of Finance (MOF) and SOA initiated. Additionally, the National Development and Reform Commission (NDRC) released the Notice on Feed-in Tariff (FiT) for offshore wind power in June 2014 to support the development of Chinese offshore wind power.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The Strategic Action Plan for Energy Development (2014-2020) was released by the State Council of the People's Republic of China on 7 June 2014. The optimization of the energy structure was put forward as one of the five missions, depending on the reduction of coal consumption and the increase of natural gas, safety development of nuclear energy and advancing the development of RE. By 2020, China aims to control the total primary energy consumption at 4.8 billion tons of standard coal and the total coal consumption at 4.2 billion tons of standard coal. The proportion of non-fossil energy consumption in primary energy consumption would be raised to 15%. China will basically form a clean, efficient, safe and sustainable energy supply system.

SOA released the Outline of Marine Renewable Energy Development (2013-2016) in December 2013, with key missions such as breakthrough key MRE technologies, improve devices technology readiness levels, build demonstration projects, construct public service for MRE industrialization and enhance the MRE resources zoning in China. In the future 3 years, two demonstration bases will be built in rich MRE resources areas for fostering industrialization.

MOST is developing a RE technology development strategy (to 2020), considering three key missions for MRE, that is, design and manufacture of MWs tidal current energy turbine, modular design and manufacture of 100 kWs wave energy devices, and research and demonstration of environment-friendly technology for tidal range energy, respectively.

LEGISLATION AND REGULATORY ISSUES

There are no additional changes in the current Chinese legislation regarding ocean energy, which is defined as the "Renewable Energy Law of the People's Republic of China (Amendment)" implemented in April 2010.

MARKET INCENTIVES

The notice on FiT for offshore wind power was released by NDRC in June 2014, according to which the FiT for non-binding offshore wind power projects is RMB 0.75-0.85 before 2017, and for licensed offshore wind power projects cannot be higher than the above mentioned prices.

PUBLIC FUNDING PROGRAMMES

In 2014, the SFPMRE by MOF and SOA entered in the sixth year. The total amount of financial support reached around RMB 800 million. More than 90 MRE projects were supported.

SEA TEST SITES

On 6 Nov 2014, NOTC and Weihai municipal government, Shandong Province, signed an agreement on the construction of a national small scale test site. With the support of SOA and Weihai City, a 5 km^2 sea area was authorized for 40 years free use of the test site. The design work was accomplished and the construction work will be initiated.

Additionally, two full scale MRE test sites have been planned, one will be located in Dawanshan, in Guangdong Province, for wave energy, the other will be on Zhoushan Islands, in Zhejiang Province, for tidal current energy.

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

Tidal range energy

Hydro China Huadong Engineering Corporation: The cooperated project for dynamic tidal power (DTP) was listed as one of the energy development cooperated projects between China and Netherlands in May 2014. After preliminary investigation and site selection by Huadong Engineering Corporation, Dongshan Island in Fujian Province was selected as one of the best sites for DTP utilization.

Tidal current energy

Zhejiang University (ZJU): ZJU turbine (60 kW) is a semi-direct drive floating horizontal axis turbine, which was co-sponsored by the 1st round of SFPMRE and National High-tech R&D Programme (863 Programme). The ZJU turbine was deployed near Zhairuoshan Island for sea trial in May 2014. During the sea trial, the maximum output power has reached 31.5 kW and the conversion efficiency is 0.371. Now, Guodian United Power Technology Co. has initiated the development of a new 300 kW turbine based on ZJU turbine.

Harbin Engineering University (HEU): Haineng I (2×150 kW) floating vertical axis turbine with 0.8m/s of cut-in speed, co-sponsored by 863 Programme and National Key Technology R&D Programme, has been suspended after several months of sea trial for mechanical failure (the one on the right in the figure below). **Haineng III** (2×300 kW) floating vertical axis turbine with 1.2m/s of cut-in speed, was supported by the 1st round of SFPMRE. Haineng III (the one on the left in the figure below) has been deployed for sea trial in Guishan Channel since December 2013 and hit by several typhoons, with total conversion efficiency of 30%.

Zhejiang Zhoushan LHD New Energy Corporation Limited (LHD): LHD L-1000 (4×300 kW) turbine project obtained RMB 19 million support from the 4th round of SFPMRE in 2013. The project completed the site selection and obtained the consent of local government in July 2014. The infrastructure and the design of the turbine were completed.

Wave energy

Guangzhou Institute of Energy Conversion (GIEC) of Chinese Academy of Sciences (CAS): Sharp Eagle I (10 kW) floating wave energy converter was firstly deployed for test in December 2012, and redeployed near Wanshan Island in July 2013 after maintenance. By 30th April 2014, Sharp Eagle I had been running for nearly 6000 hours accumulatively, with total conversion efficiency of 16.76%. With the support of the 4th round of SFPMRE in 2013, GIEC and China Shipping Industry Co. are jointly developing 100 kW device based on Sharp Eagle I.

Jimei University (JMU): Jida I (10 kW) floating wave energy converter sponsored by the 1st round of SFPMRE in 2011, was deployed near Xiaodeng Island for sea trial in May 2014. The average output power was about 600W under the wave height of 0.3 m, the maximum instantaneous output power is 1.56 kW.

China Shipbuilding Industry Corporation 710 Institute (CSIC 710): Hailong I (150 kW) converter, suspended sea trial for maintenance after 2 months of test in September 2014.

NOTC: FLB (2×50 kW) bottom-mounted flap-type converter was firstly deployed in June 2012 and endured the hits of typhoon, validating good reliability, with total conversion efficiency of 14%. With the support of the 4th round of SFPMRE, NOTC and Qingdao Haina Heavy Industry Co. are optimizing a new 50kW converter.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

Jiangxia Tidal Power Plant was built in 1980 and is owned by China Longyuan Power Group Co., affiliated to China Guodian Corporation since 2003. Jiangxia station is the largest tidal power station in China. There are totally 6 bulb turbines of 3 types, and the installed capacity is 3.9 MW. In the support of the 3rd round of SFPMRE in 2012, the upgrading project (from 3.9 MW to 4.1 MW) is ongoing; the new turbine would be assembled in the beginning of 2015.

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 reasonable planning of the tidal power plant will not cause serious siltation of the cove, nor have a significant environmental impact on local marine ecological environment.

Zhaitang Island Hybrid Power Station has been in operation since June 2013 and provided electricity for residents on Zhaitang Island. There are 300 kW tidal turbines, 150 kW wind turbines and 60 kW solar panels totally. Haineng II (2×100 kW) floating TEC (by HEU) was retrieved for the crack of blades, Haiyuan (2×50 kW) fixed TEC (by OUC) was retrieved for leakage problems.

PLANNED DEPLOYMENTS

Shengshan Island Hybrid Power Station: will provide electricity and fresh water for residents on Shengshan Island. In total, there are 300 kW wave energy converters (FLB), 150 kW wind turbines, 50 kW bioenergy device and 25 kW solar heat panels. FLB (3×100 kW) has been assembled.

Wanshan Island Hybrid Power Station: includes 300 kW WEC and 200 kW wind turbines. The controlling room has been built and the wind turbines have been installed. The ½ scale prototype for the 100 kW WEC (Sharp Eagle) has been tested and the model test of full scale prototype has been completed.

OTHER RELEVANT NATIONAL ACTIVITIES

China Association of Oceanic Engineering (CAOE): The opening ceremony of MRE Branch of China Association of Oceanic Engineering (CAOE) was held on 26th December 2013. This is the first association for collaboration among researchers, device developers, service providers, maritime engineering and stakeholders to foster the development of MRE industry in China. More than 130 members of 49 organizations affiliate to the branch.

SAC/TC546: On 25 April 2014, the National Technical Committee on Marine Energy Converters of Standardization Administration of China (SAC/TC546) was established, and is in charge of the establishment and revision of national standards for marine energy converters, and the coordination with IEC/TC114.

3rd China Marine Renewable Energy Conference: The 3rd China Marine Renewable Energy Conference (CMREC) hosted by NOTC and the Administrative Centre for Marine Renewable Energy (ACMRE) was held on 28th May 2014 in the city of Harbin, Heilongjiang Province. The theme of the annual conference is “breaking through technology, equipment development, boosting the blue energy industry”. More than 350 participants from central and local governments, universities, institutes, industries and stakeholders participated in the conference.

OI China: The 2nd Oceanology International China exhibition was held in Shanghai on 3-5 September 2014.

NIGERIA

LAWRENCE AWOSIKA
Nigerian Institute for Oceanography and Marine Research

The Nigerian Institute for Oceanography and Marine Research (NIOMR) in collaboration with FOT-K Consortium are 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.

The draft policy direction/roadmap on the ocean energy activities in Nigeria is currently been considered by the Federal Government of Nigeria. The government is also considering setting up an ocean energy activity centre, the 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

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 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.

SINGAPORE

NARASIMALU SRIKANTH[1], MICHAEL L. S. ABUNDO[1], MARY ANN JOY QUIRAPAS[1], PAVEL TKALICH[2]
[1]*Energy Research Institute @ Nanyang Technological University (ERI@N)*
[2]*Tropical Marine Science Institute (TMSI), National University of Singapore*

Despite being a small country, Singapore has significant interest in renewable energy RD&D. Noteworthy milestones in Singapore's Ocean Renewable Energy (ORE) activities include the development of various marine renewable energy test bedding sites, and collaborative projects between academic research institutes and industry, all of which benefit from the support of public agencies.
Evidence of this collaboration is seen through the establishment of the Renewable Energy Integration Demonstrator-Singapore (REIDS), an initiative led by Nanyang Technological University (NTU) and supported by the Singapore Economic Development Board (EDB) and National Environment Agency (NEA), which will be the first hybrid micro-grid in the tropics. REIDS will test and demonstrate the integration of different renewable energy sources including wind and tidal and ensure these energy sources operate well together.
At the regional level, the Southeast Asian Collaboration for Ocean Renewable Energy (SEAcORE) was initiated by ERI@N with partners from Southeast Asia to promote renewables and create new markets for partner industrial firms (ERI@N Report, 2012-2014). The Asian Centre for Energy (ACE) has recognised ERI@N's efforts in creating the SEAcORE network, making it its official technical working group on ORE in the Southeast Asia region.
On the commercial front, developments in tidal energy have been championed by Atlantis Resources Corporation whose headquarters are located in Singapore with sizable projects around the world; wave energy efforts have been spearheaded by Hann-Ocean Pte Ltd, which has developed the Drakoo (Dragon King of Ocean) wave energy converter for commercial deployment in Singapore waters.
While the technical and economic feasibility of ocean energy in Singapore waters is still being studied, a number of projects, currently in various stages of completion, are being carried out countrywide. These projects, together with the enabling ecosystem of Singapore, form the basis of this report.

OCEAN ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

To further enhance the energy efficiency across all sectors of the Singapore economy, Singapore aims to "achieve a 35% reduction in economy-wide energy intensity by 2030 (i.e. the amount of energy required to produce each S$GDP) (NCCS, 2012). Singapore is determined to embark on energy efficiency measures to achieve this national target.
With regards to policy tools for Renewable Energy (RE), the Government has set clear rules on the deployment of RE, and provided support to attract RE investments to develop Singapore to be the Research and Development (R&D) centre for RE in the region (IPSOS Consulting, 2012). To that end, the Government has been supporting RE-related RD&D projects through Government grants and other local funding schemes. These also include efforts to aid the industry's capability of developing potentially promising renewable technologies in Singapore.
Singapore has made significant investments in research and innovation in the sustainability domain. Since 2011, Singapore has announced more than S$800 million of new public sector R&D funding for energy, water, green buildings and addressing land scarcity, a national strategic imperative for a small island[3].

RELEVANT LEGISLATION AND REGULATION

The Energy Market Authority (EMA) continues to proactively enhance Singapore's market and regulatory framework so as to facilitate the deployment of RE sources. For example, in July 2014, EMA issued a Final Determination Paper, making several enhancements to the market and regulatory framework for intermittent generation sources, such as solar energy.

The Final Determination Paper on Enhancements to the Regulatory Framework for Intermittent Generation Sources (IGS) in the National Electricity Market of Singapore (Energy Market Authority) deals with the feedback from different industry players (specifically on solar), electricity market licensees, companies and the public on how to improve the handling of IGS in Singapore.

RESEARCH & DEVELOPMENT

The Energy Research Institute at the Nanyang Technological University (ERI@N), inaugurated in June 2010, is supported mainly by the Economic Development Board (EDB) to develop industry oriented innovations and train specialists in clean energy. ERI@N focuses on areas such as wind and marine renewables, green buildings, e-mobility, energy storage and fuel cells, and has been actively leading efforts related to ORE for Singapore and beyond.

ERI@N's dedicated Wind & Marine Team forms the core group that serves as the ember for Singapore's ORE RD&D. Among the key research, development, and demonstration efforts of the team are the following: 1) Ocean Energy (e.g. Tidal Currents, Wave) Resource Assessment in Singapore and Southeast Asia, 2) Ocean Energy Test Bedding Activities (e.g. Sentosa Tidal Test Site, Tanah Merah Wave Energy Test Site), 3) Advanced Materials and Coatings Development, 4) Renewable Energy Integration Demonstrator-Singapore (REIDS) - Offshore and 5) Standards Formation for ORE.

ORE is now among the emerging fields in the Singapore Maritime Institute's R&D 2025 roadmap (SMI, 2014). SMI will closely track developments on the following ORE aspects: "tidal energy, study of tidal patterns, offshore support (installation) vessel, transportation of energy back to land and integration of RE to the existing power grid."

GOVERNMENT FUNDED R&D

The Singapore Government has awarded S$15 million worth of research grants to develop energy generation and micro-grid systems to researchers in the country (Economic Development Board, 2014). This funding initiative aims to promote interdisciplinary and commercially relevant R&D in the energy sector. One of the projects funded is the DG-TISE: Flexible Distributed Generation Using Tidal In-stream Energy System for Remote Island Applications by ERI@N's Wind and Marine Renewables Team. This project aims to develop "a novel sensing and signal analysis system which will provide a tidal energy resource measurement method to account for the geographical sea bed conditions and tidal current measurements". Subsequently, a turbine will be developed for tropical sea waters, which have lower tidal flows than tidal energy hotspots such as Canada and the northern European regions.

Besides this grant, a number of ERI@N's on-going projects that have the government agencies' support are detailed below. Aside from ERI@N, the Tropical Marine Studies Institute (TMSI) of the National University of Singapore (NUS) has also done studies on the marine renewable energy research and development ecosystem; the Danish Hydraulic Institute (DHI) also supports marine renewable value chain in Singapore and beyond.

Tidal In-Stream Energy (TISE) Resource Assessment in Singapore

A macro level tidal in-stream energy assessment in Singapore waters has been done by ERI@N using data from the TMSI. Theoretically, the available Tidal In-Stream Energy (TISE) potential of Singapore is about 3 TWh annually. Technically, the extractable energy with today's TISE harvesting technology (capacity factor of around 30% to 40%) is about 900 to 1,200 GWh/year. Practically, the limit of extractable energy from Singapore waters, without damaging the environment (using a Significant Impact Factor of 10%-20%), is about 300-600 GWh per year. The actual potential will need to be determined through a detailed resource assessment and environmental studies.

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3 More information can be found on http://www.edb.gov.sg/content/edb/en/industries/industries/alternative-energy.html

Candidate sites where the tidal in-stream potential is relatively high and site characteristics (depth, navigation & shipping traffic, etc.) are technically suitable (subject to permitting and consenting requirements) have been mapped. Together with the Technical University of Munich (TUM) Campus for Research Excellence and Technological Enterprise (CREATE) Centre in Singapore, ERI@N has estimated that a total installed capacity of 250 MW of tidal power leads to achievable CO^2 emission reduction of roughly 250 kt/year (or 1.5 %) for electricity production and the calculated marginal abatement cost is about S$75 /tCO2.

Sentosa-ERI@N Tidal Test Site

Supported by Ministry of Trade and Industry's Core Innovation Fund, a joint collaboration between Sentosa Development Corporation (SDC) and ERI@N has been set up. This Sentosa Tidal Test Site project aims to build up the competency of R&D in NTU and Singapore on the harvesting of tidal energy, by providing the opportunities to develop local technologies able to harness the energy available in the narrow channel between Singapore and Sentosa. The Sentosa tidal project aims to showcase tidal energy extraction as a feasible and sustainable energy generating technology in Singapore. The location selected was the water passage between mainland Singapore and Sentosa Island.

The project commenced with an in-depth energy assessment of the region where the device was to be situated. After the energy potential of various locations was studied, the team, taking into account deployment factors and accessibility, determined the final location where the device could be located.

The final design shown below was based on a high solidity aerofoil design with measured power coefficient (Cp) around 0.35. Construction of the floating platform is completed and the 1/3 scale (0.5 kW) turbine shown in Figure 1 was installed in March 2013. In November 2013, ERI@N and SDC officially launched the Sentosa Tidal Test Site (NTU, 2013).

Floating hinged turbine support frame (Left) & Scaled (1:3) tidal turbine in tow tank (Right)

Marine Renewable Energy at Tanah Merah Ferry Terminal

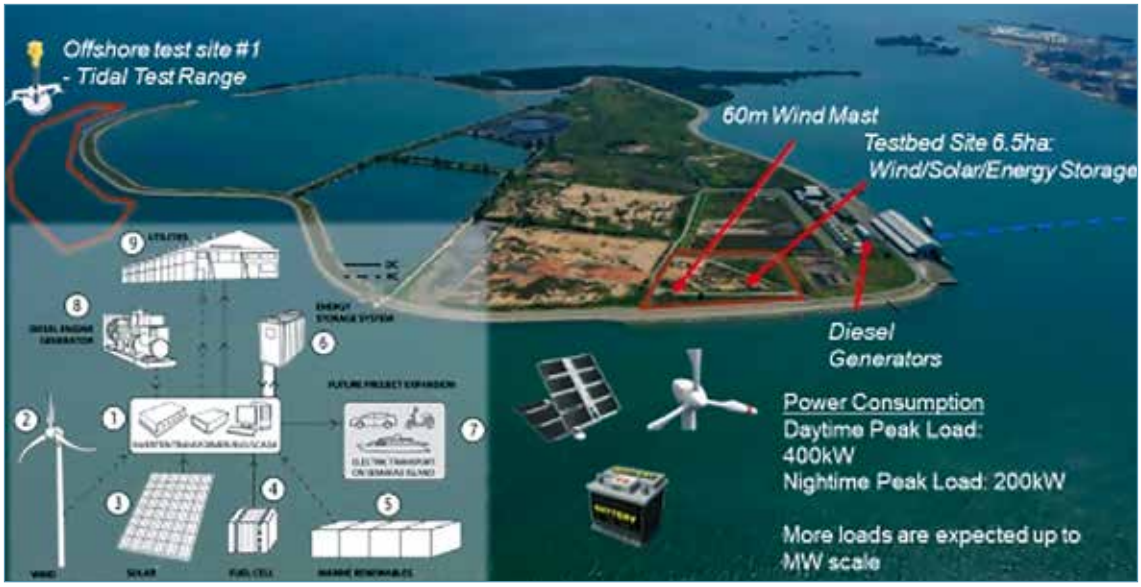
The ERI@N Wind and Marine Renewables Team has also embarked on the Tidal-In Stream and Wave Energy Resource Assessment project that includes a feasibility study, device development and prototype installation at Tanah Merah Ferry Terminal in Singapore. This project has been funded under the Maritime Clean Energy Research Programme (MCERP) between the Maritime Port Authority (MPA) and NTU.

The project aims to investigate the potential marine renewable energy sources available at Singapore's jetties. Together with Singapore Cruise Centre which operates a number of ferry terminals including Tanah Merah Ferry Terminal, ERI@N's Wind and Marine Team performed a resource assessment of the marine renewable energy that can be harnessed in a terminal or jetty setting. The tidal energy potential (using tidal barrage technology) at the terminal is 36 MWh/year with a pool area of 18,000 square meters. The wave energy potential is at least 28 MWh/year for a 100 m capture line.

ERI@N envisions that energy harvested from marine renewables in such ports/jetties in Singapore can result in (1) self-powered jetties/ports, (2) provision of excess power to nearby installation, and (3) shore power to berthing boats.

Renewable Energy Integration Demonstrator-Singapore (REIDS)

REIDS will be the first hybrid micro-grid in the region which will incorporate power generation from different renewable energy sources, including solar photovoltaic (PV), wind, tidal-current, diesel, storage and power-to-gas technologies, and ensure these energy sources operate well together (NTU, 2014). The micro-grid will be located offshore at Semakau Landfill and it is expected to produce power in the megawatt (MW) range. The scale of the micro-grid (~1 MWp), which could power around 250 households, will be suitable for small islands, isolated villages and to function as a backup emergency power supply (NTU, 2014).



Aerial photo of Semakau Island and the planned location of the renewables test bed. (http://www.ntu.edu.sg/AboutNTU/Pages/AcademicHighlights.aspx)

REIDS is a partnership, structured as a consortium between: (i) Singapore public agencies; (ii) corporations active in the energy field with a focus on integration of broad range of energy sources, end-uses and storage; and, (iii) academia and public research institutes. The consortium will be led by ERI@N, with the support of the Economic Development Board. Ten energy and clean technology industry leaders are involved in the project: Accenture, Alstom, ClassNK, DLRE, GDF Suez, Renewable Energy Corporation, Schneider Electric, Trina Solar, Varta and Vestas. REIDS is expected to "attract $20 million worth of projects over the next five years, in addition to the initial $8 million investment in infrastructure on the Semakau Landfill" (NTU, 2014). REIDS was officially launched by Minister S Iswaran during the Singapore International Energy Week (SIEW) in October 2014.

Standards Formation Participation for Ocean Renewable Energy

ERI@N has also initiated participation in the International Electrotechnical Commission's Marine Energy - Wave, Tidal and Other Water Current Converters standards technical committee IEC-TC114 through SPRING, the official body responsible for standards within Singapore. As a result, standards for ORE will be formulated to account for tropical conditions. Marine energy converters developed in regions outside the tropics may need some tweaking to suit the tropical environment, e.g. relatively lower resources (i.e. tidal currents, tidal ranges, wave heights), spatially distributed resources and load centres (i.e. island ecosystem); with some modifications, the systems and complementary technologies – including deployment and installation methods – will somewhat vary across the whole value chain.

Tropical Marine Science Institute (TMSI): Part of the Marine RE R&D Ecosystem

The TMSI of the National University of Singapore (NUS) is leading the national research effort in hydrodynamic and wind wave modelling. TMSI is building a Geographic Information System (GIS) database of bathymetry and other information important for estimation of tidal, wave, and ocean energy.

The recently developed tidal hydrodynamic forecasting system[4] is useful for the estimation of tidal power capacity in Singapore Strait.The extended regional version is under development. Regional wind-wave model has been fitted to cover the entire Sunda Shelf.

The models are indispensable tools for optimal placing of tidal power and wave energy harvesting farms. Other ocean energy resources - exploiting ocean currents, salinity and temperature gradients – can also be analysed using well-calibrated regional ocean models.

DHI: Supporting the Marine RE Value Chain in Singapore & Beyond

DHI Water & Environment (Singapore) Pte Ltd has been assisting tidal power developers in Singapore to assess the overall potential, and a number of sites have carried this through into an environmental scoping study. The Singapore straits are strongly tide-driven in terms of hydrodynamics(see Figure 11 below), but are also heavily used for industrial, shipping and recreational activities. As an extension to these studies a number of array optimisation tools and web-based online decision support systems have been developed (screen shot below).

The tidal currents of Singapore are very well mapped due to extensive monitoring over the past eight years using an array of Acoustic Doppler Current Profilers (ADCPs)– presently 14 instruments are deployed and maintained as part of other ongoing commercial and research activities. Potential for resources have also been identified in and around the industrial estate of Jurong Island with a total discharge of cooling water above 1mill m^3/hour.

DHI, which is active in Singapore providing a variety of services to the Maritime Port Authority, is collaborating with ERI@N in the development of a novel Marine Spatial Planning (MSP) software for ORE, particularly with device dependent energy assessment for various types of ORE resources.

PARTICIPATION IN COLLABORATIVE INTERNATIONAL PROJECTS

EMEC, ERI@N, and ClassNK

The European Marine Energy Centre (EMEC) and ERI@N will be collaborating to support further development of the marine renewable energy industry in Southeast Asia. ERI@N will work together with EMEC and ClassNK to set up scale test facilities in Singapore which offers a different climate and sea conditions to EMEC's own scale test sites in Orkney. This collaboration will be beneficial to both parties by leveraging the strengths of each – "EMEC in boosting the development of international markets and common standards and NTU's, with its strong expertise in sustainability research and its strategic location in Singapore, acts as a gateway to Southeast Asia" (EMEC, 2013).

Southeast Asian Collaboration for Ocean Renewable Energy (SEAcORE)

To understand the regional energy needs and ocean energy technology challenges specific to tropical conditions, ERI@N set up the Southeast Asian Collaboration for Ocean Renewable Energy (SEAcORE) with neighbouring countries, including Brunei, Indonesia, Malaysia, Myanmar, Philippines, Thailand and Vietnam. This collaboration is envisioned to be a platform for the exchange of ideas, initiatives, and experiences from R&D, policymakers, and industry. It forms a collated and active core network of expertise and technical know-how in Southeast

SEAcORE members during the Singapore International Energy Week 2014

[4] For more information, please see: http://www.porl.nus.edu.sg/forecast/public/

Asia (SEA) to set, assist, augment, and facilitate the adoption of ORE in the region. It also promotes the diffusion of renewables and creates new markets for partner industrial firms. Joint projects in resource mapping and assessment are now being discussed.

The ASEAN (Association of Southeast Asian Nations) Centre for Energy (ACE) has recognised the efforts of ERI@N in leading the SEAcORE initiative and officially made it as ACE's technical working group for ocean renewable energy in the region. ERI@N-SEAcORE together with ACE will drive projects, activities and events that lead to increasing awareness and the uptake of ocean renewables in Southeast Asia.

Joint Industry Programme (JIP)

The Joint Industry Programme is managed by ERI@N and involves PhD students, NTU professors, and local and multi-national companies who are engaged in cutting- edge research into various aspects of Offshore Renewable Energy. Today, 23 doctoral projects are in progress with research topics spanning resource forecasting, sub-structure studies, power generation, transmission, grid, installation, and maintenance.

Regional Network and International Conferences towards increasing ORE Uptake in SEA

The Energy Market Authority (EMA) of Singapore organises the annual Singapore International Energy Week (SIEW). ERI@N conducted its annual conference on offshore renewables (includes different sessions on offshore wind, and marine renewables, e.g. ocean thermal energy conversion, wave, and tidal energy) at the Asia Clean Energy Summit (ACES) 2014, in October. This conference provided an opportunity for marine energy experts, industries and organisations both within and beyond Singapore to gather and share new and cutting edge research and developments in the field of marine renewable energy. ACES 2014 attracted 200 experts worldwide to participate in the thee-day event, and will continue to be featured at SIEW 2015.

As a further development, Singapore has been chosen to be the next location for the Asian Wave and Tidal Energy Conference (AWTEC) in 2016 (AWTEC, 2014). It will be the first time that an international ocean renewable energy conference is held in Southeast Asia. ERI@N, along with experts from Japan, Korea, UK and Australia, will run the conference, focussing on the clean energy needs of SEA countries and other tropical regions.

TECHNOLOGY DEMONSTRATION

Hann-Ocean

With the support of SPRING Singapore's Technology Innovation Grant, Hann-Ocean Energy (HOE) has been developing a twin-chamber wave energy converter (WEC) "Drakoo" (Dragon King of Ocean) since 2008. Drakoo is capable of generating economic electricity from all scales of waves (0.2 m – 5.5 m) and is hence deployable in both shallow water and deep seas.

Testing of Drakoo in Singapore waters in November 2012 [5].

The internationally patented Wave Energy Converter (WEC) transforms waves into a continuous water jet driving a hydro turbine generator onboard. Drakoo has been tested successfully in NTU lab tests and in deep wave flume test verified by Narec UK. The current Drakoo model has an overall conversion efficiency (waves to electricity) of up to 55%. [6]

Hann-Ocean successfully obtained the first commercial order to supply four units of Drakoo-B0004 wave energy converters to Jurong Shipyard Pte. Ltd in June 2012. The WEC array (Drakoo-B0016) was installed at the new Jurong Mega yard at Tuas View Sea, Singapore in August 2013. The Drakoo-B0004 module is the world's first WEC that works under very low wave conditions (0.2m ~ 0.6m). This technology, which is fully developed in Singapore, will demonstrate the economic feasibility of generating electricity using small wave energy resources.

Atlantis

For more than a decade, Atlantis has been actively involved in the commercialisation of tidal power technology and the development of tidal power projects around the world. Atlantis established operations and set up its headquarters in Singapore in 2006, attracted by high quality R&D capabilities, as well as the robustness of the intellectual property protection regime. In 2011, EDB Investments (EDBI) became a stakeholder in Atlantis.

Atlantis' Solon Tidal Turbine Testing in Singapore (Left) and AR1000 – 1 MW unit (Right) [7]

Over the past few years, Atlantis has been focussing on business strategy, project, and technology development. Today, Atlantis dominates the tidal market by being the owner of the MeyGen project – with an overall goal to deliver a fully operational renewable energy plant of almost 400 MW powered purely by tidal energy. Other projects of Atlantis include tidal power development in FORCE, Nova Scotia, Canada, where a developmental Feed-in-Tariff of C$530 (around S$590) per megawatt hour (MWh) was awarded, which provides revenue support for Atlantis to deploy and operate up to three state-of-the-art AR-1500 turbines at FORCE. Atlantis also has projects in India, China and other parts of the world.

5 For more information, please see: http://www.hann-ocean.com/drakoo-b0016-array-launched-tuas-view-sea-singapore/
6 For more information, please see: http://www.hann-ocean.com/products/drakoo-wave-energy-converter/specifications/
7 For more information, please see: http://atlantisresourcesltd.com/about-atlantis/history.html

THE NETHERLANDS

HAIJO BOOMSMA
Ministry of Economic Affairs, The Netherlands

On 10 September 2014, the Netherlands officially became a party to the 'Implementing Agreement for a Co-operative Programme on Ocean Energy Systems' (the OES), with the Netherlands Enterprise Agency (RVO.nl) as Contracting Party.
In the Netherlands, both the Government and commercial parties have been studying the potential of ocean energy since the 1990s. Businesses and other organizations have joined forces in a trade association called the EWA (Netherlands Energy from Water Agency). Pilots have been carried out in Dutch waters to test various ocean energy technologies.
In the second half of 2014, the Ministry of Economic Affairs and the Ministry of Infrastructure and the Environment commissioned a study into the export potential of Dutch companies involved in energy from water (short term potential; up until 2023), and the potential contribution that this technology could make to the Netherlands' energy transition over the long term (from 2035). The results formed the basis for talks on potential follow-up activities between the above mentioned ministries and the sector.

ENERGY POLICY

NATIONAL STRATEGY AND TARGETS

The Netherlands currently does not have a national strategy for ocean energy or concrete targets. A spatial analysis of the potential of the North Sea with a view to 2050 has been made, also with regard to ocean energy. This North Sea 2050 Spatial Agenda was sent to parliament on 28 July 2014 and indicates a potential of up to 2.000 Megawatt of tidal current and wave energy to be possible, if techniques are developed further to fit the Dutch situation, with relatively low current speed. A further study was commissioned by the Ministries of Economic Affairs and Infrastructures and the Environment in 2014 in order to form the foundation for a targeted governmental vision on ocean energy. A separate study is commissioned by the working group on Offshore Wind (TKI Wind op Zee) to investigate the R&D needs of the Dutch tidal and wave energy sector (expected in 2015).
Information about North Sea 2050 Agenda available at:
http://www.noordzeeloket.nl/en/projects/north-sea-2050-spatial-agenda/index.aspx

LEGISLATION AND REGULATORY ISSUES

Although there is a central permitting system, in practice consenting requires engagement with a range of permitting bodies such as central government, province, municipality, Rijkswaterstaat, local harbour authorities, the Ministry of Defence and the regional water board. There are currently no specific aspects relating to ocean energy that are the focus of new or improved legislation or regulations.

MARKET INCENTIVES PUBLIC FUNDING PROGRAMMES

There are currently no specific market incentives for ocean energy. The Netherlands promote use of space at sea from a perspective of inviting for developments.

PUBLIC FUNDING PROGRAMMES

Between 2000 and 2010, the Ministry of Economic Affairs initiated a number of grants via generic R&D instruments. These grants are also available for ocean energy research.
In 2014, a generic demonstration scheme (DEI: Demonstrations of Energy Innovations) came into force. This is associated with the 'Energy Top Sector', part of the existing national innovation programme.
Ocean energy projects may also be eligible for the national grant scheme for the stimulation of sustainable energy production (SDE+), for which the maximum feed-in was set at € 0.15/kWh for 15 years, in 2014.

SEA TEST SITES

Marsdiep – near Texel, operated by Tidal Testing Centre NL

RESEARCH & DEVELOPMENT

KEY R&D INSTITUTIONS AND RELEVANT R&D PROJECTS

R&D Institutions:

- Tidal Testing Centre NL: tidal energy.
- ECN, Petten: aquatic biomass.
- NIOZ, Texel: aquatic biomass, impacts of tidal energy.
- Imares, Texel: aquatic biomass, environmental monitoring of tidal energy projects.
- Wetsus, Leeuwarden: aquatic biomass, blue energy.
- Deltares, Delft: tidal energy, wave energy, including test facilities.
- TU Delft, Delft: wave and tidal energy.
- MARIN, Wageningen: offshore infrastructure, test facility.
- TNO: research into corrosion and foul release coatings.

R&D Projects:

- Bluewater, Hoofddorp: tidal energy.
- Deep Water Energy, Arnhem: tidal energy.
- Tocardo, Den Oever: tidal energy.
- Teamwork Technology, Alkmaar: wave energy.
- Bluerise, Delft: OTEC.
- REDstack, Sneek: salinity gradient energy.

TECHNOLOGY DEMONSTRATION

OPERATIONAL PROJECTS

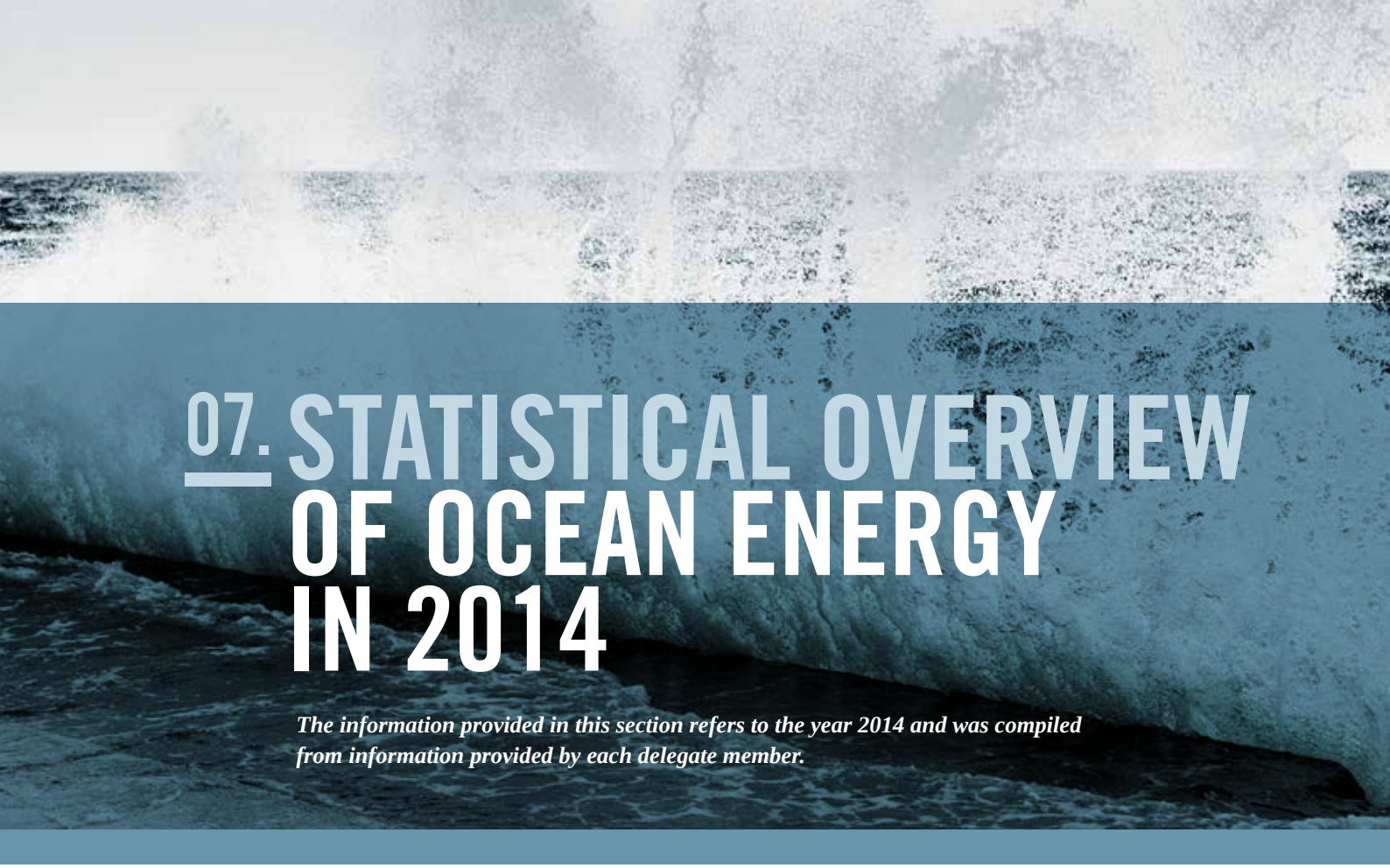
- Tidal energy pilot Westerschelde (30 kW), Vertical axis wave rotor technology
- Tidal energy pilot Den Oever (100 kW), Horizontal axis tocardo technology
- Salinity gradient energy pilot Friesland/Afsluitdijk (50 kW), using reverse electro-dialysis technology

PLANNED DEPLOYMENTS

- OTEC pilot Curacao (500 kW).
- Tidal energy pilot Marsdiep (200 kW).
- Tidal test centre (TTC) Zeeland.
- Arrays in two gates of the Eastern Scheldt Storm surge barriers (2 x 1 MW)
- Brouwersdam tidal range plant (various scenarios under consideration, after 2018)
- Several arrays in Afsluitdijk discharge gates (Stevinsluizen and Kornweerder zand)

OTHER RELEVANT NATIONAL ACTIVITIES

- Dutch Energy from Water Association (EWA).
- Dutch mirror group on IEC TC114 standards for marine energy converters.
- European Innovation Partnership Action Group on Energy from Water Works.



07. STATISTICAL OVERVIEW OF OCEAN ENERGY IN 2014

The information provided in this section refers to the year 2014 and was compiled from information provided by each delegate member.

WORLDWIDE OCEAN POWER INSTALLED CAPACITY

NETHERLANDS

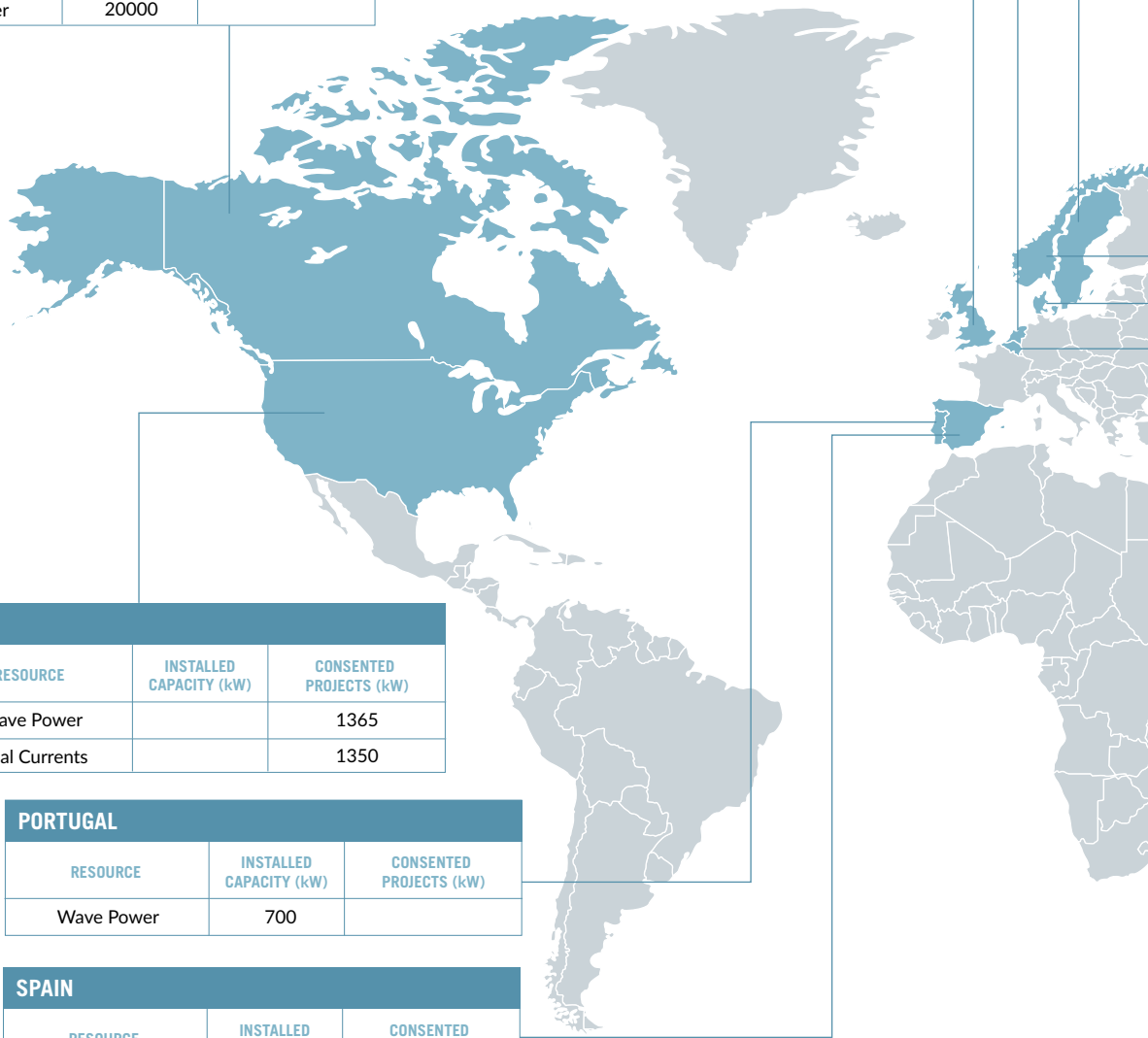
RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power		
Tidal Currents	130	3000
Salinity Gradient	50	

UK

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power	3730	40000
Tidal Currents	5600	96000

CANADA

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Tidal Currents		20450
Tidal Power	20000	



USA

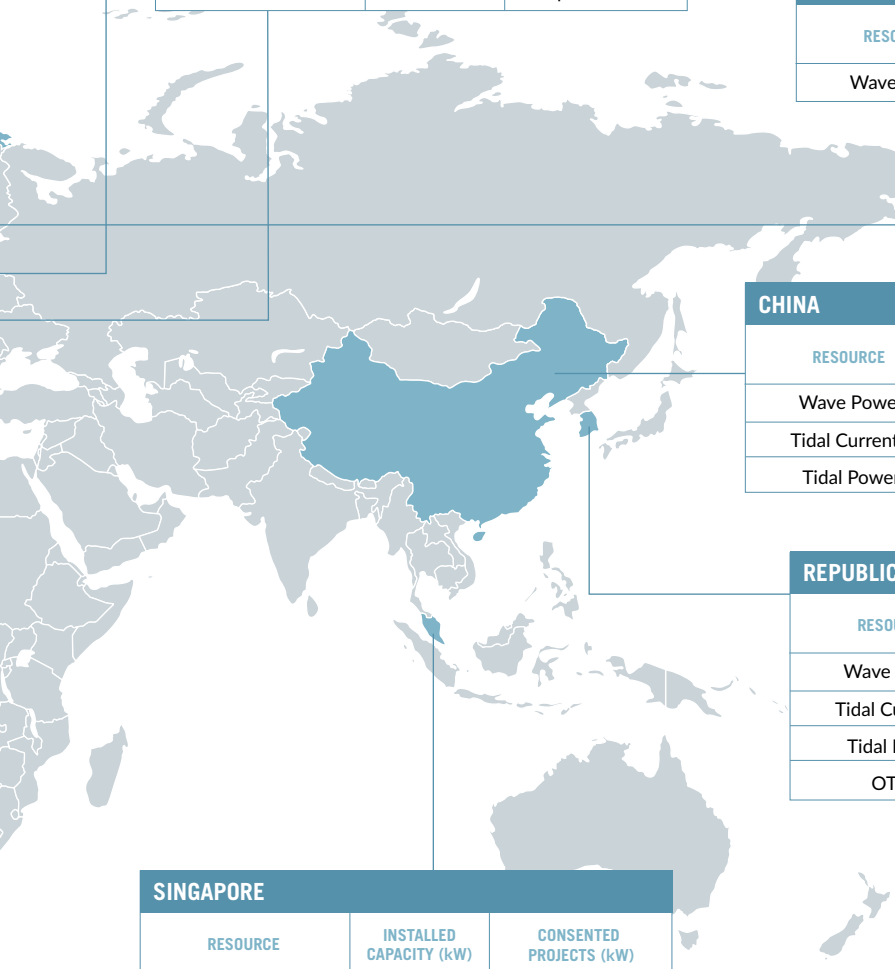
RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power		1365
Tidal Currents		1350

PORTUGAL

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power	700	

SPAIN

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



SWEDEN

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power	180	10400-10600
Tidal and Ocean Currents	7.5	

DENMARK

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power		115

BELGIUM

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

NORWAY

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power	200	

CHINA

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power	350	2860
Tidal Currents	170	4500
Tidal Power	3900	200

REPUBLIC OF KOREA

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power	500	300
Tidal Currents	1000	1300
Tidal Power	1000	1300
OTEC	220	1000

SINGAPORE

RESOURCE	INSTALLED CAPACITY (kW)	CONSENTED PROJECTS (kW)
Wave Power	16	
Tidal and Ocean Currents		2.5

OPEN SEA TESTING

COUNTRY	TEST SITE NAME	LOCATION	PROMOTER	GRID CONNECTION	STATUS
CANADA	Fundy Ocean Research Centre for Energy (FORCE) – Tidal Energy	Minas Passage (Nova Scotia)	FORCE	Yes (64 MW)	Operational
	Canadian Hydrokinetic Turbine Test Centre (CHTTC) – River Current Energy	Winnipeg River, Manitoba	University of Manitoba	Yes	Operational
CHINA	National small scale test site	Weihai Shandong	NOTC	Yes	Under development
DENMARK	DanWEC	Hanstholm & Nissum Bredning	Hans Jørgen Brodersen	no	Operational
ITALY	GEM	Strait of Messina	SEAPOWER Scarl	Yes (200 kW)	Planned (2016)
	ISWEC	Pantelleria (Sicily)	Politecnico di Torino/ Wave for energy s.r.l.	YES (100 kW)	Planned (2015)
	KOBOLD	Strait of Messina	Ponte di Archimede International Spa	Yes (60 kW)	Deployed 2000
IRELAND	National quarter scale Test Site	Galway, Ireland	SEAI/ Marine Institute/ Smart Bay Ltd	Planned for 2015	Operational
	Atlantic Marine Energy Test Site	Belmullet, Ireland	SEAI	Planned 2016	Lease - permit currently being finalised. Due for completion 2015.
NETHERLANDS	Marsdiep Offshore site	Marsdiep under Texel	Tidal Testing Centre NL	Yes	Under development
	Grevelingendam low head test site	Grevelingendam, Zeeland	Tidal Testing Centre NL / AnteaGroup	Yes	Under development
NEW ZEALAND	NZ-MEC	Wellington	AWATEA	-	Planned
UK	European Marine Energy Centre (EMEC)	Orkney	Neil Kermode	Yes	Operating
	WaveHub	Hayle, Cornwall	Claire Gibson	Yes	Operating
	FaBTest	Cornwall	Falmouth Harbour Commissioner/Mark Samson	No	Operating
	Perpetuus Tidal Energy Centre	Isle of Wight	John Buckland/Mark Francis	Yes	Planned
USA	U.S. Navy Wave Energy Test Site	Kaneohe Bay, Hawaii	U.S. Navy	Yes	Operational
	Pacific Marine Energy Center – North Energy Test Site	Newport, Oregon	NNMREC	No	Operational
	Pacific Marine Energy Center - Lake Washington	Seattle, Washington	University of Washington	No	Operational
	Pacific Marine Energy Center - Tanana River Hydrokinetic Test Site	Nenana, Alaska	University of Alaska Fairbanks AHERC	No	Operational
	Southeast National Renewable Energy Center	Boca Raton, Florida	Florida Atlantic University	No	Planned
	Center for Ocean Renewable Energy	Iles of Shoals, New Hampshire	University of New Hampshire	No	Operational
	Camp Rilea Test Site	Camp Rilea, Oregon	Oregon Military Department	No	Operational
	Pacific Marine Energy Center – South Energy Test Site	Newport, Oregon	NNMREC	Yes	Planned
	California Wave Energy Test Center (CalWave)	Vandenburg Air Force Base, California	California Polytechnic State University	Yes	Planned

SINGAPORE	REIDS-Offshore	Southern Islands	ERI@N with ClassNK & EMEC	To be determined	Planned (2017)
	Sentosa Tidal Test Bed	Sentosa Boardwalk, Singapore	ERI@N with Sentosa Dev't Corp	Yes (5kW)	Existing
	TMFT Marine RE Test Bed	Tanah Merah Ferry Terminal, Singapore	ERI@N with Singapore Cruise Centre	No	Existing
PORTUGAL	OceanPlug	São Pedro de Moel	Enondas	To be determined	Existing
SPAIN	Bimep	Basque Country	EVE	Yes (20MW)	Operational
	PLOCAN	Gran Canaria (Canary Islands)	Oceanic Platform of the Canary Islands (PLOCAN)	Expected by the end of 2015	Operational
SWEDEN	Lysekil wave energy research site	Lysekil	Mats Leijon/ Rafael Waters	Yes (Early 2015)	Operational
	Söderfors	Söderfors/Dalälven	Uppsala University	Planned 2015	Operational

MAJOR INDUSTRY PLAYERS INVOLVED IN R&D AND DEMONSTRATION PROJECTS

COUNTRY	INDUSTRY PLAYER	SECTOR (utility, energy company, etc)	TYPE OF INVOLVEMENT
Canada	Minas Energy	Project Developer, tidal current	Awarded FIT for project to be developed at FORCE ; Minas partnered with Marine Current Turbines (MCT) and Bluewater Energy Services
	Black Rock Tidal Power	Project Developer / technology developer, tidal current	Awarded FIT for project to be developed at FORCE ; Includes SCHOTTEL, TidalStream, and several local and international partners
	Atlantis Operations Canada	Project Developer / Technology Developer, tidal current	Awarded FIT for project to be developed at FORCE; Partnered with Lockheed Martin and Irving Shipbuilding
	Cape Sharp Tidal Venture	Project Developer / Utility, tidal current	Awarded FIT for project to be developed at FORCE ; Includes OpenHydro/DCNS partnered with Emera
	Fundy Tidal Inc.	Project Developer, tidal current	Awarded COMFITS for projects to be developed in the Bay of Fundy; Includes Tribute Resources (International Marine Energy); Devices to be deployed under the COMFIT approvals include Tocardo, Clean Current, Nautricity
	Clean Current power systems	Technology developer, river / tidal current	Deployed at CHTTC
	RER	Technology developer, river current	Deployed in the St. Lawrence near Montreal, QC
	New Energy Corporation	Technology developer tidal / river current	Technology demonstration
	Idénergie	Technology developer, river current	Technology demonstration
	Verdant Power	Technology developer, river current	Technology demonstration
	Mavi Innovations	Project Developer, tidal / river current	Technology demonstration

	Jupiter Hydro Inc.	Technology Developer, tidal / river current	Technology demonstration
	Water Wall Turbines	Technology Developer, tidal / river current	Technology demonstration
	HydroRun Technologies Ltd.	Technology Developer, river current	Technology testing
	Accumulated Ocean Energy (AOE)	Technology Developer, Wave	Technology testing
	Grey Island Energy	Technology Developer, Wave	Technology testing
	Mermaid Power	Technology Developer, Wave	Technology testing
	Seawood Designs Surf Power	Technology Developer, Wave	Technology testing
China	China Longyuan Power Group Corporation Limited	Energy company	Operation of the Jiangxia tidal power station
	Qingdao Haina Heavy Industry Corporation Limited	Manufacturer	Manufacture of FLB wave energy converter prototype
	China Shipping Industry Corporation Limited	Manufacturer	Manufacture of Sharp Eagle wave energy converter prototype
	Guodian United Power Technology Corporation Limited	Manufacturer	Manufacture of ZJU turbine prototype
	Zhejiang Zhoushan LHD New Energy Corporation Limited	Developer	Project of 1.2 MW tidal current plant
	Zhejiang Jianghe Hydropower S&T Corporation Limited	Manufacturer	Manufacture of NENU turbine prototype
	China Shipbuilding Industry Corporation 710 Institute	Developer	project of Hailong device
	China Southern Power Grid	Utility	Wave energy demonstration engineering design
	China Three Gorges Corporation	Energy company	Ttidal current energy demonstration engineering design
Ireland	ESB	Utility	Westwave – 5 MW Wave Energy array
Netherlands	Tocardo	Developer	Producer of tidal energy turbines
	Bluewater Energy Services	Engineering	Generic floating structure for tidal current turbines
	Schottel Hydro	Developer	Producer of tidal current turbines
	Dutch Expansion Capital	Investor	Project management and investments for tidal turbine system
	Nijhuis pompen	Developer	Producer of low head hydropower turbines
	Blue motion energy	Developer	Producer of free flow technologies
	REDstack	Developer	Producer of salinity gradient power installations
	Bluerise	Developer	Producer of OTEC plants
	Teamwork Technology	Developer	Developer of wave energy system
	SlowMill	Developer	Developer of wave energy system
New Zealand	EHL	Developer	Device development
UK	Forum	Utility	Wave energy testing
	Alstom	Engineering manufacturer and service provider	Alstom acquired the Rolls-Royce-Tidal GenerationLtd *Deep Gen* turbine technology (now named *Oceade*) which will be installed in the MeyGen Pentland Firth tidal stream demonstration phase.
	EDF Energy	Utility	Has signed power purchase agreement with Developer Tidal Energy Ltd.
	Siemens	Engineering manufacturer and service provider	Owner of Marine Current Turbines (though now seeking a buyer for the company)
	Lockheed Martin	Aerospace	Contract with Atlantis to optimise AR1500 device
	A&P Group Limited	Marine fabrication	Collaborator for development of DP barge for high flow environments
	Alpha Electro-Technology Limited	Electrical engineering services	Collaborator for development of biofouling removal technology
	BAUER Renewables Limited	Offshore installation services	Collaborator for development of DP installation vessel for high flow environments
	Bluewater Services (UK) Limited	Tidal energy foundation solution developer	Collaborator for development of synthetic rope fairleads
	Bridon International Limited	Rope manufacture	Collaborator for development of synthetic rope fairleads
	Det Norske Veritas UK	Certification services	Collaborator for development of DP installation vessel for high flow environments
	Garrad Hassan and Partners Limited (now DNV GL)	Design engineering and consultancy services to renewable energy sector	Collaborator for development of multi rotor turbine foundation system
	Green-Tide Turbines Limited	Tidal energy device developer	Collaborator for development of biofouling removal technology

	IT Power Limited	Design eng. and consultancy services to r. energy sector	Collaborator for development of DP barge for high flow environments
	Keynvor MorLift Limited	Offshore operations and vessels	Collaborator for development of DP barge for high flow environments
	Mojo Maritime Limited	Design engineering and consultancy services to marine sector	Collaborator for development of DP installation vessel for high flow environments and for development of multi rotor foundation system
	Nylacast Limited	Manufacture of cast nylon plastic products	Collaborator for development of synthetic rope fairleads
	Plant Integrity Limited	Non-destructive testing technology	Collaborator for development of biofouling removal technology
	Reygar Limited	Marine control systems services	Collaborator for development of DP barge for high flow environments
	SEACON (Europe) Limited	Subsea connector supplier	Collaborator for development of subsea electrical hub
	Tension Technology International Limited	Design and engineering services for ropes and marine systems	Collaborator for development of synthetic rope fairleads
	Tidal Generation Limited (now Alstom)	Tidal device OEM	Collaborator for development of subsea electrical hub
	TidalStream Limited	Foundation designer	Collaborator for development of multi rotor turbine foundation system
	Voith Turbo Limited	Drive train manufacture and testing	Collaborator for development of DP installation vessel for high flow environments
USA	ABB	Original Equipment Manufacturer	Wave component R&D
	Atargis Energy,Inc.	Technology developer	Wave system R&D
	Columbia Power Technologies, Inc.	Technology developer	Wave system RD&D
	Ecomerit/Dehlsen Associates, LLC/ Aquantis	Technology developer	Wave and ocean current system R&D
	DNV GL	Ocean R. and Eng. and Certification	Marine renewable energy
	Dresser Rand	Original Equipment Manufacturer	Wave component RD&D
	Fred Olsen	Offshore operator	Wave system RD&D
	Lockheed Martin Corporation	Technology developer	OTEC system R&D
	M3 Wave Energy Systems, LLC	Technology developer	Wave system R&D
	Murtech	Technology developer	Wave system R&D
	Northwest Energy Innovations	Technology developer	Wave system RD&D
	Ocean Energy	Technology developer	Wave system RD&D
	Ocean Power Technologies, Inc.	Technology developer	Wave system RD&D
	Ocean Renewable Power Company	Technology developer	Current energy system RD&D
	Oceana Energy Company	Technology developer	Current energy system R&D
	Open Hydro	Original Equipment Manufacturer	Current energy system RD&D
	Oscilla Power	Technology developer	Wave system R&D
	RCT	Original Equipment Manufacturer	Wave and current component R&D
	Resolute Marine Energy, Inc.	Technology developer	Wave system RD&D
	Re Vision Consulting, LLC	Ocean Research and Engineering	Marine renewable energy R&D
	Snohomish County Public Utility District #1	Utility	Current energy project development
	Sound & Sea Technology, Inc.	Ocean Research and Engineering	Marine renewable energy/Undersea systems
	Verdant Power, Inc.	Technology developer	Current energy system R&D
	Vortex Hydro Energy, LLC	Technology developer	Current energy system R&D
Republic of Korea	Korea Water Resources Corp. (K-water)	Utility	Operation of Shihwa tidal barrage power plant
	Korea East-West Power Co., Ltd.	Utility	Operation of Uldolmok tidal current pilot plant
	Hyundai Heavy Industry Co., Ltd.	Heavy Industry	Full-scale demonstration of 1MW tidal current device
	Korea Electric Power Corporation	Utility	Prototype demonstration of attenuator with liquid column oscillator
			Basic research on OTEC utilizing discharged water from power plant
Spain	SENER Ingenieria y Sistemas S.A.	Power & Process	Engineering Property and Construction Management of bimep; active partner in the OceanLider Project and other Projects related to the design of auxiliary vessels for supporting offshore marine farms.
	ABENGOA Seapower	Energy Company	R&D projects in wave and tidal energy, engineering for construction of marine energy projects, and the development of different tools mainly focused on grid and performance of marine energy devices.
	IBERDROLA	Utility	IBERDROLA, through its UK subsidiary Scottish Power Renewables, is promoting projects based on ocean energy devices (wave & tidal) out of Spain. In Spain, IBERDROLA is partner with TECNALIA in OCEANTEC Energías Marinas.

08. APPENDICES

Appendix 1

ENERGY TECHNOLOGY INITIATIVES

The International Energy Agency provides support for international collaboration on energy technology research, development, deployment and information dissemination. These energy technology initiatives (formally known as Implementing Agreements or 'IAs') function within a framework created by the IEA - *the International Framework for International Energy Technology Collaboration* - in support of energy security, economic growth, environmental protection and engagement worldwide.
The experts participating in the activities of the Implementing Agreements represent public and private sector entities worldwide. Together, these experts share knowledge – and resources – to advance energy technologies.

This IEA technology collaboration programme is open to IEA member and non-member countries. Typically, participants are:

- Governmental or energy technology entities representing governments,
- Research institutes and universities,
- Energy technology companies.

Each Implementing Agreement has a unique scope and range of activities. There are currently 40 IAs working in the following areas:

- Efficient end-use technologies (buildings, electricity,industry, transport);
- Fossil fuels (greenhouse-gas mitigation, supply,transformation);
- Renewable energies and hydrogen (technologies and deployment) and fusion power (international experiments); and
- Cross-cutting issues (information exchange, modelling, technology transfer).

Renewable energy technologies provide clean, flexible, standalone or grid-connected electricity and heating or cooling. Ten IAs deal with renewable energy technologies:

- Bioenergy
- Geothermal
- Hydrogen
- Hydropower
- **Ocean Energy Systems**
- Photovoltaic Power Systems
- Renewable Energy Technology Deployment
- Solar Heating and Cooling
- SolarPACES
- Wind Energy Systems

Further information is available at: http://www.iea.org/techinitiatives/

Appendix 2

MEMBERSHIP OF THE EXECUTIVE COMMITTEE

CHAIRMAN

Mr. Jose Luis Villate
TECNALIA
Spain

VICE-CHAIR

Dr. Keyyong Hong
KORDI
Korea

VICE-CHAIR

Mr. Henry Jeffrey
The University of Edinburgh
United Kingdom

SECRETARY

Dr. Ana Brito e Melo
WavEC – Offshore Renewables
Portugal

DELEGATES

COUNTRY	DELEGATE	ALTERNATE
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	Mr. Lin Cui National Ocean Technology Center
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. Declan Meally 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	Dr. Lae-Hyung Hong Ministry of Land, Transport and Maritime Affairs	Dr. Keyyong Hong Korea Ocean Research and Development Institute
Mexico	Dr. Sergio Alcocer Instituto de Ingeniería UNAM	Dr. Gerardo Hiriart Energias Alternas, Estudios y Proyectos SA Replaced by: Mr. Carlos Ortiz Gomez General Directorate of Information and Energies Studies
Monaco	HE Bernard Fautrier Government of the Principality of Monaco	
The Netherlands	Mr. H.W.Boomsma Ministry of Economic Affairs	Mr. H.P.E.M. Reijnders Netherlands Entreprise Agency
New Zealand	Dr Craig Stevens National Institute for Water and Atmospheric Research (NIWA)	Mr. Nick Eldred AWATEA

Nigeria	Prof. Lawrence Awosika Nigerian Institute for Oceanography and Marine Research Replaced by: Dr. Emmanuel Olusegun Oyewo Nigerian Institute for Oceanography and Marine Research	Mr. Kola Onadipe Prof. David A. Aderibigbe FOT-K Consortium
Norway	Mr. Harald Rikheim Norges Forskningsråd	Mr. Tore Gulli Fred Olsen Ltd
Portugal	Dr. Paulo Justino Laboratorio Nacional de Energia e Geologia (LNEG)	Prof. António Falcão Instituto Superior Técnico
Singapore	Prof. Subodh Mhaisalkar Energy Research Institute	Dr Srikanth Narasimalu Energy Research Institute
South Africa	Dr Thembakazi Mali SANEDI	Ms. Kubeshnie Bhugwandin Eskom Research, Testing & Demonstration
Spain	Mr. Luis Hilario Alonso Mijares Ministerio de Industria, Turismo y Comercio	Mr. José Luis Villate TECNALIA
Sweden	Ms. Maria Olsson Swedish Energy Agency	
UK	Mr. Trevor Raggatt Department of Energy and Climate Change	Mr. Henry Jeffrey The University of Edinburgh
USA	Dr. Alison LaBonte U.S. Department of Energy	Dr. Robert Thresher National Wind Technology Center

Appendix 3

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
26	13 -14 May 2014	Paris	FRANCE
27	10 – 11 November 2014	Halifax	CANADA

PLANNED MEETINGS

MEETING	DATE	PLACE	
28	May 2015	Kassel	GERMANY
29	October 2015	Ensenada	MEXICO

Appendix 4

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 5

TERMINOLOGY FOR OES

TERM	DEFINITION
ANNEX	An 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	The 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.
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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