IEA | OES
Ocean Energy Systems

IEA-OES

INTERNATIONAL ENERGY AGENCY
IMPLEMENTING AGREEMENT ON OCEAN ENERGY SYSTEMS

annual report 2007

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PUBLISHED BY IEA-OES EXECUTIVE COMMITTEE
ACTING EDITOR IEA-OES
DESIGNED BY P-06 ATELIER
CIRCULATION 2000 EXEMPLARS
PRINTED BY

Contents

Chairman's Message

Welcome to the Annual Report of the IEA Implementing Agreement on Ocean Energy Systems (IEA-OES) for the year 2007. The report provides an overview of activities of the Executive Committee of the IEA-OES and its member/observing countries to enable the deployment of ocean renewable energy technologies worldwide. This is the first year of the second five-year mandate of the IEA-OES, and this year our program focused on conversion technologies for producing electricity from ocean waves, marine currents, tidal barrages, ocean temperature gradients and ocean salinity gradients, as well as other ways to utilize this renewable resource, such as the production of portable water through desalination. I am very pleased to report the progress in our portfolio and the continuing growth in participation.

Interest in IEA-OES membership continues. The year started with addition of three new member countries, Norway, Germany and Mexico, bringing total membership to 12 for the Implementing Agreement. Other countries are also in the process of becoming members. For the first time, individuals representing countries from five continents participated in the meeting of the Executive Committee.

In order to enhance the technology development and deployment collaboration with South Africa and Brazil, representatives of the IEA-OES participated in the IEA Networks of Expertise on Energy Technologies (NEET) initiatives held in 2007.

Over the past year, there has been tremendous activity in information exchange and dissemination, including limited research and developmental activities. 2007 saw the successful completion of wave data catalogues. Significant progress in developing an information DVD for various stakeholders and an online library for relevant publications is noteworthy. This year we also extended an existing Annex on developing guidelines for conversion devices and initiated a new Annex on integration of ocean energy to electrical grids. An expert workshop on environmental issues associated with ocean energy conversion process was also held.

In co-operation with other interested groups and organizations, the IEA-OES held specific discussions with the IEA Renewable Energy Technology Deployment (RETD) Implementing Agreement, approached RETD for collaborative policy-related activities and participated in the workshops of the IEA Expert Committee on Integration of Renewable to Electrical Grids. We also actively supported the International Electrotechnical Commission (IEC) initiative to develop relevant standards for the development of a new industrial sector.

As part of our outreach and communication strategy, the IEA-OES participated in the IEA Ministerial Technology Fair in Paris and cosponsored a symposium on water and energy in Mexico. Various members spoke on the current collaborative activities of the Implementing Agreement at several national and international workshops, symposiums and conferences.

In 2007, the management of the common fund of the IEA-OES was transferred to the Wave Energy Centre in Portugal.

By the end of 2007, more than 25 countries were involved in ocean renewable energy technology development activities. Although continued and new government policies and initiatives from the United Kingdom, Portugal and Ireland for enabling the commercialisation of ocean energy technologies in 2007 are noteworthy, the lack of targeted national priorities and policies for ocean energy by other countries remains a major barrier for developing and deploying reliable ocean renewable energy technologies.

I look forward to 2008 with enthusiasm, in particular to see more active collaboration through the Annexes as well as with other Implementing Agreements. I eagerly anticipate the deployment of multi-unit MW-size wave and tidal current technologies, and welcome countries such as South Africa, Brazil, Korea, China, New Zealand, Spain, Sweden and Italy as they become members of this Implementing Agreement.

I take this opportunity to thank all Executive Committee Members, Operating Agents and Experts for their dedicated efforts and contributions to the collaborative work and success of IEA-OES.

Gouri Bhuyan
Chairman

Executive Summary

The IEA Ocean Energy Systems 2007 Annual Report reviews the progress of the activities in the Implementing Agreement for Co-operation in Research and Development on Ocean Energy Systems (IEA-OES) under the auspices of the International Energy Agency (IEA)*, during the year 2007.

The International Energy Agency (IEA) was established as an autonomous body within the Organisation for Economic Co-operation and Development (OECD) in 1974 to implement an international energy program and act as Policy Advisor to countries on energy, including renewable energy. Today the IEA has 26 member countries. The IEA provides a framework for 42 international collaborative energy research, development and demonstration projects known as Implementing Agreements.

The IEA Ocean Energy Systems Implementing Agreement (IEA-OES) is a collaborative venture among various member countries – Canada, Belgium, Denmark, Germany, Ireland, Japan, Mexico, Norway, Portugal, United Kingdom, the USA – and the European Commission.

Chapter 1 of this report gives an **overview of the IEA-OES**: its membership, the Executive Committee (ExCo) meetings and actual collaborative tasks (Annexes), highlighting the major achievements in 2007. The outcomes of the three collaborative tasks of the IEA-OES: I) Collection and dissemination of information, II) Guidelines for prototype testing and III) Grid integration, are presented in chapter 2.

An overview of the **global ocean resource and technology maturity** of various ocean energy systems is presented in Chapter 3. Several tidal barrage plants, with a capacity up to 240 MW, are operating on a commercial basis worldwide, and new initiatives on this type of development are in progress in various countries. Several ocean wave technologies are expecting pre-commercial deployment in Europe. A number of demonstration projects in the range of 1 to 3 MW are awaiting deployment throughout the world, especially wave and tidal (marine) current projects. Conversion technologies for harnessing energy associated with ocean thermal gradients (OTEC) and salinity gradients are at the research and early developmental stage.

Chapter 4 gives an overview of **ocean energy supporting policies** based on information provided by the IEA-OES members and key representatives from other countries.

Environmental issues related with ocean energy systems started being discussed in the IEA-OES as an area where collaborative research is needed. The first expert meeting organised by the IEA-OES with relevant experts from several countries took place in November 2007 in conjunction with the 13th ExCo meeting in Messina. This topic is addressed in Chapter 5 with a view of present reality.

Chapter 6 presents a **summary from each IEA-OES member country and representatives from some other countries** on national programs, governmental initiatives for the promotion and development of ocean energy, relevant research activities, ocean energy projects taking place in the country, Research, Development and Demonstration (RD&D) investment and relevant national association activities during the year. Several governmental initiatives were launched in 2007 towards the development of technologies and market for ocean energy.

Ana Brito-Melo
Secretary to the Executive Committee

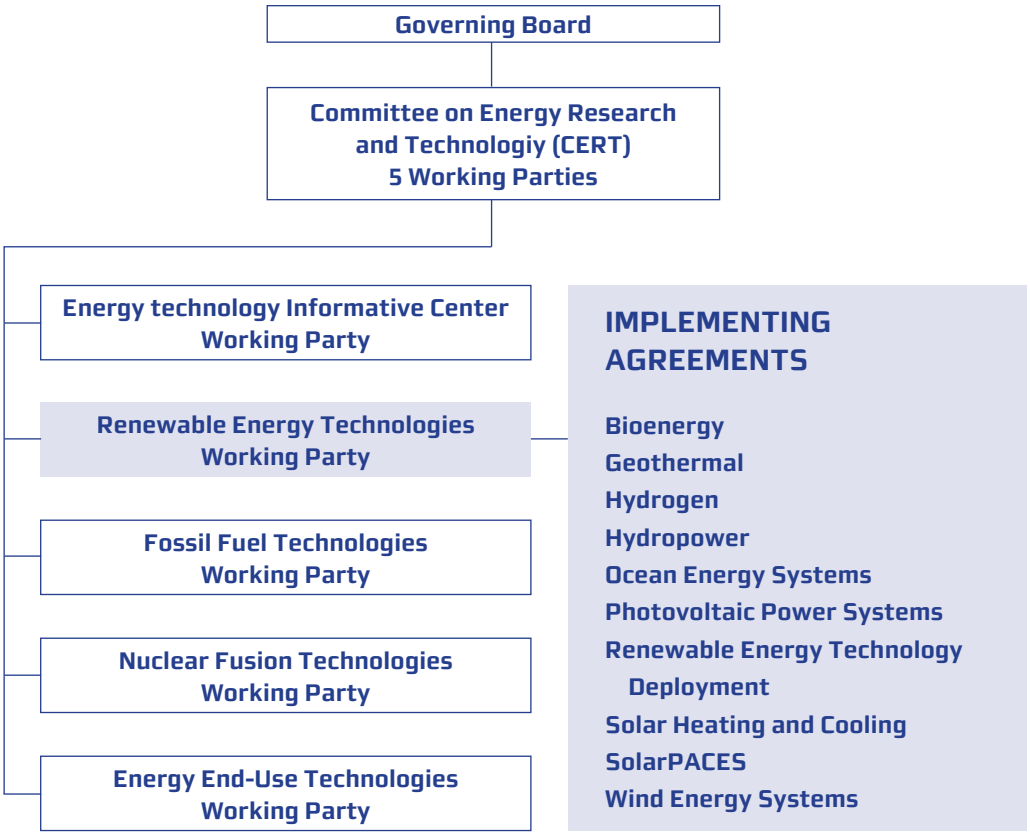
*The IEA-OES also known as the Implementing Agreement on Ocean Energy Systems functions within a framework created by the International Energy Agency (IEA). Views, findings and publications of the IEA-OES do not necessarily represent the views or policies of the IEA Secretariat or of all its individual member countries.

1. Ocean Energy Systems Program

IEA-OES

The Implementing Agreement on Ocean Energy Systems (IEA-OES) is one of eleven IEA Implementing Agreements within the Renewable Energy domain of the International Energy Agency. Implementing Agreements are supervised by the IEA Committee on Energy Research and Technology (CERT).

The IEA-OES was set up in October 2001. The work program for the first five-year term (2002-2006) of the IEA-OES Implementing Agreement was completed and the Implementing Agrement has entered its second 5-year term (2007-2011) mandate.



Mission of the IEA-OES

To facilitate and co-ordinate ocean energy research, development and demonstration through international co-operation and information exchange, leading to the deployment and commercialisation of sustainable, efficient, reliable, cost-competitive and environmentally sound ocean energy technologies.

Strategic Objectives (2007-2011)

1. To actively encourage and support the development of networks of participants involved in RD&D, prototype testing and deployment, policy development and implementation, and facilitate networking opportunities.
2. To become a trusted source of objective information and be effective in disseminating such information to ocean energy stakeholders, policymakers and the public.
3.To promote and facilitate collaborative research, development and demonstration to identify and address barriers to, and opportunities for, the development and deployment of ocean energy technologies.
4. To promote policies and procedures consistent with sustainable development.
5. To promote the harmonisation of standards, methodologies, terminologies and procedures where such harmonisation will facilitate the development of ocean energy.

Membership

In 2007 Germany, Mexico and Norway joined the IEA-OES. Representatives from Brazil, Indonesia, Sweden and South Africa participated in meetings of the Executive Committee for the first time in 2007.
In the October 2007 ExCo meeting, New Zealand, Sweden, and South Africa were officially invited by the IEA-OES Executive Committee.
Further, in October 2007, the Chair received an expression of interest to join the IEA-OES from the Government of Spain, and a positive indication from the Government of Brazil at the NEET workshop in Brazil (November 2007). By electronic voting on 28 December 2007, ExCo made a decision to formally invite Spain and Brazil to join the IEA-OES.

Year	Country	Contracting party
2001	Denmark	Ministry of Transport and Energy, Danish Energy Authority
2001	Portugal	Instituto Nacional de Engenharia Tecnologia e Inovação (INETI)
2001	United Kingdom	Department of Trade and Industry (DTI)
2002	Ireland	Sustainable Energy Ireland (SEI)
2002	Japan	Saga University
2003	Canada	Powertech Labs Inc.
2003	European Commission	Commission of European Communities
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
2007	Mexico	The Government of Mexico
2007	Norway	The Research Council of Norway

Table 1.1. Contracting parties to the IEA-OES (status: end 2007)

Executive Committee Meetings

The work program within the Implementing Agreement is co-ordinated by an Executive Committee (ExCo), which in turn is typically represented by a federal department or its nominees from member countries. Under the IEA-OES, the ExCo develops the strategy to pursuit and establishes collaborative programs. The ExCo meets twice every year. The 2007 ExCo meetings were held in Mexico City (March 2007) and in Messina, Italy (October 2007).

12th ExCo meeting

20-21 March 2007, UNAM, Mexico City, Mexico

This meeting was held at the Universidad Autónoma de México (UNAM) in Mexico City, hosted by UNAM. The Mexican delegate, Mr. Gerardo Hiriart, was the local organiser of the meeting.

The meeting corresponded with a two-day international symposium, "Water and Energy: Energies from the Ocean and Desalination", (22-23 March 2007) at UNAM. The first day of the symposium was devoted to presentations by the IEA member and observer countries and the second day was devoted to presentations by other organisations involved in ocean energy activities.

Members and observers at the 12th IEA-OES ExCo meeting
Mexico City, Mexico

13th ExCo meeting

16-17 October 2007, Messina, Italy

This meeting was held at the foundation Orcynus Orca in Messina (Sicilia/Italy), and was hosted by Ponte di Archimede, a company that carries out field research and experiments on a platform equipped with a patented Kobold turbine moored in the Strait of Messina. This project harnesses the energy of marine currents (the ENERMAR project). Prof. António Fiorentino from Ponte di Archimede, who has been attending previous ExCo meetings as an Observer, was the local organiser of the meeting.

Following the ExCo meeting, the members and observers visited the Kobold turbine in the Strait of Messina. The group also visited the cavitation tunnel scale model of Ponte di Archimede, in which the turbine has been tested.

Further a workshop, "Environmental issues and Ocean Energy Systems", was organised by the Alternate member from Canada, Ms. Melanie Nadeau, with presentations of 10 invited experts from eight countries (Canada, Denmark, Germany, Norway, Portugal, Sweden, the USA and UK) to initiate the discussion for a future Annex under this topic.

Members and observers at the 13th IEA-OES ExCo meeting
Messina, Italy

Work program

Collaboration has taken place through three specific Tasks, known as Annexes (Table 1.2). Progress under these tasks is described in Chapter 2.

Task 1
Review, Exchange and Dissemination of Information on Ocean Energy Systems
Operating Agent: INETI, Portugal

Task 2
Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems
Operating Agent: The Ministry of Environment and Energy, Danish Energy Agency, acting through RAMBØLL, Denmark

Task 3
Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids
Operating Agent: Powertech Labs Inc., Canada

Table 1.2. Cooperative research tasks in 2007 defined in Annexes to the IEA-OES

Task 1 was initially established for a five-year term. During 2006 the Executive Committee voted to extend this task indefinitely and to make participation compulsory for all contracting parties to the Implementing Agreement. Task 2, in its initial phase, covered testing facilities and testing procedures in order to develop guidelines for the presentation of technical design and data, and for the assessment of system performance. A first report, "Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems, 2003", focused on tank-testing scale models, providing overviews of testing facilities and guidelines for testing in IEA-OES member countries, assessing preliminary cost and presenting results. In 2006, this task was extended for an additional three-year period (2007-2009) to develop guidelines for evaluating performance of prototype conversion systems in open sea, using a cost-shared scheme among the participating contracting parties. Task 3 was formally approved by the ExCo in November 2006 and early in February 2007 the work program was finalised based on the outputs of a kick-off meeting with experts from several organisations.

Country	Task 1	Task 2	Task 3
	Dissemination of Information	Recommended Practices	Integration in electrical grids
Belgium	X	X	
Canada	X	X	X.OA
Denmark	X	X.OA	
European Commission	X		
Germany	X		
Ireland	X	X	X
Japan	X		
Mexico	X	X	
Norway	X	X	
Portugal	X.OA		
United Kingdom	X	X	X
United States of America	X	X	

Table 1.3. Participation of member countries in Annexes during 2007 (OA indicates Operating Agent that manages the task)

Highlights in 2007

The milestones of the 2007 work program can be summarised as follows:

- **Increased Membership** – In 2007, three countries joined the IEA-OES: Germany, Norway and Mexico. Mexico was one of the IEA's targeted countries for enhanced R&D collaborations.
- **Co-sponsored an International Symposium on Water and Energy in Mexico City**.
- **Spread of the IEA-OES worldwide** – During 2007, there was a notable increase in the observering countries attending Executive Committee meetings: Sweden, South Africa, Indonesia and Russia attended the ExCo meetings for the first time this year. Further, the governments of Spain and Brazil expressed interest in joining the IEA-OES, New Zealand started the IEA-OES membership process, and representatives from Korea, China and Italy continued efforts in their respective countries to join the IEA-OES.
- **Launch of Annex III – Integration of Ocean Energy Systems into Electrical Grids** – This annex, managed by Powertech Labs of Canada, entered in force in early 2007.
- **Environmental issues** – The first workshop to discuss environmental issues related to Ocean Energy Systems was organised by the IEA-OES. Representatives from several countries attended this workshop and shared their work; their presentations served as strong foundations for later discussions.
- **Leadership Role in Supporting Establishment of an International Standardisation Committee** – The ExCo held discussions and made specific recommendation to the Standard Management Board of the International Electrotechnical Commission (IEC) in establishing a new Technical Committee (IEC TC 114) to develop relevant standards for wave and tidal current energy converters.
- **New IEA-OES publication** – The report, "Wave Data Catalogue, 2007", compiled country-by-country reviews of wave data in IEA-OES member countries, prepared by INETI, Portugal, was published.
- **Ocean Energy Glossary** – A glossary defining main terms in the field of wave energy, marine current energy, tidal energy, OTEC and salinity gradient was prepared during 2007 by the collaborative action of the IEA-OES and the European-funded project, "Coordinated Action on Ocean Energy" (CA-OE).
- **Active Collaboration with the Renewable Energy Technology Deployment Implementing Agreement (RETD IA)** – RETD agreed to include wave energy in its recent model developed for estimating society costs and benefits related to renewable energy deployment by end of 2007. The IEA-OES received an invitation from the RETD to collaborate in a project intended to accelerate the deployment of offshore renewable energy technologies.
- **IEA's "Integration of Renewables into Electricity Grids" Project** – The IEA-OES participated in an IEA project with the aim to provide insight into technical and policy issues in this area.
- **Statistical information on Ocean Energy** – In order to provide authoritative information to the IEA publications, the members began to compile data on the following: i) Global Ocean Power Installed Capacity, ii) RD&D Investment in Ocean Energy and iii) Global Resource.

Fund Administration

Since January 2007, the IEA-OES common fund has been managed by the Wave Energy Centre in Portugal. The annual contribution to the common fund by each member country is 7000 Euros. The common fund provides financial resources for managing the Executive Committee and the Secretariat. It additionally covers dissemination activities expenses under Annex I (editions of documents and newsletter, maintenance of website, etc). Annex I is a mandatory Annex in which participants assign specific resources and personnel to carry out the work. Annex II and Annex III are based on cost-shared and task-shared activities. There is a participation fee for each of the Annexes. The budget associated with the Annexes is managed by the respective Operating Agent of the Annex.

2. Task Status Reports

Annex I: Review, Exchange and Dissemination of Information on Ocean Energy Systems

Operating Agent: Instituto Nacional de Engenharia e Tecnologia e Inovação (INETI), Portugal

Overall objective

The objective of this Task is to collate, review and facilitate the exchange and dissemination of information on the technical, economic, environmental and social aspects of ocean energy systems. This available knowledge should facilitate further development and adoption of cost-effective ocean energy systems. In addition, the results of this Task will facilitate identification of further Annexes, as well as continuing to promote information exchange. Ocean waves and marine currents energy systems ("waves and currents systems") are the current priority.

List of countries participating in the Annex

This Annex is a mandatory Annex of the IEA-OES.

Activities in 2007

The complete list of activities undertaken under this Annex and status by end of 2007 is presented in Table 2.1.

ANNEX I – TASKS	DELIVERABLE	STATUS
Task 1.1: Dissemination material		
Subtask 1.1.1: Website		continuing
Subtask 1.1.2: Newsletter		continuing
Subtask 1.1.3: Informative poster for exhibitions	IEA-OES Document No: T01.1.3	completed
Subtask 1.1.4: Glossary on ocean energy	IEA-OES Document No: T01.1.4	continuing
Subtask 1.1.5: On-line reference library		continuing
Subtask 1.1.6: Development of an informational DVD		Initiated in 2007
Task 1.2: Publications		
Subtask 1.2.1: Wave and Marine Current Energy – Status and Research and Development Priorities (2003)	IEA-OES Document No: T01.2.1	completed
Subtask 1.2.2: Review and analysis of ocean energy systems development and supporting policies (2006)	IEA-OES Document No: T01.2.2	completed
Subtask 1.2.3: Wave Data Catalogue (2007)	IEA-OES Document No: T01.2.3	completed
Task 1.3: IEA-OES workshops, co-sponsored symposiums and organisations of site visits		
Subtask 1.3.1: Workshop, "Ocean Energy The International Energy Agency, United Kingdom and European Commission Programs", Thistle Hotel, Brighton, UK, 30 October 2002		completed
Subtask 1.3.2: Open Session on National Activities, INETI, Lisbon, 26 February 2004		completed
Subtask 1.3.3: Workshop, "Grid Integration of Ocean Energy Systems", Danish Energy Agency, Copenhagen, 5 November 2005		completed
Subtask 1.3.4: Co-sponsored Symposium, "Canada and the World of Ocean Renewable Energy", Royal BC Museum, Victoria, BC, May 4-5, 2006		completed
Subtask 1.3.5: Co-sponsored Symposium, "Water and Energy: Energies from the Ocean and Desalination", UNAM, Mexico city, 22-23 March 2007		completed
Subtask 1.3.6: Workshop, "Environmental Issues and Ocean Energy Systems", 18 October 2007, University of Messina, Italy	IEA-OES Document No: T01.3.6	completed
Subtask 1.3.7: Site visit to a tidal stream plant turbine Kobold from Ponte di Archimede, Messina, 17 October 2007		completed

ANNEX I – TASKS	Deliverable/Ref Doc.	Status
Task 1.4: Participation in relevant events		
Subtask 1.4.1: Presentations in conferences and publications		
Paper published at Proc. of the European Wave Energy Conference (2003)	IEA-OES Document No: T01.4.1	completed
Paper published at Proc. of the 6EWTEC, Glasgow, UK (2005)	IEA-OES Document No: T01.4.2	completed
Paper published at Proc. of WREC, (2005)	IEA-OES Document No: T01.4.3	completed
Paper published at Proc.of the Int. Conf. on Ocean Energy, Bremenhaven, (2006)	IEA-OES Document No: T01.4.4	completed
Paper published at Proc. of the 26th OMAE conference, (2007)	IEA-OES Document No: T01.4.5	completed
Paper published at Proc. of the 17th ISOPE Conference, (2007)	IEA-OES Document No: T01.4.6	completed
Paper published at the 7EWTEC conference, Porto, Portugal, (2007)	IEA-OES Document No: T01.4.7	completed
Task 1.5: Ocean energy statistical information		
Subtask 1.5.1: Global Ocean Power Installed Capacity	IEA-OES Document No: T01.5.1	Initiated in 2007
Subtask 1.5.2: RD&D Investment in Ocean Energy	IEA-OES Document No: T01.5.2	Initiated in 2007
Subtask 1.5.3: Global Wave and Tidal Current Resource	IEA-OES Document No: T01.5.3	Initiated in 2007
Subtask 1.5.4: Economics of the Ocean Energy	IEA-OES Document No: T01.5.4	Initiated in 2007
Task 1.6: Collaborative actions		
Subtask 1.6.1: Collaboration with the IEC – TC 114		Initiated in 2007
Subtask 1.6.2: Collaboration with the IEA RETD		Initiated in 2007
Subtask 1.6.3: Collaboration with the IEA project, "Integration of Renewables into Electricity Grids"		Initiated in 2007

Table 2.1. List of subtasks under Annex I

Task 1.1: Dissemination material

Subtask 1.1.1: Website

The website www.iea-oceans.org is the first source of information about the activities of the IEA-OES. It provides easy access to its major IEA-OES documents: Annex descriptions, reports, newsletter, membership information as well as notification of upcoming events.

Subtask 1.1.2: Newsletter

A printed, colour newsletter is prepared by the Secretary and available on the website every six months to present national activities on ocean energy. Members provide material of interest to the Secretary and ensure that the newsletter reaches its target audience in the respective countries. Further, a brief section includes an update of the technologies "going to the sea". Nine issues of the newsletter had been published by the end of 2007.

The following national developments in the participating countries can be found in the two newsletters published in 2007:

- CEODOURO Project – Implementation of a breakwater integrated OWC power plant in Oporto, Portugal, by João Maciel, EDP Inovação, **Portugal**
- International Symposium on Water and Energy: "Energies from the Ocean and Desalination", by Gerardo Hiriart, UNAM, **Mexico**
- Tidal Current Energy Developments in China, by L. Zhang and K. Sun, Harbin Engineering University, **China**
- Sustainable Development Commission studying tidal power in the UK, by Karla Hill, Sustainable Development Commission, **UK**
- The 7th European Wave and Tidal Energy Conference in Porto, Portugal, September 2007, by António F. O. Falcão, Instituto Superior Técnico, **Portugal**
- Ocean Energy Activities in Mexico, by Gerardo Hiriart, UNAM, **Mexico**
- "Ocean Energy is Making Waves in Renewable Energy" by Kathryn Jeffery, Oceanenergy Limited, **Ireland**

Subtask 1.1.3: Informative poster for exhibitions

A second poster was produced during 2007 and presented at exhibitions. The former poster just covered waves and tidal current energy and this new one is focused further on tidal, OTEC and salinity gradient.

Subtask 1.1.4: Glossary on ocean energy

The Ocean Energy Glossary was prepared under the Co-ordinated Action on Ocean Energy (CA-OE), a three-year project (2005-2007) established and supported by funding from European Commission Sixth Framework Research Program for Energy Environment and Sustainable Development. The primary aim of this glossary is to provide an efficient reference to the ocean energy specific terms for professionals and the general public. Further, it is meant to give some contribution to promoting better practice and use of common concepts in the ocean energy field. Given the role of international organisations in promoting the use of "standard" concepts, the IEA-OES proposed, in collaboration with the CA-OE project, to develop a glossary to influence harmonisation of terminology in Ocean Energy. The Ocean Energy Glossary contains a comprehensive set of definitions of the main terms in the field of wave energy, marine current energy (tidal stream), tidal energy, OTEC and salinity gradient. The definitions in the Ocean Energy Glossary are primarily based on the comprehensive Marine Energy Glossary that was developed by Entec UK Ltd in partnership with the Carbon Trust (2005)[1]. While initial elaboration of the glossary and interpolation towards the first published version was completed by December 2007 within the CA-OE project, the updating will be done under IEA-OES.

Subtask 1.1.5: On-line Reference Library

The On-line Reference Library developed at INETI during 2007 it is under finalisation.

Subtask 1.1.6: Development of an informational DVD

In 2007 started the preparation of the DVD on Ocean Energy with the objective to promote ocean energy as a viable energy resource, and educate decision makers as well as the public about what ocean energy is and how it can contribute to sustainable energy production.

Task 1.2: Publications

The IEA-OES disseminates publications on the IEA-OES website and through the IEA OPEN Energy Technology Bulletin (http://spider.iea.org/impagr/cip/index.htm) which is a newsletter to disseminate the activities within the IEA's energy technology and R&D community.

Subtask 1.2.3: Wave Data Catalogue for Resource Assessment

This catalogue was prepared by the Portuguese delegate, Dr Teresa Pontes from INETI, under the framework of the IEA-OES. This document provides an overview of wave data appropriate for wave energy resource assessment and characterisation; the data is available in the IEA-OES member countries. In addition to collating and comparing such information, the report will serve to inform discussion on weather a new Annex on resource assessment should be pursued at this time.

The catalogue is based on existing wave data collected via a questionnaire provided to each member country, observers and targeted observers, and complemented by a web search, and focuses:

- In situ data: wave data collected by moored data buoys, measurements made from fixed platforms and their characteristics (location, water depth, availability);
- Remote sensed data: satellite/radar in use and their characteristics (sensor, coverage, availability, exact repeat period);
- Wind-wave numerical model results: their identification, description and coverage, as well as other technical information.

[1] http://www.carbontrust.co.uk/technology/technologyaccelerator/glossary.htm

Task 1.3: IEA-OES workshops, co-sponsored symposiums and organisations of site visits

Subtask 1.3.5: Co-sponsored Symposium "Water and Energy: Energies from the Ocean and Desalination"

The International Symposium on Water and Energy: Energies from the Ocean and Desalination was held during 22 and 23 March 2007 at the National University of Mexico (UNAM), co-sponsored by the IEA-OES. An average of 100 persons attended daily the two-day meeting. Thirty papers where presented from 18 different countries and a round table at the end was organised with the participation of five Mexican institutions where they discussed the necessary steps to improve the survey of currents, waves and tides in the national seas.

Presentations were made about the policies to promote the ocean energies by the United Kingdom, USA, Canada, Portugal and Germany. Several presentations were made about technical developments by representatives of Brazil, Australia, Korea, Italy, Canada, Germany, Scotland, Norway, Denmark and Portugal. Other countries such as Chile, Russia and Dominican Republic, presented their vision about the future of those energies in their countries. The Mexican delegation presented the possibilities of tidal storage, tidal currents generation, wave pumping and generation, hydrothermal vents in the Gulf of California to generate electricity and new ideas to desalinate sea water. According to the participants, it was a very good meeting where the exchange of information and getting acquainted with each other were the main points.

Symposium "Water and Energy: Energies from the Ocean and Desalination" Pat Leahy Acting (Director of the US Geological Survey), Sergio Alcocer (Director of the Institute of Engineering of UNAM), Ruben Flores (Undersecretary of Electricity of the Ministry of Energy), and Gouri Bhuyan (IEA-OES Chairman).

Subtask 1.3.6: Workshop "Environmental Issues and Ocean Energy Systems"

The IEA-OES held a workshop on 18 October, 2007 in Messina, Italy, entitled "Potential Environmental Impacts and Ocean Energy Devices." The workshop was held as a gathering of experts to identify environmental research needs and areas for international collaboration on the issue of environmental impacts and ocean energy devices. Expert representatives from various countries presented information on new ocean technologies, testing facilities, research results relating to environmental impacts, risk decision making, and lessons learned from demonstrations of ocean energy devices. Following the presentations, an open discussion period was held to identify priorities and to consider forming an annex to address research and development dealing with environmental effects: it was generally felt that the IEA – OES can play a role in alleviating some of the potential environment-related barriers facing ocean energy technology penetration. There seems to be a lack of understanding by stakeholders regarding the potential environmental impacts associated with these devices.

A summary of the presentations from each of the invited experts, main discussion topics and recommendations are included in the Workshop Proceedings produced by National Renewable Energy Laboratory (USA) & Natural Resources Canada (Canada).

Subtask 1.3.7: Site visit to a tidal stream plant – Kobold turbine from Ponte di Archimede

Since 2001, a pilot tidal turbine plant called ENERMAR has been moored in Italy's Strait of Messina, close to the Sicilian coast, about 150 m offshore in waters 18 m to 25 m deep. This project was developed by "Ponte di Archimede S.p.A." (Messina, Italy).

Ponte di Archimede (PdA) is planning on participating in some tasks of the IEA-OES on behalf of Italy. The 13th Executive Committee meeting (October 2007) was hosted by PdA and included the organisation of a site visit to the pilot tidal plant.

The purpose of the ENERMAR project is to demonstrate the exploitation of marine currents by means of an innovative patented Kobold turbine. This turbine can be defined as a vertical axis hydro turbine able to convert the kinetic energy contained in the marine currents into mechanical energy. The numerical modeling of the turbine to predict the turbine behavior and output rate was developed at the Department of Aeronautical Engineering of University of Naples. This numerical activity was coupled with experimental activities with wind tunnel tests of a larger model of the Kobold turbine.

Global efficiency of the system has been measured to be around 25%, computed as a ratio between the produced mechanical power and the theoretical power available in the current.

Ponte di Archimede is interested in exporting knowledge of its device. Studies are currently in progress to provide renewable energy to remote islands in the Republic of China, the Philippines and Indonesia by installing turbine farms of the patented ENEMAR system. This is an ongoing project together with UNIDO – the United Nations Industrial Development Organisation – and the governments of the three countries.

Kobold turbine visited by the IEA-OES group

Task 1.4: Participation in relevant international events and meetings

The IEA-OES continued to strengthen its dissemination activities through presentations in events, conferences and symposiums relevant to ocean energy. The Chair and Vice-Chair attended various meetings and workshops organised by the IEA Secretariat. Members of the Executive Committee attended several national and international conferences and presented the activities of the IEA-OES during 2008.

UKERC (UK Energy Research Centre) road mapping event, Oxford (January 2007)

IEA-OES Vice-Chair, Mrs. Katrina Polaski, attended a two day workshop aimed to gain consensus around a research road map for ocean energy for the UK and for other jurisdictions. The workshop was organised by Dr. Markus Meuller of Edinburgh University. The presentations by attendees of the workshop were meant to provide examples and an understanding of the planning and needs assessment work done by other bodies working on marine renewables. The presentation from the IEA-OES was focused on the matrix of barriers and objectives included in the IEA OES Strategy document for 2007 – 2011. It was recommend the IEA-OES to continue engaging with the UKERC on the road mapping exercise and consider providing, through Annex I, some facility for continuing the project and broadening it to make it applicable beyond the UK.

FP7 Ocean and Wind Technologies EU Conference, Dublin (28 February 2007)

The European Commission, with support from Ireland, organised a Major European Conference and Brokerage Day on "European Ocean and Wind Technologies" within the EU RTD 7th Framework. The Conference, hosted by Sustainable Energy Ireland (SEI) and the European Commission representation in Ireland, included expert participants from EU member states and representation from Irish R&D organisations and industries within the Energy and Ocean Technology sectors. The main objectives of the day were to inform about the content of the Energy Work Program, the first call for proposals and future R&D FP7 Research priorities. IEA-OES Vice-Chair, Mrs. Katrina Polaski, participated in this event and launched the IEA-OES report, "Review and analysis of ocean energy systems development and supporting policies", the report prepared by Future Energy Solutions, UK, for Sustainable Energy Ireland, on behalf of the IEA's Implementing Agreement on Ocean Energy Systems.

IEC Standardisation Management Board (SMB) meeting, Geneva (June 2007)
With an invitation from the Chair of the SMB of the International Electrotechnical Commission (IEC), the Chair attended the meeting of the IEC SMB meeting, held in Geneva in June. He also made a presentation on behalf of IEA-OES to the SMB.

OMAE 2007, San Diego, California (June 2007)
T. Pontes, delegate from Portugal, presented her paper, "Implementing Agreement on Ocean Energy Systems", published in the Proceedings of the 26th International Conference on Offshore Mechanics and Arctic Engineering (OMAE) 2007, June 2007.

ISOPE 2007, Lisbon (July 2007)
A. Brito Melo, as Secretary of the IEA-OES, presented the paper, "Ocean Energy Systems Implementing Agreement: An International Collaborative Program" published by A. Brito-Melo, G. Bhuyan, K. Nielsen, K. Polaski, T. Pontes and G. Shanahan, in Proceedings of the 17th International Offshore and Polar Engineering Conference, Lisbon, 1–7 July, 2007.

Energy Ocean 2007, Oahu, Hawaii (August 2007)
Walt Musial, as delegate from USA, presented the "International Energy Agency's Implementing Agreement on Ocean Energy Systems (IEA–OES)."

7th European Wave and Tidal Energy Conference, Porto (September 2007)
Gouri Bhuyan, as Chairman of the IEA-OES, presented the paper "The Strategy for the Next Five Years – International Energy Agency's Ocean Energy Systems (IEA-OES) Implementing Agreement" by G. S. Bhuyan and A. Brito-Melo.

Participation in IEA Events

IEA Technology Fair at the IEA Ministerial Meeting, Paris (May 2007)
Documents published by the IEA-OES were distributed in the IEA Technology Fair during the IEA Governing Board at Ministerial level.

51st Renewable Energy Working Party (REWP) meeting, Paris (March 2007)
Attended by the IEA-OES Vice-Chair Katrina Polaski.

52nd REWP meeting and IEA meeting "Trading and Transmission: a Roundtable", Berlin (October 2007)
Attended by the IEA-OES Chairman.

South Africa Networks of Expertise in Energy Technology (NEET) Workshop, South Africa (February 2007)
This workshop was intended to be the first of a series stimulated by the request of the G8 and the IEA Governing Board with the aim of facilitating co-operation with the international business community and developing countries. During this workshop, IEA Working Parties and IAs had the opportunity to present and discuss with the South African stakeholders from government, industry, research, and academia what energy technology collaboration can achieve. The IEA-OES was represented in this workshop by Ms. Alla Weinstein, director of the EU-OEA (European Ocean Energy Association), observer in previous IEA-OES ExCo meetings, and requested by the ExCo to present the IEA-OES in the NEET workshop on behalf of the IEA-OES.

Brazil NEET Workshop, Brasilia (November 2007)
This workshop organised by the IEA in collaboration with the Ministry of Mines and Energy (MME), was attended by the IEA-OES Chairman.

Task 1.5: Ocean energy statistical information

The IEA-OES aims at gathering statistical information and members and observers were requested to start collecting this information on a national level.

Subtask 1.5.1: Global Ocean Power Installed Capacity

In response to IEA's REWP request on data on cumulative installed generation capacity in electricity sector, the IEA-OES started to compile information based on feedback received from various members and observers on the ocean energy installed capacity or under installation.

Subtask 1.5.2: RD&D Investment in Ocean Energy

In response to IEA's REWP request on data on RD&D trends relating to ocean energy for the time period of 1990 through 2006, the IEA-OES started to compile information from the members in order to complement or fill in the gaps in the official IEA statistics.

Subtask 1.5.3: Global wave and tidal current resource characterisation

In the March ExCo meeting, a new activity was suggested on characterisation of the scale of the global resource for different countries. A small working group on tidal resource was proposed with the aim of presenting a proposal to be discussed in forthcoming meetings. It was reinforced the need of the IEA-OES to generate theoretical resource opportunities for different forms of ocean renewable resources in a country basis, in very simplified terms but backed by published scientific documents.

Subtask 1.5.4: Present economics of ocean energy

The ExCo discussed the need for the IEA-OES to provide authoritative information related to present and future economics of ocean energy. Members agreed on the importance of a task that would provide information to the IEA. Relevant reports and information generated through Carbon Trust, other recent publications, and other European initiatives will be reviewed to produce a brief summary on present cost of wave/tidal current demonstration projects, future cost of plants and cost of energy based on certain policy scenarios and assumptions (learning rates, installations, etc.) for the ExCo to review and possibly adopt the information at a later stage for input to IEA.

Task 1.6: Collaborative actions

Subtask 1.6.1: Collaboration with the IEC

Further to the resolution from the last ExCo meeting on IEA-OES's willingness to provide input to IEC on their proposed standard-making activities, the Chair sent a letter to the Standardisation Management Board (SMB) of IEC and subsequently attended IEC SMG meeting held in Geneva on 5 June and provided the necessary recommendation to the SMG. On behalf of the ExCo, the chair provided a conditional commitment that the IEA-OES would assist the IEC standardisation process through the Operating Agents of Annexes I, II and III.

Subtask 1.6.2: Collaboration with the IEA RETD

At the ExCo meeting in March 2007, a discussion was held on the possibility of collaborating with the IEA Implementing Agreement on Renewable Energy Technology Deployment (RETD). The ExCo agreed to collaborate on one of their projects involving development of a model for estimating societal costs and benefits related to renewable energy deployment. This calculator, "RecaBS – Renewable Energy Costs and Benefits to Society", was developed by RETD with the primary objective of estimating the costs and benefits of electricity from renewable energy sources to conventional technology. Wave energy was included in this model.

Further, by the end of 2007, the IEA-OES had received an invitation from the RETD to explore and identify areas of mutual interest and to prepare a joint project proposal that could maximise the synergies between the agreements in order to deliver a comprehensive report on ways to accelerate the deployment of offshore renewable energy technologies. This project can benefit from the work of the offshore wind experiences and is expected to include an offshore energy deployment framework, substantiated by evidence-based analyses, and recommendations for future policies design, including best practices for allocation of seafloor rights for national and regional policy makers, utilities and project developers.

Subtask 1.6.3: Collaboration with the IEA project "Integration of Renewables into Electricity Grids"

The ExCo agreed to collaborate with the project undertaken by the IEA called "Integration of Renewables into Electricity Grids" to provide insight into technical and policy issues in this area (2007-2008). The Chair attended two expert meetings in 2007, the first meeting held in Paris in May dealt with the technological issues, and the second meeting held in Berlin in October dealt with policy, market and regulatory issues. He also provided inputs to a draft report prepared by IEA's contractor. The report is expected to be published by the IEA Secretariat prior to the G8 meeting in Japan in 2008.

Expected deliverables planned for 2008

More active collaborations during 2008 through the current Annexes and potential new Annex are expected. Some of the expected deliverables planned for 2008 can be summarised as below:

- The informational DVD on ocean energy will be concluded.
- Further discussion on environmental issues and establishment of a new Annex on the topic are expected.
- Specific activities related to policy, resources and economics of ocean energy will be initiated.
- Collaboration with the IEA RETD IA for carrying out projects on accelerating the deployment of offshore renewable energy technologies will be initiated.
- Task reports from some of the work packages of the current Annex II and III are also expected in 2008.
- Enhanced networking activities through participation in different IEA events to increase memberships will be pursued.

Annex II: Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems

Operating Agent: The Ministry of Environment and Energy, Danish Energy Agency (acting through RAMBØLL), Denmark.

Overall objectives

The objective of this Task is to develop recommended practices for testing and evaluating ocean energy systems and, in this way, to improve the comparability of experimental results. This Annex was extended in 2006 to address prototypes and the overall objective of the extended work program is to provide the necessary basis in order to present the performance of different ocean energy systems in a comparable format.

Launch of the new work program

The extension of the work program of Annex II was launched in February 2007. The new work program has the following specific tasks and deliverables:

Task 2.1: Generic and site related wave and tidal data
Four generic scatter diagrams that reflect typical wave conditions and typical tidal flow conditions at different member states' coast lines will be compiled. The goal is to enable comparison between the performance of different wave energy systems and of different tidal energy systems.

Task 2.2: Development and evaluation protocol for ocean energy systems
The objective of the protocol is to provide a document that in simple terms explains steps needed in the development of ocean energy systems. The protocol aims at explaining in a common language the objective and expected outcome of each step for developers and supporting bodies. Criteria for moving from one step to the next will be explained and discussed.

Task 2.3: Guidelines for open sea testing and evaluation of ocean energy systems
Guidelines for different types of ocean energy systems will be compiled based on best practice and experience from the ocean energy community.

Summary and accomplishments for 2007

February 2007 saw the launch the Annex II extended work program with experts from several countries in a Kick-off meeting hosted by the UK Department of Trade and Industry, at the DTI Conference Centre, London. The Work program of Annex II was reviewed and the leaders of each subtask were selected.

During 2007, much interest in the development of standards for ocean energy has been seen especially in connection with the testing ongoing at EMEC in the UK and several draft guidelines have been prepared. Some of these have been discussed on the EU level under the Co-ordinated Action on Ocean Energy, and a separate EU proposal "EquiMar" (*Equitable testing and Evaluation of Marine Energy Extraction Devices in terms of Performance, Cost and Environmental Impact*) that focus on standards was submitted by Edinburgh University and selected for funding during 2007. Further the IEC standardisation body announced in 2007 that it will develop standards for ocean energy trough the activities of the IEC TC 114. National standardisation committees are being formed and the first international meeting will be held during 2008.

It is the vision that the Annex II extension guidelines can help form the general picture of the focus areas that need to be addressed in the more detailed standards and interact with the standards being developed.

List of countries participating in the Annex

PARTICIPATING MEMBERS*	
Task 2.1: Generic and site-related wave and tidal data	
Task 2.1.1 Generic and site-related wave data	**Portugal**, Denmark, Canada, Ireland, USA, Norway and Belgium
Task 2.1.2 Generic and site-related marine current data	**Canada**, USA, UK, Norway and Ireland
Task 2.2: Development and evaluation protocol for OES	
Task 2.2.1 Development protocol wave	**Ireland**, Denmark, Canada, UK, Norway, Portugal and Belgium
Task 2.2.2 Development protocol tidal	**UK**, Canada, Ireland, Norway and Mexico
Task 2.3: Guidelines for open sea testing and evaluation of OES	
Task 2.3.1 Monitoring and data acquisition wave and tidal	**UK**, Canada, Ireland, Portugal, Norway, Denmark, USA
Task 2.3.2 Data preparation and presentation of results wave and tidal	**Ireland**, Canada, UK, Portugal, Norway, Denmark, USA
Task 2.3.3 Guidelines on design, safety and installation procedures wave and tidal	**UK**, Canada, Ireland, Portugal, Norway, Denmark and USA

*Task leaders are in bold

Key Deliverables planned for 2008

During 2008, it is the plan that each task leader provides a draft report on what is seen as best practice on his or her respective task. The draft reports will be based on ongoing activities and existing information available to the task leader at this point in time. These reports will then be compiled by the operating agent and circulated among all participants for comments and discussion.

Annex III: Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids

Operating Agent: Powertech Labs Inc., Canada

Objectives

The primary purposes of this Annex are to conduct co-operative research into the generation, transmission and economics of integrating ocean energy into electrical grids and to provide a forum for relevant information exchange. Specific objectives of the Annex are as follows:

- Identify potential differences and opportunities associated with the integration of wave and tidal current energy plants into electrical grids, in comparison with wind energy
- Develop a relevant interconnection guideline for electrical utilities and project developers who are considering connecting pilot wave and tidal current projects to the grids
- Create a comprehensive database for characterizing well-advanced wave and tidal current conversion systems
- Demonstrate the integration of wave and tidal current energy plants into electrical grids through case studies involving simplified network modeling techniques, and identify the near-term and longer-term practical level of the ocean power that could be integrated in target geographical areas for a member country
- Coordinate the work of this Annex with relevant activities being carried out within IEA and by individual participating members

Subtasks and Activities

The new work program has the following specific tasks:

Subtask 3.1: Identify issues and opportunities

The scope of this subtask includes identifying integration issues that are different from those involved with the integration of wind energy and the opportunities associated with the integration of ocean energy. Based on an analysis of the issues and opportunities, , an interconnection guideline will be developed.

Subtask 3.2: Describe the dynamic characteristics of ocean energy electricity generators

The scope of this subtask includes:

- Reviewing the steady-state power characteristics of device types
- Developing dynamic models for devices
- Analyzing the impact of a wave/tidal current generator on the design of an offshore network

There are a wide variety of energy conversion chains associated with harnessing power from waves and tidal currents. These variations are associated with both the mechanical and the electrical sub-conversion systems. For example, a particular conversion process could have air turbines, hydraulic turbines, hydraulic pumps, reciprocating devices or propeller types. As well, different types of electrical generators are used in the conversion chain, such as synchronous, induction, permanent magnet and linear generation. Ocean power generators may or may not have governors or voltage regulators, and they may be connected through inverters or other types of power conversion equipment. So there are many options to be considered.

There is a need to gather and develop an authoritative, comprehensive and unbiased dynamic characteristics of relevant wave and tidal current conversion technologies, and to present results in such a way that these models can be easily used for carrying out load flow and network stability analysis.

Subtask 3.3: Identify the near-term and longer-term practical potential of ocean power, through case studies involving the integration of ocean energy plants with distribution and transmission networks

The scope of this subtask includes carrying out case studies involving network modeling for integrating ocean energy plants into distribution and transmission networks.

Specific case studies involving some target market areas within participating countries will also determine the present capacity limits for integrating ocean energy resources. The case studies will determine what

could be obvious market potential for ocean energy resources in these target areas, and the associated distribution and transmission grid upgrading costs, considering future scenarios. These simplified case studies must consider a system-wide perspective. They could also include a cross-boarder network analysis to determine capacity and identify congestion.

Contributions from the participating members for this subtask will be in the form of case studies that:

- Illustrate network modeling
- Identify:
  - Grid constraints and limitations
  - The synergy of integration with other renewable energy forms such as:
    - Offshore wind combined with offshore wave
    - Ocean renewable energy combined with hydropower and other types of generation

Subtask 3.4: Coordinate activities

The scope of this subtask is primarily to coordinate the activities of this Annex with other relevant IEA implementing agreements and initiatives.

Participating Countries

In 2007, the United Kingdom, Ireland and Canada confirmed their participation in this Annex. It is expected that other countries will join this Annex in 2008.

Achievements and Progress in 2007

A kick-off meeting for the Annex, hosted by the UK Department of Trade & Industry, DTI (currently known as Department for Business, Enterprise and Regulatory Reform, BERR), was held in London on February 22, 2007, to finalize the proposed work program and identify members interested in participating in different work packages. The Executive Committee approved the revised work program in March 2007.

Subtask 3.1 was started in September 2007. With a contribution from the Canadian participant, significant progress with this subtask was made in 2007. Inputs to this subtask from other participating members will be sought in early 2008.

The grid integration of renewable resources becomes convenient and manageable if prediction methods are effective. Also, the nature and extent of resource variability may play an important role in accommodating alternative power generation plants into the electric grid. Unlike many other renewables, the tidal energy resource at a particular area is perfectly predictable for years ahead. The expected cyclic characteristic of aggregated power generation from a tidal current turbine farm could be viewed similarly to that of the power generation from tidal barrage plants that have been operated commercially for decades. In essence, a tidal current turbine farm could effectively be dispatchable. Even though forecasting tools have not yet been developed for wave resources, the accuracy of predicting wave resources in a particular area is higher than that for wind resources. It should be noted that electrical power generated from ocean thermal gradient and salinity gradient resources are expected to be firm output.

Some wave energy conversion devices, especially those with an intermediate conversion process, may inherently allow energy storage for short time durations. This acts as a low-pass filter removing some of the high-frequency power oscillations generated from wave variations or device operation. As shown in Figure 2.1, wave energy converters that incorporate a hydraulic power take-off with accumulators[2] or reservoirs for artificial head creation[3] may eliminate the oscillations at the front-end conversion and produce a relatively time-averaged output.

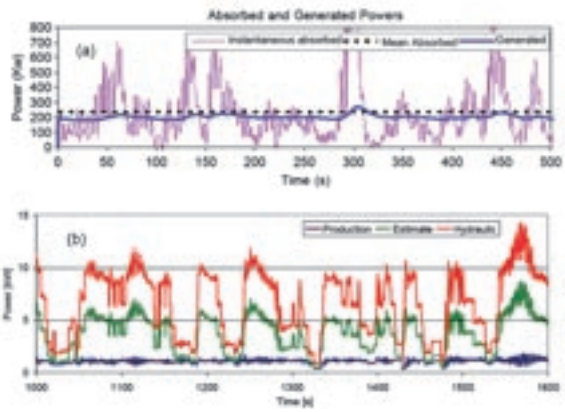


Figure 2.1: Averaged power output from a wave energy device, examples of (a) hinged contour device (b) overtopping device

[2] Ross Henderson, "Design, simulation, and testing of a novel hydraulic power take-off system for the Pelamis wave energy converter", Renewable Energy, no. 31, pp. 271–283, 2006.

[3] P. Frigaard, J. Tedd, J.P. Kofoed, E. Friis-Madsen, "3 years experience with energy production on the Nissum Bredning Wave Dragon Proto Type."; CA-OE workshop, Lisbon, Nov. 2006.

The presence of a wide variety of ocean energy systems, especially wave power converters, makes it challenging to study their design and operational characteristics. Such investigations are critical in developing numerical models and analyzing the impact of these systems on electrical networks. Most tidal stream generators are analogous to wind turbines, and they mostly utilize designs, concepts, and equipment that partly originated in the wind industry (see Figure 2.2). In sharp contrast to wind and tidal turbines, wave energy converters operate on diverse principles and may require cascaded conversion mechanisms. Although tidal turbines can be viewed through the established terms and definitions used in the wind energy literature, studying ocean energy devices poses a unique challenge. Different systems operate on different methods of wave-device interaction (such as heave, pitch, or surge) and may need pneumatic, hydraulic or mechanical power take-off methods.

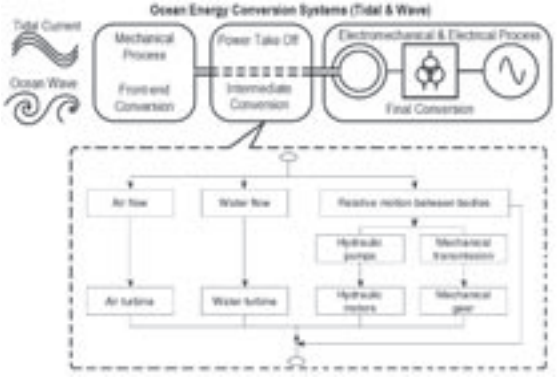


Figure 2.2: Diversity of wave and tidal current converter system structures[4]

It is important to identify and realize the possible extent of power quality and network interaction issues pertaining to ocean energy conversion methods, since their integration into the electric power system is subject to a multitude of design, operational and economic factors. While the nature and extent of such impacts posed by ocean power plants is interrelated with all of these issues to varying degrees, several fundamental areas deserve more attention[5].

The terminating areas of an electrical system, where ocean power development activities may well take place, are typically rated for supplying only a limited load. Subject to geographic location, network strength and load/generation scenarios, many ocean energy plants may see distribution systems and weak transmission networks as their first interface layer to the grid. Thermal limits and switchgear ratings of such electrical networks may require capacity enhancement if ocean power projects are to take place.

A number of power quality issues are typically attributed as localized effects, in the neighbourhood of a sizable power plant or electric load. Such effects include steady-stage voltage rise, flicker and harmonics emission, switching phenomena and reactive power flow.

Electrical networks are designed and operated while the line-voltages are maintained within standard values. With a time-varying generation station (such as wave or tidal), the voltage profile throughout the network could take more non-linear and complex shapes, especially in the vicinity of a power plant coupled to a weak network. Such additional generation may force the steady-state voltage to rise, exceeding the prescribed limits. Unless proper mitigation and averaging schemes are in place, resource variations may contribute to this factor[6].

In addition to the localized effects described above, other factors relevant to larger power systems and their study domains (stability, load flow, ancillary services, fault ride-through, etc.) may also require attention. This depends on the type and scale of ocean power plants and on the mechanism of their integration. Since the technology has not reached that level of maturity, this area would require further assessment through case studies and system modelling.

Plans for 2008

Contribution from participating members from the UK, Ireland and others for subtask 3.1 will be sought. A final subtask report will be prepared for the participating members.

Activities for subtasks 3.2 and 3.3 will begin during early 2008. As part of subtask 3.4 activities, progress of this Annex will be coordinated with other relevant IEA and external activities.

An annual progress meeting will be held in 2008.

[4] Powertech Labs Report on An Assessment of Variable Characteristics of the Pacific Northwest Region's Wave and Tidal Current Power Resources, and their Interaction with Electricity Demand & Implications for Large Scale Development Scenarios for the Region; Phase 1;Report No: 17458-21-00; Dec 2007, Sponsored by the Bonneville Power Administration, British Columbia Hydro, and BC Transmission Corporation.
[5] Econnect Consulting, Ocean Energy Conversion Expert Group, Report from Meeting in Vancouver, April 2006, project No: 1698.
[6] Department of Trade & Industry (DTI), UK, "Development, Installation and Testing of a Large scale Tidal Current Turbine, Tech. Report Contract No: T/06/00210/00Rep.

3. Global Activities and Technology Status

Oceans constitute more than two-thirds of the earth's surface and act as a large collector of solar energy. This concentrated energy is transferred through complex wind-wave interactions into wave motion. In addition, tidal variations are created due to earth-moon gravitational pulls, rotational tilt and rate of spinning. Global hydrological cycles, climatic conditions and geographic features contribute to other forms of energy flux.

Ocean renewable energy resources can be broadly categorized into: (a) Tides, (b) Waves, (c) Tidal (Marine) Currents, (d) Temperature Gradients, and (e) Salinity Gradients[7].

Tides: Potential energy associated with tides can be harnessed by building barrage or other forms of construction across an estuary.

Waves: Kinetic and potential energy associated with ocean waves can be harnessed using modular technologies.

Tidal (Marine) Currents: Kinetic energy associated with tidal (marine) currents can be harnessed using modular systems.

Temperature Gradients: Thermal energy due to the temperature gradient between the sea surface and deepwater can be harnessed using different Ocean Thermal Energy Conversion (OTEC) processes.

Salinity Gradients: At the mouth of rivers where fresh water mixes with salt water, energy associated with the salinity gradient can be harnessed using pressure-retarded reverse osmosis process and associated conversion technologies.

Tidal energy is predominant in certain locations because of their unique geographic formations and strong tide conditions, as shown in Figure 3.1. The estimated annual potential of global theoretical tide and marine current resources is in the order of 300+ TWh and 800+ TWh, respectively. Strong wind variations within 30° to 60° latitudes and circumpolar storms near the southern latitude account for high-energy ocean waves in those areas, as shown in Figure 3.2. The theoretical wave energy potential is estimated to be 8,000 to 80,000 TWh per annum. Significant temperature gradients in tropical coastal areas, as shown in Figure 3.3, indicate opportunities for OTEC within the Tropic of Capricorn and the Tropic of Cancer. The global theoretical potential of ocean thermal gradients and salinity gradients is estimated to be 10,000 TWh and 2,000 TWh, respectively. Although the practical level of these ocean renewable resources will be a fraction of the theoretical levels, it is on the same order as that of the present capacity of electricity generation worldwide.

Other renewable ocean resource concepts such as hydrothermal vents, along with the hybridization of the aforementioned schemes, are also being pursued for energy utilization. With the emergence of novel concepts and the reported success of several deployments, the ocean renewable energy sector, especially the field of tidal current and wave energy conversion technologies, has gained significant attention throughout the world.

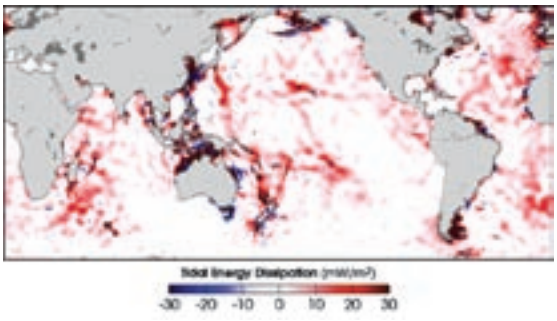


Figure 3.1: Tidal energy dissipation[8]

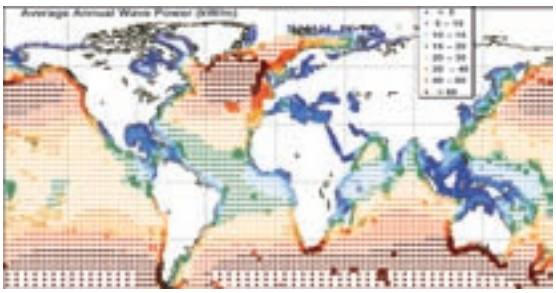


Figure 3.2: Wave energy intensity distribution[9]

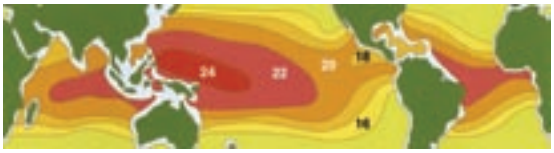


Figure 3.4: Water temperature (°C) difference between ocean surface and 1000 m depth[10]

[7] Polinder, H. ; Scuotto, M., "Wave Energy Converters and their Impact on Power Systems", in International Conference on Future Power Systems, Nov. 2005.
[8] NASA. (2007, Nov.). [Online]. Available: http://science.hq.nasa.gov/missions/satellite 14.htm
[9] Data from the ECMWF, European Centre for Medium-Range Weather Forecast
[10] Presentation by Dr. Ikegami, the Sage University, Japan, Symposium on Canada & the World of Ocean Energy, 2006

Further to the evaluation of the development of ocean energy technologies, as reported in the IEA-OES 2006 report, additional evaluation of the technologies and their development status was carried out in 2007[11]. Ocean energy systems are being developed in a number of countries, as shown in Figure 3.4, with the United Kingdom leading the development effort, followed by the United States. Canada and Norway also have a significant number of technology development activities.

The current development status of the harnessing of ocean renewable energy resources was analysed, as defined below:

***Commercial*:** Technologies that have been operating on a commercial basis for a significant period of time

***Pre-Commercial*:** Systems that are claimed to be at a level of advancement where commercial deployment is reasonably expected within a few years

***Full-Scale*:** Devices or concepts that have seen at least one full-cycle development regardless of their scope of commercial production or present status

***Part-Scale (Sea)*:** Technologies that have undergone tests in the sea (part of the full system or part-scale model of the prototype)

***Part-Scale (Tank)*:** Devices, concepts, and prototypes that are in the research and development phase undergoing tests in a laboratory environment

***Concept Design*:** Systems that have attracted attention due to their unique and promising features, and that may or may not be realized in the future

The maturity of the ocean renewable energy conversion technologies is shown in Figure 3.5. Several tidal barrage plants, with a capacity up to 240 MW, are operating on a commercial basis worldwide, and new initiatives on these types of development are also in progress in selected countries. Several ocean wave technologies are expecting pre-commercial deployment in Europe. A number of demonstration projects in the range of 1 to 3 MW are awaiting deployment throughout the world, especially in the wave and tidal (marine) current conversion category. Conversion technologies for harnessing energy associated with ocean thermal gradients and salinity gradients are at the research and development stage.

Authors: Gouri Bhuyan and Jahangir Khan, Powertech Labs, Canada

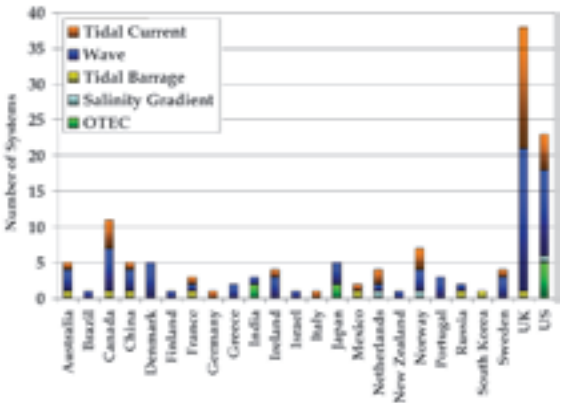


Figure 3.4: Ocean energy-related research, demonstration and commercial activities as of Dec. 2007

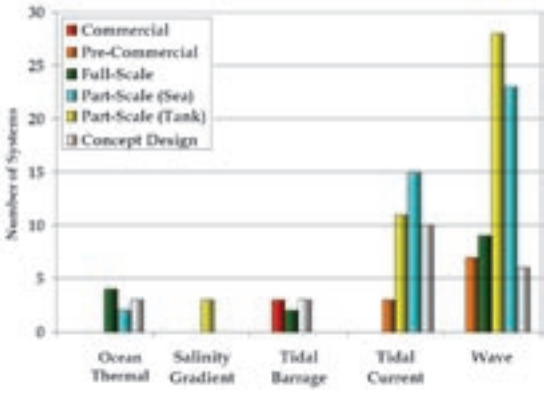


Figure 3.5: Technology maturity of various ocean energy conversion schemes

[11] An Assessment of Variable Characteristics of the Pacific Northwest Region's Wave and Tidal Current Power Resources, and their Interaction with Electricity Demand & Implications for Large Scale Development Scenarios for the Region'; Phase 1; Powertech Labs Report No: 17458-21-00, Sponsored by Bonneville Power Administration, British Columbia Hydro and BC Transmission Corporation, December 2007.

4. Ocean Energy Systems Promoting Policies

"Generally, government funding for ocean energy RD&D is growing... As several technologies are nearing the market deployment and pre-commercial stage, some governments are reacting by proposing market support mechanisms to cover the current cost gap, and consenting arrangements to accelerate the rate of deployment while advancing industry learning and improving cost competitiveness."

"Review and analysis of ocean energy systems development and supporting policies", A report for the IEA's Implementing Agreement on Ocean Energy Systems on behalf of Sustainable Energy Ireland , 2006

Governmental Policies

The IEA categorises[12] policies into three groups that affect technology development and market uptake:

- **Research and innovation policies** that help to develop emerging and improved technologies (e.g., government dedicated research, development and demonstration RD&D programs).
- **Market deployment policies** that underwrite the cost of introducing technologies into the market to improve technical performance and to encourage development of an industry (e.g., market deployment support mechanisms).
- **Market-based energy policies** that provide a competitive market framework, and may internalise externalities in terms of energy security, environmental protection and economic efficiency.

Considering most of the ocean energy conversion technologies being at different stages of development, and some being new and at an early stage of development compared to other renewable and conventional generation technologies, a broad range of targeted national and regional policies is necessary to enable deployment of ocean energy world-wide.

By end of 2007, there are only a small number of countries that have a longer-term target deployment of ocean power, and have implemented a relevant national policy. The following sections provide a summary of these policy initiatives:

The **United Kingdom (UK)** is the leading country in which a specific market-based energy policy has been developed in the last years towards the development of wave and marine currents energy. Some specific policy instruments related to ocean energy are capital grants, obligations, tradable certificates, guaranteed prices (feed-in tariffs), and regulatory and administrative rules.

In **Ireland,** the Government launched, in March 2007, the White Book "Delivering a Sustainable Energy Future for Ireland", which set a target deployment of 500 MW of ocean energy power by 2020. This document followed the strategy document for ocean energy launched in 2006 by the Irish Government.

In **Portugal**, the government launched an attractive feed-in tariff of up to 26 c€/kWh for the demonstration phase (which decreases for the pre-commercial and commercial phases), and a pilot zone with simplified licensing procedures designed to support both the initial phase of the demonstration and the pre-commercial and commercial phases of wave energy utilisation.

In **Spain,** there is no national strategy for ocean energy, however one Spanish region – the Basque Country – has a target 5 MW of installed wave power by 2010 and for that purpose, an investment of 15 M€ has been allocated.

In **France,** a first governmental initiative took place in ocean energy: a new law setting a feed-in price of 15 c€/kWh for electricity produced using wave energy was launched in March 2007.

In **Denmark**, since the end of the Danish Wave Energy development program in the year 2002, there has been no dedicated development policy on ocean energy. However, interest in developing wave energy technology among developers is growing in Denmark, with much work carried out on a private basis.

In **Sweden**, activities in wave energy have achieved considerable developments in 2007 with funding from the Swedish Energy Agency, a governmental entity.

In **Norway** the world's first prototype on osmotic power is under construction and further research activities and developments on wave energy and tidal energy are taking place with support from the Norwegian government and through EC funding.

[12] Source: Renewable Energy, Market and Policy Trends in IEA Countries, IEA, 2004

In **Germany,** there is a continuing high interest in ocean energy with relevant R&D activities into developing wave, tidal current and osmosis power in the framework of mainly European research projects. Germany offers investment and production tax credits as well as a feed-in tariff for ocean energy system developments and projects.

During 2007 a number of ocean energy projects were running under the Sixth Framework Program (FP6) of the **European Commission**, and the projects selected in 2007 under the FP7 program (2007 –2013) for EC funding are expected to start during the first half of 2008. Further, the EC adopted a Communication setting out its vision for an Integrated Maritime Policy for the EU on October 2007, with a detailed action plan setting out an ambitious work program for the years ahead.

In the **USA**, public funding at the State level was available for setting a wave energy test site and trust in Oregon. A new streamline-permitting procedure for ocean energy systems was announced during 2007.

During 2007, the Government of **Canada** announced programs that can assist in supporting the ocean energy industry in Canada, and is working along with provincial governments on interim regulatory approaches for offshore renewable energy. The Nova Scotia provincial government initiated a Strategic Environmental Assessment process for ocean energy in the province. Also, the provincial governments of British Columbia and New Brunswick released respective policy on allocation of crown lands for ocean energy related projects.

In **New Zealand,** the principal change in 2007 was the introduction of the *Energy Strategy and Energy Efficiency and Conservation Strategy*, in particular the announcement of the Marine Energy Deployment Fund. Marine energy was for the first time explicitly included in NZ Governmental policies and several projects are taking place at various stages of development.

In **Brazil**, by end of 2007, ocean energy was included, for the first time, in the Science and Technology plan approved by the Ministry of Science and Technology, and a wave energy prototype is under development with public funding.

In **South Africa**, a national research program in renewable energy, including ocean energy, was launched by the newly formed South African National Energy Research Institute (SANERI). In addition to the targets set by the SA Government in the White Paper, the Western Cape Provincial Government announced in June 2007 that it will source 15% of its energy from renewables by 2015.

In **India**, the interest in ocean energy continues with main research activities on ocean energy conducted at NIOT, the technical arm of the Ministry of Earth Sciences of the Government of India, on low temperature thermal desalination and wave energy for remote islands.

In **Japan**, following the "Basic Law of the Sea" launched in mid-2007, the Japanese government is starting to prepare a maritime plan whose first draft should be announced in the beginning of 2008. OTEC will be an important field of activity in Japan with the ongoing Ocean Energy R&D 2002-2011 by the Japanese Government.

In **Korea**, the construction of three tidal barrages are being planned with an overall installed capacity reaching 2000 MW and during 2007 the construction of one of them started – Sihwa Tidal Power Plant in South Korean coast – the largest such project in the world.

Demonstration Infrastructures

Over past few years, several countries have taken specific measures to establish public demonstration infrastructure to enable development, demonstration and commercialisation of technologies as well as to address other regulatory and environmental issues. The following sections provide a summary of such types of initiatives:

In 2003, the first initiative for a test centre for full-scale prototypes was established in UK, Orkney, the European Maritime Energy Centre (EMEC)[13]. It comprises a Wave and a Tidal Test Site, both grid connected, providing independent assessment of devices' energy performance and survivability, as well as real-time monitoring.

[13] www.emec.org.uk

An innovative project promoted by the South West RDA (Regional Development Agency) – the Wave Hub[14] – started to be planned in 2005. During 2007, the necessary funding was secured as well as government approval to start its construction. Wave Hub provides a high voltage sub-sea cable about 16 kilometres offshore and connected to the National Grid. In Ireland, the Galway Bay Wave Energy Test Site[15] for 1:4 scale prototypes was established by the Marine Institute, in association with Sustainable Energy Ireland. The test site is situated on the North side of Galway Bay.

In spring 2007, the Portuguese government announced a Maritime Pilot Zone of up to 320 km^2, in water depths between 30 m and 90 m, located at the West coast of São Pedro de Moel. This zone will have simplified and fast licensing procedures with the aim to attract demonstration and industrial development to Portugal, increase renewable energy production and allow for an early understanding of potential consequences with respect to environmental, geomorphologic and overall potential impacts. A managing company in charge of promoting the infra-structure of the pilot zone will be set-up in order to start its realisation.

The Basque government has recently announced the planning of an infrastructure similar to the Wave Hub with 20 MW installed capacity offshore the northern Spanish autonomous region, the Basque country.

A grid-connected wave energy test site at Nissum Bredning in the north western corner of Denmark was built to enable various technology developers to test and demonstrate their technologies built at different scales.

In Norway, plan exists for creation of a pilot zone in Runde[16].

Also, in France, the government announced funding for development of a test site.

A test facility was commissioned off the Oregon coast near Newport, USA and is attracting developers.

Also, in Canada, the government of Nova Scotia has announced that it will build a public tidal current demonstration infrastructure in the Bay of Fundy.

In summary, over the last decade, several countries have been undertaking different promoting policies for the development of ocean energy. The UK has adopted an energy policy designed to attract and support technology developers, building a consistent program for wave and marine current energy development, and by end of 2007, the UK has by far the most companies in this sector.

In Ireland, a governmental strategy was set up to accelerate the development of wave energy through financial support to Irish technology developers, and three Irish companies have developed technologies that have reached the sea tests phase. Portugal chose a strategy to create attractive conditions to facilitate the development of a wave energy industry by introducing feed-in tariffs and a large-scale pilot zone with simplified licensing procedures; many technology developers are interested in performing sea trials on the Atlantic Portuguese coast. These three are seen as exemplary countries in which ocean energy development was approached in different ways by the governments.

Authors: Ana Brito e Melo, Portugal, and Gouri Bhuyan, Canada

[14] www.wavehub.co.uk
[15] www.marine.ie/home/aboutus/organisationstaff/researchfacilities/Ocean+Energy+Test+Site.htm
[16] Presentation at the IEA-OES Workshop, Messina, October 2007 by Dr Lars Golmen, Norwegian Institute for Water Research, Norway

5. Environmental Issues in Ocean Energy Systems

The ocean energy systems (OES) will become a new source of employment and an economic shifter for coastal areas. In general, fish stocks will be increased as long as fishing is prohibited or restricted in those areas. In addition, there are much more positive impacts to encourage the development of OES. Nevertheless there are some small doubts about the magnitude of certain negative impacts for the marine environment. Finding clarifications about this is a key priority to enable sustainable and efficient ocean energy implementation. Moreover, it is essential to gain favourable public opinion, the most important barrier to the final development of large-scale implementation. Fortunately, many developers and governments are keen to promote the view of marine RE as "environmentally friendly" and so are open to discussion about ways to research or reduce adverse environmental impacts.

The assessment of some of these impacts is a highly complex process, not only because of the medium where these projects are developed but also due to the variety of devices (together with its early stage of deployment), and the different ways in which they interact with the surrounding environment. The lack of baseline data, standard methodologies, high cost and lack of funding are some existing barriers to gain a full understanding. Knowledge is seen to be growing but little has yet been proven. The impacts of a few schemes have been assessed based on estimations and predictions, rather than measured effects.

To date, several studies have already been performed, not only for single devices and small arrays but at a strategical level, in order to consider cumulative impacts. This has allowed for the identification of the major uncertainties on which further research efforts are needed. As described above, some impacts depend on the device and the chosen site in which they are deployed. Thus a proper site selection and strategic planning policy approach like SEA (Strategic Environmental Assessment) (e.g. Scotland and Nova Scotia) are desirable to avoid or minimise impacts (this approach also aids in streamlining the permitting process). This initial planning approach assists in avoiding conflict with other sea uses, the potential damage to visual, cultural or archaeological resources, identifies areas of special concern, acoustic receptors of relevance, threatened or endangered species, tourism and recreation areas, etc.

The wave and tidal test centre, EMEC (European Marine Energy Centre) has taken some noteable initiatives. Since its beginning, it has opened an effective early and continuous dialogue with the concerned entities in order to facilitate developers knowledge about environmental concerns and what they have to assess.

The majority of the projects for tidal devices have undertaken exhaustive Environmental Impact Assessments (EIA) like Marine Current Turbines for the deployment of their 1.2 MW tidal turbine to be installed

off Northern Ireland. This study showed that, in general, blades from these type of devices do not pose a significant threat to wildlife, as they are slow-moving and can be easily avoided. There is no evidence yet that marine mammals and fishes are sucked into the turbines, but this analysis is based upon pilot-scale schemes only, and further research is still required. It is believed that the oscillatory device has a larger footprint than the turbine device and therefore may result in more impact on the seabed as a result of installation. Also barrage deployments may have bigger adverse environmental impacts.

Regarding wave energy, some developers have also carried out a very complete EIA (e.g., the overtopping device Wave Dragon in Wales) while it has not been a necessary requirement for others (it depends on each country's regulations). The southern British offshore infrastructure for the demonstration of arrays of wave energy devices, WaveHub, was obliged to carry out an environmental impact assessment following the worst-case scenarios.

On the other hand, OTEC has been seen as an ocean energy resource that could have pose major environmental impacts. Researchers are trying to help OTEC in reducing its impacts and become a more promising technology with added benefits such as desalination.

For the past two years, there has been an increasing interest for environmental issues related to ocean energy systems. Special sessions have been included in well established conferences (like EWTEC) and workshops have been carried out on many occasions at European or international level such as Wavetrain (EU), CA-OE (EU), or the one organised by the IEA-OES in October 2007. In general, it can be said:

- There is a lack of experience (data, methods, etc), especially in countries with no oil and gas industry. This means major investments for baseline studies and monitoring programs.
- A platform of communication is urgently required such as COWRIE[17] for Offshore Wind. It will join efforts to solve major uncertainties. Collaboration for the first test and pilot zones (EMEC, WaveHub, Galway Bay, Nissum Bredning, Portuguese Pilot Zone) should be seen as an essential catalyser.
- Guidance is needed to help developers and governments. The existence of Protocols or standardised methods could help for comparison exercises.

Author: Cristina Huertas-Olivares, Wave Energy Centre, Portugal

[17] COWRIE (Collaborative Offshore Wind Research into the Environment) – independent company set up to raise awareness and understanding of the potential environmental impacts of the UK offshore windfarm program (http://www.offshorewindfarms.co.uk)

6. National Activities

In this section an overview of the activities during 2007 and the political situation of each IEA-OES country member is provided by the respective delegate. Representatives and national experts from other countries have also provided information on their relevant national activities.

AUSTRALIA

Tom Deniss, Oceanlinx

There is little in the way of government programs specifically for ocean energy in Australia but it is hopeful that the newly elected government will instigate such programs. They have already indicated they will immediately ratify the Kyoto Protocol, something the previous government has refused to do. There are some programs in place for renewable energy in general. There are three known companies involved in developing wave energy in Australia, but this is essentially all privately funded: Oceanlinx, Sea Power Pacific (CETO) and BioPowerSystems.

Technology demonstration and projects

Oceanlinx Port Kembla OWC plant: 100 kms south of Sydney, 500 kW peak, operating but down for modifications at the moment (as of Nov 27, 2007); performance has been as predicted; will continue to operate and use as a test bed and demonstration plant for the near future; it has been predominantly privately funded.

Summary of relevant national association activities

- Environment Business Australia (www.environmentbusiness.com.au)
- Clean Energy Council (www.cleanenergycouncil.org.au)

BELGIUM

Julien De Rouck, Ghent University

Policy & Prospects

The public authority considers the assessment of RD&D in the field of wave energy on the Belgian Continental Shelf (BCS) a priority for several reasons, in particular the future targeted shares of renewable in the energy supply.

On the Belgian North Sea Wind Energy Platform (BNSWEP) set up in 2006, assessments on the possibility to use the BCS for wave energy projects in the future are considered.

By virtue of a royal decree of December, 20, 2000, modified by a decree of May, 17, 2004, the Minister for Energy can deliver domanial concessions for the construction and the exploitation of installations of electricity production, generated from water, currents or winds, in the territorial sea and the exclusive economic zone of Belgium. The decree in question determinates precisely the zone where the installations may be set up. It also specifies the criteria of granting and the procedure by which the concessions are being issued.

Research and Development

Ocean Energy research in Belgium focuses mainly on wave energy (by means of point absorber systems and overtopping devices) and in a lesser extent on the feasibility of tidal energy on the Belgian Continental Shelf.

The Sustainable Economically Efficient Wave Energy Converter (SEEWEC) project presents a robust floating platform with 21 point absorbers: the FO^3, meant to be installed near shore and intended to lead to competitive

and economically effective exploitation of wave energy along (European) coasts. The concept of the FO³ device combines experience from the offshore industry with knowledge of energy conversion from waves by use of point absorbers. The long term objective is to be able to produce electricity at a competitive cost to electricity from other renewable sources. The first step is to become competitive to offshore wind. The SEEWEC project is financially supported by the European Community under the 6th Framework Program and is coordinated by Ghent University.

Within the SEEWEC project, the performed research at Ghent University can be subdivided into two topics. On a small, individual platform scale, parameters such as buoy geometries, motion control and power absorption are being studied for an individual point absorber and for the interaction between multiple point absorbers in a platform. On a larger, numerous platform scale, the optimal wave farm lay-out is being investigated through numerical modelling in a mild-slope wave propagation model.

Special attention is paid to the mechanical aspects, and materials & production of the buoys. The composite material has been carefully selected and tested. The winding process of the composite is optimized in order to obtain robust point absorbers, able to withstand wave impacts. The production process has been established in order to reach low cost and mass production.

Further research incorporates slamming tests of the buoys, the quantification of wave energy potential on the Belgian continental shelf and the North Sea and the selection of optimal locations for a farm of wave energy converters.
A newly started research involves describing and investigating the behaviour of waves on overtopping devices. Through numerical and experimental studies, the objective is to achieve more efficient dimensioning and optimal operational procedures for floating and onshore wave overtopping converters.

In 2008, the first step in a feasibility study of tidal energy on the Belgian Continental Shelf is foreseen.

BRAZIL

Francisco M. Miller, Petrobras, with information provided by Prof. Segen F. Estefen, COPPE/UFRJ

R&D activities have been conducted by COPPE/UFRJ with the development of one shoreline wave device, and lately by Petrobras. A Governmental effort is at the beginning, at the sponsorship of the Ministry of Science and Technology, and a participation of other electrical utilities and universities is expected for the next year. A few demonstration projects shall be started in 2008.

Policy & Prospects

There wasn't any national program or governmental support specially for ocean energy until the end of 2007, when the Ministry of Science and Technology (MCT) approved a Science and Technology plan that includes Ocean Energy as of of its priorities. An initial meeting will take place at COPPE on 22nd, January 2008 as a first effort to establish a National Network for Ocean Energy Development.
During the NEET Workshop that took place in Brasilia in November 2007, the Executive Secretary of the Ministry of Mines and Energy indicated that Brazil will become a member of IEA-OES. The representatives will be named soon.

Research and Development

R&D activities:

- COPPE/UFRJ has developed a shoreline wave power converter device based on pumping water to a hyperbaric chamber, and producing electricity through a Pelton Type turbine. This device has been tested in a small scale model and simulated for Ceará coast and Rio Grande coast conditions. COPPE is also conducting

a redesign study of the tidal barrage of Bacanga river estuary. This barrage was constructed in the 70´s and it was planned to be the first tidal power plant in Brazil, but has never been operational. Now, due to silting of the estuary and deterioration of the barrage, the plant must be redesigned to comply with the actual difference of water level of 2,5 m, instead of the former 7m.

- PETROBRAS has been developing an Ocean Energy Atlas, studying new devices and prospecting opportunities for demonstration projects in Brazil. A reduced scale model of COPPE's shoreline device has been tested in the Ocean Tank, using the wave climate of Rio Grande coast, and the results are now being analysed. A cooperation with FURG (Federal University of Rio Grande) is being signed to make a simulation of ocean conditions at Rio Grande do Sul coast and a feasibility study for an offshore installation.

Key institutions:

- COPPE/UFRJ: The department of Ocean Engineering of COPPE/UFRJ (Federal University of Rio de Janeiro) has been developing research activities in ocean energy since 2001, taking advantage of its high knowledge in naval and offshore technology. The Submarine Technology Laboratory has developed the hyperbaric wave power device, and studies for other devices have been conducted.
- PETROBRAS/CENPES: CENPES is the biggest research center in Latin America, and is responsible for the whole R&D activities for PETROBRAS. The Renewable Energy Division in CENPES is responsible for the R&D activities for renewable energy and develops projects in solar energy, wind power, hydrogen, biomass, biofuels, energy efficiency and ocean energy. Since 2004 this division has been studying ocean energy.

Technology demonstration and projects

- **Pecém Ocean Energy Project**: This project has been developed by ELETROBRAS, Ceará State Government and COPPE, to install a 50 kW prototype at Pecém Port (Ceará coast), using COPPE´s device.
  - Technology: Hydraulic pumping + Pelton Turbine
  - Size: 50 kW (full scale)
  - Name: Usina de Pecém
  - Location: Pecém Port, Ceará State
  - Developer: COPPE/UFRJ, ELETROBRAS, Ceará State Government
  - Current Status: cooperation contract under signature
  - Funding: public (Government and Public Utility Company – Eletrobras)

CANADA

Melanie Nadeau, Natural Resources Canada, CANMET Energy Technology Centre

This year has seen much activity in ocean energy with several initiatives underway such as the Bay of Fundy Strategic Environmental Assessment and the Nova Scotia request for proposals for the multi-user facility and technology providers. The Government of Canada along with provincial governments are working on interim regulatory approaches for offshore renewable energy to ensure the successful deployment of devices. Both governments are also involved in R&D related support activities for the sector. Technology development is on–going with companies such as Blue Energy, SyncWave and Wave Energy Technologies doing tank tests and Coastal Hydropower and New Energy doing field trials as well as Clean Current at Race Rocks. Evidence of the growing interest in ocean energy can be attested with the two well-attended OREG Symposiums.

Policy & Prospects

In 2007, the Government of Canada announced programs that can assist in supporting the ocean energy industry in Canada, including the following:

I. **EcoEnergy Technology Initiative** – Approximately 230 million CDN will be invested in energy S&T to fund research, development and demonstration of clean energy technologies.
II. **EcoEnergy Renewable Energy Initiative –** Investment of more than 1.5 billion CDN to boost Canada's renewable energy supply. This program is expected to encourage 4000MW of new renewable power capacity between 2007 and 2011 (14.3 terawatt-hours of new generation). One cent per kwh of production will be offered to qualifying projects over a 10 year period. It is anticipated that proposed project (s) must have a total capacity of 1MW or larger.
III. **Ecotrust for Clean Air and Climate Change** – Approximately 1.5 billion CDN of funding has been allocated on a national basis to provinces and territories to develop technologies including renewable energy technologies and encourage energy efficiency.

The Government of Canada recognizes the importance of supporting clean energy technologies, increasing renewable energy supply, and improving energy efficiency in Canada. The Canadian Government is currently working on a framework for the management of offshore renewable energy resources (including ocean energy) in areas under federal jurisdiction. In recognition of the potential future opportunities for generating clean electricity from the emerging ocean renewable energy industry, this framework will provide an effective and efficient regulatory environment for future ocean energy projects.

The British Columbia (BC) government speech from the throne presented aggressive targets for fighting climate change and decreasing the dependence on carbon in the province. The new energy plan released in February supported this by setting the target for BC to be energy self-sufficient by 2016. The Energy Plan stated ocean energy as a "future supply option with great potential" and included mechanisms such as a 25 million CDN Innovation Clean Energy Fund, and a standard offer for projects under 10 MW in an effort to support clean energy projects . The province has also published an interim directive on lands access for ocean energy and is in the process of developing a provincial strategy.

In early 2007, the Nova Scotia government invested $500,000 CDN to help develop green energy such as tidal power and get a better understanding of natural gas deposits. Of this, a grant was awarded to the Offshore Energy Environmental Research (OEER) to conduct a Strategic Environmental Assessment (SEA) for offshore renewable energy in the Bay of Fundy. Nova Scotia issued requests for proposals which included the development of multi-user facility in the Bay of Fundy and tidal in-stream technology providers.

Along with supporting the Bay of Fundy Strategic Environmental Assessment, the government of New Brunswick released an Interim Policy on allocation of Crown Lands for Research in Support of In-Stream Tidal Power Generation. The purpose of this policy is to provide interim guidance to the government and the public concerning dispositions of submerged Crown land for research to support the future development of in-stream tidal power generation.

Research and development

The British and Canadian High Commission in collaboration with Natural Resources Canada organized a UK-Canada Marine Energy Workshop to share best practices and identify opportunities for collaboration in marine energy. The workshop brought together over

40 participants from the UK and Canada including scientists and technologists, government researchers, utilities and industry representatives. A number of collaborative ideas and projects were discussed with proposed actions to carry these forward.

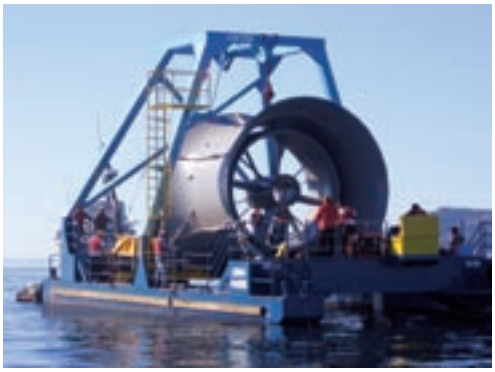
The first Ocean Energy Technical Advisory Committee (TAC) was held by Natural Resources Canada in November to discuss objectives of an R&D program and future related activities. Federal research projects commenced in 2007 focusing on the development of codes and standards, conducting environmental baseline research and providing a more detailed resource assessment.

The Offshore Energy Environmental Research Association (OEER), a not-for-profit corporation, has been examining the potential for offshore renewable energy in the Bay of Fundy and is leading the SEA for the area. Since its inception in 2006, OEER has been dedicated to fostering offshore energy and environmental research and development. OEER members include Acadia University, St. Francis Xavier University, Cape Breton University and the Nova Scotia Department of Energy. For more information, see www.offshoreenergyresearch.ca.

Western universities including the University of British Columbia and the University of Victoria have been continuously conducting research for their respective technology developments, the Blue Energy Ocean Turbine and the Syncwave Power Resonator. Similarly, the eastern universities have been involved with OEER in advancing research for the deployment of ocean energy devices.

Technology demonstration and projects

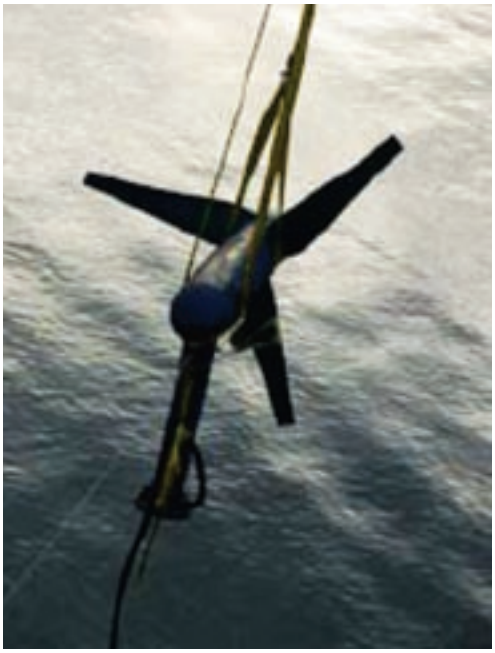
Clean Current Power Systems Inc. has completed testing of their 65kW tidal current turbine located at Race Rocks, British Columbia. The tidal turbine has successfully extracted power in flows up to 6.6 knots and was extracted from the water in May of 2007. The unit is currently undergoing careful inspection and it is intended that it be refitted with a new bearing systems. All lessons learned at Race Rocks will be incorporated into the commercial scale design.



Race Rocks tidal current project, Brit×ish Columbia

Building on experience from the RITE projects in New York's East River, *Verdant Power Canada Inc.* is working on the Cornwall Ontario River Energy (CORE) project planned for operation in the St. Lawrence River, Canada. The CORE project will demonstrate the feasibility and commercial viability of Verdant Power Canada's river-powered Free Flow™ Turbine. CORE will be conducted in a two-phase project over 4 years, with initial operations having begun in the Fall of 2007. The ultimate goal of the CORE project is to develop 15 MW in Cornwall, Ontario.

Nova Scotia Power Inc. (NSPI), the provincial utility, has commenced a tidal stream demonstration pilot scale project that is planned to be in operation by September 2009. NSPI will partner with Open Hydro for this demonstration project and will install a submersible gravity base which will be lowered to the bottom of Minas Passage in the Bay of Fundy. Their objective is to evaluate the efficacy of tidal stream turbine technologies and to gain hands-on experience in installing, operating and maintaining a tidal generation system. The focus of this project will be a 1 MW demo unit but it is antici-



Verdant Power Canada Inc. tidal current project

Vertical axis hydro turbines for in-stream river applications developed by New Energy Corporation Inc.

pated that the collection of information will have some applicability to a larger scaled up array of units.

New Energy Corporation Inc. has built 5 kW, 10kW and 25 kW vertical axis hydro turbines that will be deployed in Manitoba, Alberta and British Columbia for in-stream river applications. The Company has been receiving interest from remote communities in Canada, as well as from Japan and India. New Energy has plans to demonstrate this technology as a tidal power generation on British Columbia's west coast. This will entail the installation of 500 kW power-generating capacity in a narrow channel between Maude Island and Quadra Island, adjacent to Seymour Narrows, near Campbell River, BC.

Relevant National Association's Activities

In early summer of 2007, the Ocean Renewable Energy Group (OREG) held a symposium in Nanaimo, British Columbia which included a public information session and a regional opportunity forum. In October, OREG held its annual Fall Symposium in Saint John, New Brunswick. This event drew participants from across Canada, the US and the UK. Updates on local initiatives, technology projects development activities across Canada and thoughts on the importance of regional business development were presented. During the event, Marine Current Turbines announced the signing of two MOUs with Canadian project development companies. OREG has been very active throughout the year and has seen an increase in membership nearing 100.

CHINA

Policy & Prospects

On August 31st 2007, the National Development and Reform Commission issued "Middle and Long Term Program of Renewable Energy Development". One of the targets for renewable energy development is to tackle the shortage of power and fuel supply in remote areas by using renewable energy. With about 32,000 km of coastline and more than 6,500 offshore islands, China has a large potential for tidal and wave energy generation.

Research and Development

RD&D activities in tidal current energy have been carried out by Harbin Engineering University (HEU) and wave energy activities have been conducted by Guangzhou Institute of Energy Conversion, Chinese Academy of Sciences.

Ongoing Projects on Ocean Energy Development in China:

- National survey of ocean energy and evaluation of its utilization
- Demonstration study of comprehensive development and utilization of offshore islands.
- Technology research on low-cost ocean energy development and utilization (supported by the Ministry of Science and Technology)
- Demonstration project for ocean energy development and utilization of islands.

Technology Demonstration and Projects

Tidal Power

China has developed several small tidal power projects, and Jiangxia tidal power station built in 1980 is the largest experimental station in China to date, with installed capacity of 3.2 MW, located at Zhejiang Province.

Tidal current

In China recent activities in tidal current concern the construction and operation of two prototypes in Zhejiang province: The floating project Wanxiang-I 70kW (1996-2002) and Wanxiang-II 40kW project constructed in the end of 2005 by Harbin Engineering University. The prototype is bottom standing and the electric power output is used by a light tower near a bridge.

Wanxiang-II 40kW tidal current prototype plant in Zhejiang province

Wave Energy

In China there is large experience and knowledge on the construction of a few onshore small scale oscillating water column (OWC) plants, being the most recent one the grid-connected 100kW OWC power plant, built in 2000, in Shanwei City of Guangdong Province by Guangzhou Institute of Energy Conversion. After its deep involvement in OWC technology over some decades, Guangzhou Institute of Energy Conversion has started to research with a new kind of technology, using an oscillating buoy and hydraulic system instead of OWC and air turbine. A 50 kW onshore oscillating buoy wave energy device was built in April 2006. This plant has a buoy capturing wave power and uses three pumps with capacities of 10kW, 20kW and 40kW to convert the captured energy into hydraulic energy. The hydraulic energy is used to drive two hydraulic motors connected with one 20kW and one 30kW generators respectively. An energy buffer with capacity of 10 MJ is used to produce electricity in a stand-along mode as well as to use the excess energy for desalination.

50 kW onshore oscillating buoy wave power device, energy buffer system, and desalination device

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DENMARK

Kim Nielsen, Ramboll, Denmark

Policy and Prospects

Since the end of the Danish Wave Energy development program in year 2002 there has been no dedicated development Policy on Ocean Energy in Denmark.

Research and Development

The interest in developing wave energy technology among developers is growing in Denmark – much work is carried out on private basis.

EnerginetDK www.energinet.dk supports development of renewable energy in Denmark within a frame of 130 mio DKK. In 2008 three Wave Energy projects will receive 2,8% of these funds or 3,6 mio DDK based on applications submitted in 2007.

Technology Demonstration and Projects

Floating Power Plant A/S Poseidon's Organ Demon×stration Project (www.floatingpowerplant.com) - is currently being constructed for offshore test at Vindeby offshore wind turbine park, by the coast of Lolland in Denmark. The test system is 37 meters wide, 25 meters long, 6 meters high (to deck) and weighs approximately 200 tons. The test system is being built in Nakskov harbor and will be lunched in the spring of 2008. Dong Energy and private shareholders give financial support the project.

FLOATING POWER PLANT A/S Poseidons Organ under construction

Wave Star Energy A/S, (http://www.wavestarenergy.com) – continues testing the 24 meters long 1:10 scale model in Nissum Bredning until August 2008. The 20 floats on each side of the machine are one meter in diameter and generate electricity up to about 5.5 kilowatt. A half scale unit of two floats on a pier in the North Sea is being constructed supported with 4 mio. DDK of funding from Energi DK in 2007. The ultimate future goal of Wave Star Energy is to produce series of 240-metre long Wave Star machines of 6 megawatt.

Wave Dragon, (http://www.wavedragon.net) – The 237 tonnes prototype project in Nissum Bredning has continued since march 2003. The prototype has been continuously tested until January 2005. In April 2006 a modified prototype was deployed at a more energetic wave climate in Nissum Bredning and the tests are planned to continue with newly secured funding. In Wales the planning of a 7 MW Wave Dragon to be deployed 2-3 miles off Milford Haven and tested for 3-5 years is progressing.

Waveplane AS, (www.waveplane.com) – since 2007 the development of the waveplane project has been undertaken by a new company in Denmark, financed by private investors. The plan is to develop and deploy a full scale prototype in year 2009.

Dexa Wave Energy ApS project

LEANCON Wave Energy Project

Dexa Wave Energy ApS (http://www.dexa.dk) – is a relatively new project developer in Denmark that has secured private investment for the project development. In some aspects the project reminds one of the Cockerel raft utilising the relative motion between the front and rear of a hinged raft.

LEANCON Wave Energy, this project is concerned with the development of a floating structure containing a large number of manifolded OWC units. Tests have been carried out at the inverters home in the open sea and in Aalborg University. The project has received funding from EnerginetDK.

Bølgevingen (Wave Wing) www.waveenergyfyn.dk – is a project supported by EnerginetDK for small scale testing and documentation.

Relevant National Association's Activities

In 2007, the Danish Wave Energy Association (http://waveenergy.dk/) also hosted its two meetings for national interaction between developers and interested parties.

EUROPEAN COMMISSION

Anna Gigantino, European Commission, DG RTD

EU Renewable Energy Policy Context

Energy technologies will be crucial to successfully fighting against climate change and securing world and European energy supply. Technology is vital in reaching all our energy and climate change policy objectives: to reduce greenhouse gas emissions by 20% and ensure 20% of renewable energy sources in the EU energy mix; to reduce EU primary energy use by 20% by 2020. Research and innovation in energy technology are therefore vital in meeting the EU's ambition to reduce greenhouse gas emissions by 60-80% by 2050.

The development of renewable energy – particularly energy from wind, water, solar power and biomass – is a central aim of the European Commission's energy policy. Europe's potential to develop a new generation of decarbonised energy technologies, such as off-shore wind, solar technology, or second generation biomass, is enormous.

However, actions to develop new energy technologies, lower their costs and bring them to the market must be better organised and carried out more efficiently. This is why the European Commission is proposing the Strategic Energy Technology Plan, a comprehensive plan to establish a new energy research agenda for Europe. This Plan is to be accompanied by better use of and increases in resources, both financial and human, to accelerate the development and deployment of low-carbon technologies of the future.

The European Commission is proposing a new approach, which focuses on more joint planning, making better use of the potential of the European Research and Innovation area and fully exploiting the possibilities opened up by the Internal Market. In particular, the Plan includes the commitment to set up a series of new priority European Industrial Initiatives focusing on the development of technologies for which working at Community level

will add most value. The Plan proposes the strengthening of the industrial research and innovation, by aligning European, national and industrial activities; it also proposes the creation of a European Energy Research Alliance to ensure much greater cooperation among energy research organisations as well as improved planning and foresight at European level for energy infrastructure and systems.

More information is included in the SET-plan document, available at:
http://ec.europa.eu/energy/res/setplan/communication_2007_en.htm

Following the extensive public consultation which ended in June 2007, the European Commission adopted on 10 October 2007 a Communication setting out its vision for an Integrated Maritime Policy for the EU, together with a detailed action plan setting out an ambitious work program for the years ahead. The Communication and Action Plan are accompanied by a report on the results of the consultation which revealed strong stakeholder support for the Commission's initiative.

The new policy will be built on Europe's strengths in marine research, technology and innovation. The Communication and accompanying Action Plan list a range of concrete actions covering a wide spectrum of issues, ranging from maritime transport to the competitiveness of maritime businesses, employment, scientific research, fisheries and the protection of the marine environment.

The full package as well as further information on maritime affairs can be found at:
http://ec.europa.eu/maritimeaffairs/index_en.html

Ocean Energy support under the FP7 (2007-2013)

The first call for proposals of the Seventh Framework Program (FP7) was launched in December 2006, and included three different topics for Ocean Energy, concerning respectively "New components and concepts for ocean energy converters", "A strategy for ocean energy" and "Pre-normative research for ocean energy". The projects, selected in 2007 for EC funding, and currently still being negotiated for a global amount of around 7 M€, are expected to start during the first half of 2008.

Undergoing ocean energy projects supported by the EC

During 2007, a number of ocean energy projects were running with the support of the Sixth Framework Program (FP6).

Two Directorate-Generals of the European Commission are charged with management and monitoring these projects: the Directorate-General for Research (DG Research) for projects with medium to long term impact, and the Directorate-General for Transport and Energy (DG TREN) for demonstration projects.

The table below provides a summary of the Ocean Energy research projects funded by the European Commission in 2007:

Project acronym	Duration (months)	EC funding for the whole duration
WAVE DRAGON MW	36	2.431.000 €
SEEWEC	36	2.299.755 €
CA-OE	39	1.593.000 €
WAVE SSG	30	1.000.000 €

Furthermore, six new demonstration projects are currently in the starting phase and one additional project will support strategic activities of the recently established European Ocean Energy Association.

The Intelligent Energy Europe program provides funding for the WAVEPLAM (WAVe Energy PLanning and Marketing) project, for a period of 36 months.

FRANCE

Hakim Mouslim, Research & Project Engineer at Ecole Centrale de Nantes/CNRS

The French Atlantic coast faces a favourable wave climate. The wave resource theoretical potential is estimated at 420 TWh/year. This potential nearly equals the electrical energy consumption in the country. In the past wave energy activities in France were focused on R&D supported by public funding. However, in 2007 **the creation of a test site in the Pays de la Loire region** (west coast and near Nantes) was announced and the positive decision including means of financing was made in summer 2007. The building of the facilities is expected to be finished by mid 2010. The first project in the water is expected to be launched shortly after finishing the building works and commissioning.

The program of the test site is supported by public funding (around 5M€) and designed for research and initial demonstration. This site will not be used for production but it will be fully instrumented with grid connection and onshore test facilities. The site will be open for both French and international device developers.

Policy & Prospects

Since March 2007, a new law has set **a feed-in price of 15c€/kWh** for electricity produced using wave energy. This is a premiere for wave energy in France.

A new project supported by the French government and the local region "Pays de la Loire" intends to build a grid connected test site for the experimentation of wave energy converters. This test site project launched by the "Ecole Centrale de Nantes" started in 2007 securing €5M as part of a public funding program. The site will be fully instrumented to enable initial demonstration of wave energy devices and also research on marine and oceanographic applications. It is expected to be running the first tests by mid 2010 but certain research experiments may start sooner.

Research and Development

Research and Development activities in wave energy are mainly focused on the Fluid Mechanics Laboratory, a research unit formed by the "*Ecole Centrale de Nantes*" and the National Scientific Research Centre (CNRS). This research unit has one of the largest wave tank facilities in Europe and has developed more than 25 years experience in wave energy.

The SEAREV Wave Energy Converter

The SEAREV wave energy converter development project is lead by the "Ecole Centrale de Nantes" and integrated within an industrial consortium. The project is based on strong numerical modelling of hydrodynamics and fluid structure interaction developed by the Fluid Mechanics Laboratory. Numerical models have been calibrated and validated through various experimental testing activities.
A 1:12 model was tested at the "Ecole Centrale de Nantes" wave tank facility during the summer of 2006. This production model was a first generation production model of SEAREV which helped the validation and calibration of the numerical codes used for the simulation of the device.

A second model at 1:25 scale was tested during the summer of 2007. The experiments were meant to conduct survivability tests with a new generation of the device. Several mooring designs have been tested. The different configurations lead to validation of numerical mooring models and calibration of several parameters.

A second 1:12 model is expected to be tested in Nantes in the summer of 2008 and a full scale 500kW prototype may be under construction for testing activities in the summer of 2010.

GERMANY

Jochen Bard, Institut fuer Solare Energieversorgungstechnik, ISET

With respect to available resources in the range of some percentage of the electricity consumption, a continuing high interest in ocean energy can be found in Germany in the public as well as in research and industry. Currently around 15 R&D institutes and universities are involved in developing wave, tidal current and osmosis power in the framework of most European research projects. In addition, there are around 25 companies involved into system and component development and supply to different technologies mainly in Europe. The four major German utilities have published plans to invest into ocean energy technologies, mainly wave and tidal. There is no installation developed in Germany yet, but a first Limpet type wave power plant of 250 kW has been announced to be installed on the North Sea coast.

The public funding in the framework of the National energy research program is currently limited to tidal turbine concept and component development. The total amount of public funding between 2001 and 2008 is around 2.5 Mio Euros. A feed in tariff for electricity from wave and tidal energy similar to the tariff for small hydropower (around 7 to 10 percent) is available under the renewable energy act of 2005. A first international conference on Ocean Energy was held in 2006. A series of the national marine energy forum will be continued in April 2008. Germany became a member of the IEA OES in year 2007.

INDIA

Purnima Jalihal, National Institute of Ocean Technology, NIOT

India has a vast coastline of about 7500 km and a lot of Islands. India is actively undertaking the Ocean Renewable Energy research with the following objectives:

1. Providing a viable alternative source for drinking water needs of the Mainland and island population.
2. Developing technologies towards low powered wave energy devices for the needs of remote islands.
3. Developing OTEC based energy devices to make the desalination plants both on the barge and the islands self-sufficient.

Policy & Prospects

Ministry of Earth Sciences under the Government of India works through National Institute of Ocean Technology to carry out Research and Developmental works in Ocean Technology. The work towards developing technologies like wave powered devices and low temperature desalination is being done under this program of Ocean Renewable Energy. Besides NIOT, there are a few independent groups, like the Indian Institute of Technology, Chennai, that work on laboratory scale models of these wave power devices.

Research and Development

The thrust areas of research revolve around Desalination based on Ocean Thermal Gradient, and Wave Powered Devices.

National Institute of Ocean Technology, Chennai: The institute is the technical arm of the Ministry of Earth Sciences, Government of India, working towards development and dem-

onstration of field scale models of Ocean Renewable Energy Devices. As a part of its mandate, NIOT has until now setup a 100 m^3/day Island based Low Temperature Thermal Desalination Plant at Kavaratti, India, in 2005 and demonstrated a 1000m^3/day Experimental Barge Mounted Desalination Plant off Chennai Coast, India, in 2007. NIOT is also working on wave powered devices meant for remote islands.

Indian Institute of Technology, Chennai: The institute has research groups working towards the development of laboratory scale wave energy devices, and the development of technologies for distribution and restructuring of wave energy.

Technology Demonstration and Projects

	Low Temperature Thermal Desalination		Wave Energy Device	Backward Bent Duct Buoy
	Barge Mounted Plants	**Island Based Plants**	**OWC based**	**OWC based floating device**
Technology	Desalination using Ocean Thermal Gradient	Desalination using Ocean Thermal Gradient	Oscillating Water Column based Wave Energy Devices	Backward bent duct buoy for wave power
Size and Scale	1000 m^3/day Experimental Demonstration	100m^3/day Operational Plant for Island	Operational Plant 15kW Capacity	Small Scale
Project Name	1MLD Desalination Plant	Kavaratti Desalination Plant	Wave Energy Plant	BBDB
Location of the Plant	Chennai, India	Kavaratti, India	Vizhinjam, India	Chennai, India
Developer	NIOT	NIOT	NIOT	NIOT
Current Status	Demonstrated the Operation in 2007.	Plant is operational, supplying to the island	Powering an RO based desalination plant for the local community	Currently under field tests
Results Achieved	Successfully Completed	Successfully handed over to island in 2006	Concept successfully demonstrated in 2001	Undergoing field tests
Plans	Setup of a medium scale operational 10,000 m^3/ day plant	Setup of similar plants in other islands of the region	No further plans as the Wave Power in the territorial waters of India is small	Development as a small scale wave powered device for remote islands
Funding	Public	Public	Public	Public

A view of the 1000 m3/day Barge Mounted Desalination Plant.

A view of the 100 m3/day Island Based Desalination Plant at Kavaratti, with an inset of Islanders getting the distributed water.

IRELAND

Graham Brennan, Sustainable Energy Ireland

The development of Ocean Energy technology in Ireland is identified as priority area by the Government and its importance is reflected in its relevant recent energy policy announcements. Work is progressing in accordance with the guidelines expressed in the Ocean Energy Strategy which was launched in 2006. The establishment of the 1:4 scale wave energy test site in Galway Bay has given a significant opportunity to companies to pursue their development activities in an efficient manner. Attention is now focused on the establishment of a full scale grid connected test site which will serve to support preparations for a large scale developmental commercial site with strong growth potential.

Policy & Prospects

- In March 2007 the Irish Government published an Energy White Paper which set a target deployment of 500MW of ocean energy power by 2020.
- The Ocean Energy Strategy was launched by the Irish Government in April 2006. This sets forward a 4 phase framework to support the development of ocean energy in Ireland. Phase 1 of this program is currently underway with support provided for research and development activities up to 1:4 scale together with support for 3rd level research activities. Attention is now focused on preparations for the development of a test site and a larger pre-commercial development site.
- The Government established the Parsons Award which provides 20mEuro support for energy research in 3rd level institutes primarily focused on the areas of wind, biomass and ocean energy. The awards provide funding for post doctoral researchers for periods of 7 years.
- The 1:4 scale test site in Galway Bay is operating successfully and provides access to developers for periods of up to 6 months. Terms of access include safety, structural and operational requirements.

Research and Development

- **Sustainable Energy Ireland** is the national energy agency and provides grant support for R&D activities and technology developers in ocean energy (www.sei.ie).
- The **Marine Institute** is responsible for the general development of Ireland's ocean resources which include areas such as fishing, tourism and energy. They are also the operator of the Galway Bay test site.
- **Hydraulics and Maritime Research Centre in University College** Cork is a key ocean energy research facility in Ireland with special interest in ocean energy research and coastal engineering. The group expanded its staff size in 2007 following the allocation of long term 3rd level research funds.
- **University of Limerick** has been actively pursuing the development of air turbines for use with oscillating water column devices. They have also secured long term funding under the Parsons Award scheme and intend to pursue ocean energy research activities.
- The **Electricity Research Centre in University College Dublin** has had significant involvement in the integration and the study of management issues for intermittent renewable generators such as wind power systems operating on the national grid. Their interests include modelling of dynamic response of electrical generators and tidal energy systems.
- The **Department of Communication Energy and Natural Resources** is the Government Department with responsibility for promoting renewable energy in Ireland.

Technology Demonstration and Projects

Open Hydro

The Open Hydro tidal turbine is owned and developed by an Irish company based in Dublin with manufacturing facilities in Greenore, Co. Louth. The Open-Centre Turbine's simple design means that it can withstand harsh ocean tides, while having no impact on marine mammals since it has no oils which can leak, no exposed lade tips and a significant opening at its centre. A 250 kW turbine is currently being tested at the European Marine Energy Centre (EMEC) in the Orkney Islands which was supported by a grant of 370kEuro from Sustainable Energy Ireland (SEI). Testing of the turbine is ongoing at EMEC. The company have won two commercial contracts to build devices in the Channel Islands and Canada.

Ocean Energy Buoy

The Ocean Energy Buoy (OE Buoy) is a floating oscillating water column device which generates power from compressed air which is created with each passing wave. The OE Buoy was optimised at 1:50 scale in the Hydraulics and Maritime Research Centre (HMRC) at University College Cork before being tested at 1:15 scale in a large wave tank in Nantes. The current 1:4 scale machine was first installed in Galway Bay in December 2006 where maximum wave heights reached 8m during the winter period. The machine was successfully tested from December 2006 through to the summer of 2007 without a turbine in order to give comparison with previous tank test work. In September 2007 the OE Buoy was fitted with an air turbine and returned to test where it is continuing to perform successfully. SEI provided cumulative grant support of 515kEuro.

Wavebob

The Wavebob is a point absorber device. The Wavebob has been tested at 1:50 and 1:20 scale before a decision to build a 1:4 scale machine was taken. A large scale prototype was installed in Galway Bay in 2006. The developers have an ongoing test program of development at the test site. Some testing work was conducted in 2007 with a further round of testing planned for Galway Bay throughout 2008. To date SEI have provided grant support of 210kEuro.

Other companies which have projects ongoing in Ireland at present include Finavera Aquabuoy and Technology From Ideas. These companies are receiving support of 185kEuro.

Relevant National Association's Activities

Ireland operates an Ocean Energy Forum bi-annually which is free to all interested groups. The Forum has been very successful and is quickly growing in size. It provides an open forum for developers, researchers, policy makers and market operators to address the key barriers facing the development of ocean energy in Ireland.

The Forum is currently operated by the Marine Institute and HMRC with input from SEI. There were two meetings held in 2007 as follows:

- 28th June 2007 in University College in Cork
- 15th Nov 2007 in Marine Institute Offices in Galway

ITALY

The activity in Italy concerning Ocean Energy is still confined to the initiatives undertaken by the research and development company "Ponte di Archimede", in the framework of the Enermar project.

There are two organisations in Italy supporting ocean energy:

- Ministry of Foreign Affairs (www.esteri.it/ita/index.asp)
- Region Sicilia (www.regione.sicilia.it/)

The Cooperation with UNIDO (United Nations Industrial Development Organization) for the installation of prototypes of the Kobold Turbine in the waters of three Eastern Countries is recognised as an important initiative towards the promotion of ocean energy.

Technology Demonstration and Projects

The Kobold turbine is 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 installation 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. During 2007 activities in the Kobold turbine concerned the collection of data including a complete map of the systems performance with power output for any current velocity and any number of revolutions of the turbine used in the power optimization procedure.

This project has been disseminated among the developing countries in which UNIDO operates and the first three countries that expressed interest were the People's Republic of China, the Philippines, and Indonesia. A joint-venture was created, under the auspices of UNIDO, between "Ponte di Archimede" and the Indonesian Walinusa Energy Corporation. A place to install the tidal current plant in Indonesia has been identified in the Lomboc island (immediately on the east of Bali) and the project is expected to be completed by the end of 2008.

References:

http://www.pontediarchimede.it/

JAPAN

Policy & Prospects

- The *Basic Law of the Sea* has been enforced on July 20th,2007 (On April 20, the Diet enacted the Law) in view of the importance of developing, utilizing and preserving resources within the EEZ and on the continental shelves around Japan, while calling for international cooperation in ocean resources development, protection of the ocean environment, disaster prevention, sea rescues, etc.
- The Japanese government plans to prepare the first draft of its maritime plan by late October, announcing the final draft in January 2008.
- A Task force on Ocean Energy in the Marine Technology Forum has been started to promote Ocean Technology and Development, the basis for the Road Map on Ocean Development in Japan.

Research and Development

OTEC

Institute of Ocean Energy, Saga University (IOES), has been supported by the Japanese Government and within the 21st COE Program of "Advanced Science and Technology for Utilization of Ocean Energy" it was built an experimental OTEC system (30kW) using ammonia/water mixtures as working fluid. Future plans under this program concern the development of a floating ocean nutrient enhancer, 'TAKUMI', using OTEC as power source.

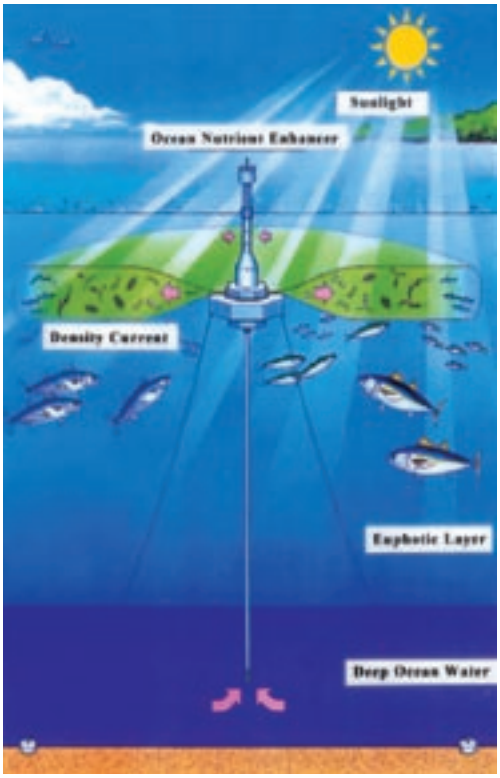
Wave Energy

Research activities on the Backward Bent Duct Buoy (BBDB) wave energy device invented by Mr. Masuda are still progressing in Saga University.
Sea trials with Impulse turbine for OWC wave energy devices are progressing within a join collaboration of Matsue National College of Technology, Saga University and the Ministry of Land Infrastructure and Transport.

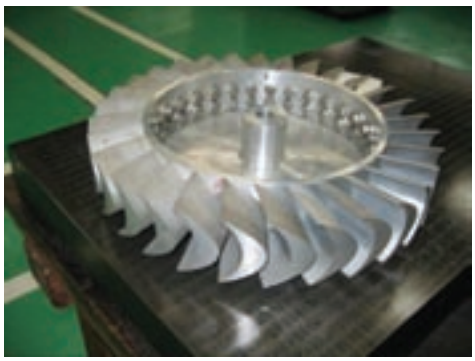
References:

– *IEA-OES Annual Report 2006*
– *Presentation by Dr. Ikegami, Saga University, at Messina ExCo meeting October 2007*

Experimental OTEC plant (30kW) using Ammonia/Water Mixtures as Working Fluid



Aquaculture project 'TAKUMI' using OTEC



Impulse turbine and demonstration plant with turbine impulse in Niigata since 2005

MEXICO

Gerardo Hiriart, Instituto de Ingeniería, UNAM

Research and Development

Tidal energy

In Mexico there are no tidal power plants that use the energy of the oceans, nor projects of development of any type of these power facilities. Although it has been discussed that the Sea of Cortés has an enormous potential for electric generation. Estimations of this potential have been made by the Institute of Engineering of the UNAM.

A numeric model has been carried out to estimate the potential energy of the tides in the Gulf of California due to the fact that in this area there is a concentration of energy, reaching a tide height of approximately 6 m, in the season of spring tides. This form of energy can be exploited with a tidal power plant that practically works like a hydroelectric of low head in which a dam is built to be able to create a level difference. There are three operation ways to generate electricity and numerical simulations have been made to know the behaviour in these three generation ways:

- Flood Generation. – When the tide is ascending and it enters into the reservoir – in this case the generation is from the sea towards the reservoir.
- Ebb generation – When the tide is descending and it leaves the previously full reservoir in high tide – in this case the generation is from the reservoir toward the sea.
- Flood – ebb generation in flood-ebb – This generation way is as its name indicates a combination of the two previous and the generation is done in two ways.

Afterwards detailed simulations have been made for four different reservoir sizes in the high Gulf of California.

Current energy

The energy of the currents can be divided into two types according to the generation source: i) the one that takes place with the ascent and descent movement of the tide, called tide currents, and ii) the other, called oceanic currents, takes place with the gradients of temperature and salinity. UNAM is working on the development of a device able to take advantage of this energy and to transform it into electric power and further on the quantification of the potential that exists in the Gulf of California. Recent campaigns of measurements of currents have been carried out by UNAM. It has been found that the maximum speed is of 1.40 m/s and the average speed is of 0.56 m/s, the average power for m^2 is of 171.00 watts, multiplied by the area of the channel where depths are around 15 m, it is obtained a power of 96 MW. Supposing that 36% of this energy can be exploited, the amount of 302 GWh/year would be obtained taking into account that turbines are placed in the whole traverse area of the channel. Laboratory tests have been carried out to verify the efficiency of the system.

Technology Demonstration and Projects

Wave Energy Project in Baja California, in Santa Rosaliita y Rosarito – Project financed by the Federal Commission of Electricity: Feasibility study of two projects in the proximities of the towns of Santa Rosaliita and Rosarito, Baja California State, including the following activities in each place: Evaluation of the selected places, evaluation of the resource, hydrographic measurement, geotechnical measurement, economic analysis and conceptual design of the device specific of each place. In this study it has been considered the technology developed by Oceanlinx.

Relevant National Association's Activities

On the 22nd and 23rd of March the **International Symposium of Water and Energy** took place, organized jointly by the Council of the Circum-Pacific, the Committee of Energy of the Ocean of the International Agency of Energy and the Institute of Engineering, with the participation of representatives from 19 countries. The inauguration was done by engineer Rubén Flores García, undersecretary of Electricity of the Secretary of Energy who came in representation of Georgina Kessel, director of this Secretary. Other participants were Doc Pat Leahy, director associated of the Geologic Service of USA and vice-president of the Council Circum-Pacific, Gouri Bhuyan, president of the Committee of Energy of the Ocean and the director of the Institute of Engineering, Dr. Sergio Alcocer de Castro.

NETHERLANDS

P. C. Scheijgrond, Ecofys Netherlands BV

The Dutch ocean energy potential is made up of the North Sea, the river delta Westerschelde open to the sea in the south and the Waddenzee around the islands in the North. Furthermore there are some enclosed bodies of water as part of the Dutch Delta works, the largest being the IJsselmeer, Oosterschelde and Grevelingen. These bodies have little or reduced tidal influences, but could have potential as a tidal flow, barrage or osmotic resource. Furthermore there are many rivers and canals with a low hydraulic gradient which could be considered for zero-head applications.

The Dutch resource potential for energy from the seas and rivers has not been studied in detail. Several publications from both consultancies and developers claim potentials for specific locations or technologies. For example, the tidal stream resource at the exit of the Oosterschelde dam has been estimated to be in the order of 100-200MW when using tidal flow technologies. The developers of the Dynamic Tidal Plant predict a potential of 10.000MW along the Dutch coast line. The wave resource on the North Sea has average energy levels of up to 11kW/m wave width offshore. Another study estimated the osmotic energy potential in the Netherlands at 16 TWh.

Policy & Prospects

At present the Dutch government has not developed policies to support ocean energy technologies. Support is only available for those technologies that are identified to "make a considerable contribution to the renewable energy mix of the Dutch grid". Ocean energy is not yet identified as promising resource for the Dutch renewable energy mix at present.

However, a new program called WINN (Water Innovations) has the objective to identify and realise pilots to demonstrate "on land" technologies that generate electricity from water (e.g. low head hydro and osmosis). The program is under management of the Dutch Directorate for Public Works and Water Management (Rijkswaterstaat).

A new support scheme for sustainable energy SDE (Stimuleringsregeling Duurzame Energie) will be disclosed early 2008 and it is unknown whether ocean energy will be mentioned separately. The scheme is developed by the Ministry of Economic Affairs (EZ) and will be managed by SenterNovem.

Research and Development

- **Alkyon Hydraulic Consultancy & Research** offers expertise in coastal and offshore hydraulic engineering and research. They are developers of the Dynamic Tidal Power system.
- **ECN – the Energy Centre Netherlands** develops high-level knowledge and technology for sustainable energy systems and transfers it to the market. In the past they have cooperated on ocean energy projects.
- **Ecofys Netherlands bv** is the largest independent consultancy dedicated to sustainable energy in the Netherlands. Several studies related to tidal, wave and osmotic energy have been published for local and national authorities. Ecofys is also developing the Wave Rotor.
- **KEMA** is a commercial enterprise, specializing in high-grade business and technical consultancy, inspections and measurements, testing and certification, related to products, processes and equipment for the production, distribution and use of electricity. They have carried out a number of feasibility studies for pumped storage concepts.
- **Teamwork Technology BV**. Technology and business development of sustainable technology, modeling of the physical process, engineering of demo equipment and monitoring during testing. Operates a test site for (tidal) turbines. Specialist in electrical direct drive equipment and grid connections.
- **Technical University of Delft** is involved in the technical development both generic and device specific issues ranging from direct drive generators, hydraulic computation modelling and systems development.
- **Wetsus** is a centre for sustainable water technology, especially research into Reversed Electro Dialysis (RED): prevention of fouling, system and membrane design

Technology Demonstration and Projects

Dynamic Tidal Power (DTP)

The concept of DTP by Alkyon Hydraulic Consultancy & Research and H2iD proposes to build a very long artificial T-shaped dam perpendicular to the (Dutch) coast and to the tidal flow. The existence of such dam in a tidal flow creates a hydraulic head over the two sides which can be used to drive conventional low head hydro turbines mounted in the dam. In a tandem array (ie two dams) with proper spacing with respect to the tidal wave, the hydraulic head of both T-dams combined could yield a virtually constant power when producing into the same grid.

The validity of this tidal power concept was elaborated in a study in 1997 assigned by SenterNovem. A pilot project to test the required low head turbines is planned to start in 2009 in one of the dikes of the Delta Project (Grevelingen Dam). The feasibility of a pilot project for a large T-dam in China has recently been considered. This should take place in the framework of a joint Sino-Dutch DTP-Platform.

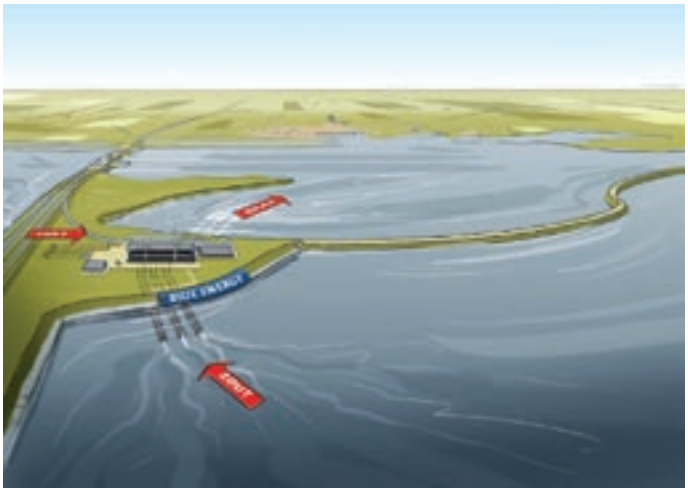
Dynamic Tidal Power schematic concept for Dutch coast, by Alkyon and H2iD.

Hydropower Magnifier
Entry Technology BV in Rhenen (NL) is working on a concept called the Hydropower Magnifier. The physical principle behind this system is based on wave energy: Waves generated by a low head wave maker are concentrated on a higher energy state (head) and in a final step converted into electrical power. A feasibility study has been supported under the NEO program (New Energy Research) of SenterNovem.

HydroRing, renewable hydro-energy
HydroRing is being developed by HydroRing BV (www.HydroRing.eu). HydroRing is an axial flow rotor with magnetic rim bearings and power take off in the rim of the rotor housing. Since there is no need for a central shaft, it is expected that fish can pass easily. HydroRing is designed to be installed in existing weirs and locks throughout Europe and for remote area's in developing countries. A Dutch EOS DEMO (New Energy Research) grant was awarded for a field demonstration together with the Dutch Directorate for Public Works and Water Management (Rijkswaterstaat). The demonstration started in July 2007. By the end of 2008 the prototype will be installed in a weir in the Netherlands.

REDstack
REDstack is a spinoff company from Wetsus. The scientific research of Wetsus on Reverse Electro Dialysis ('Blue Energy') is applied at REDstack into a technical design of a stack assembly of membranes and electrodes to generate electricity from salt and fresh water. When fresh water flows into sea water, huge energy can be derived from the difference between the chemical potentials of concentrated and diluted salt concentrations. In several projects within the New Energy Research program of SenterNovem, low-cost membranes and other key-components are under development. The promising results raised interest of different industrial and power supply companies and water authorities to invest in pilot tests. Parties agreed on the following development path:

- Industrial pilot (kW-scale) on saline flows in a salt factory (Financial supported by SenterNovem, Innowator project; 2007-2009)
- Feasibilty study and definition of requirements for a communal power plant of 200 MW at the Afsluitdijk (Private funding, 2008)
- Communal pilot (10-40 kW) on sea water and river water (2009-2010) at the Afsluitdijk
- Communal pilot (1 MW) on sea water and river water (2010-2012) at the Afsluitdijk



Artist impression of a RED stack plant at the IJsselmeer (www.redstack.nl)

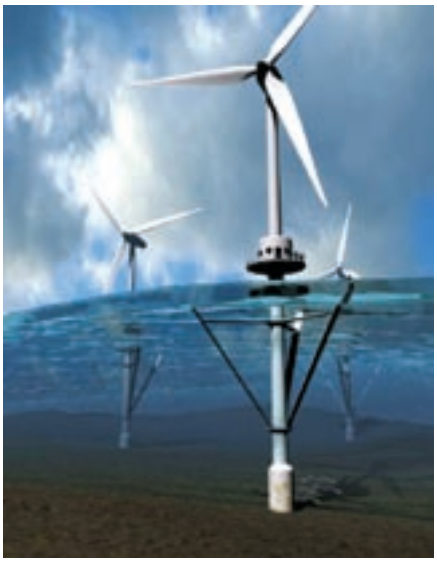
Tocardo
The Tocardo turbine, developed by Tocardo bv, is an axial flow turbine with two fixed blades. The turbine has no gearbox; instead it has a permanent magnet direct drive generator and therefore an expected low maintenance profile (10 year cycle). With a variable speed control the device is able to run at velocities up 3.6m/s. A 2.8m diameter machine has been tested in a sluice gate at the Afsluitdijk during the summer of 2005. This project was funded by the partners together with the province of North Holland and the regional fund "Kop & Munt".

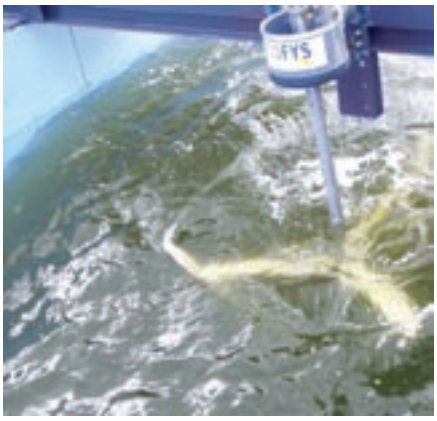
Tocardo turbine by Teamwork Technology, demonstrated at the Afsluitdijk in a sluice gate (www.tocardo.nl)

There are two ranges of products planned:

Tocardo 2800 -4500
A small diameter turbine for inshore purpose which makes use of existing civil constructions to connect to. These systems are sized to the channels and water flows in which they are applied and are rated from 40kW 2.8m up to 150 kW at 4.5m diameter. In 2007 three turbines will be installed with a total rating of 120kW. In 2010 a project is expected for 1 MW rated set of seven turbines.

Tocardo 10000-20000
A larger diameter turbine 10m diameter. This design is especially for offshore purpose. The project development for this product is ongoing. The target is to install the first systems in 2008 or 2009 in the Pentland Firth (North Scotland) with a total rated power of 10MW.





Wave rotor artist impression and model tests at NaREC

Wave Rotor
The Wave Rotor is a new wave turbine working on simple wind turbine principles and is capable of converting both tidal and wave energy directly into electrical power. The Wave Rotor exploits the orbital velocities within waves and utilizes the principle of hydrodynamic lift to turn a set of blades around a vertical axis.

Experimental trials were successfully completed at NaREC on a 10th scale model of Ecofys' Wave Rotor (www.Ecofys.nl) and also at IFREMER in Brest in waves and tidal currents. The NaREC test was funded via the Carbon Trust's Marine Energy Challenge Program under the supervision of Halcrow. A grid-connected model test in the sea in Denmark was funded by the Danish Wave energy Program. Currently a construction is being prepared for a 30kWp rated Wave Rotor which will be suspended from a pier in the Westerschelde in 2008 in cooperation with the city council of Borsele and Total NV (more information: www.Ecofys.nl).

Relevant National Association's Activities

There is no association which represents the industry. However, a listed group of over 50 individuals in the Netherlands have a direct interest in the development of this industry. They are representing offshore contracting and engineering companies, research institutes, developers, policy makers and consultancies. Some events organised in the recent past include:

- **Dag van Maarssen**, launch of the Water Innovations program, November 2007
- **Coordinated action on Ocean Energy**, Amsterdam, two day workshop on component design, reliability and production, March 2006
- **"Marine Parks",** an initiative by the Innovatie Netwerk aims to combine functions at sea, combining wind, wave, tidal and bio cultures at sea. The emphasis is on the latter, investigating offshore mussels, algae and fish farming.
- **The POSEIDON vision** (initiated by Econcern) presents a vision for harvesting renewable ocean resources and creating a system that will ensure a sustainable electricity supply. It includes an offshore grid – connecting wind, wave and osmotic power projects to national grids – as well as offshore carbon-neutral power plants. It is also a focal point for existing initiatives by a range of project developers, linking them to developing power markets and new technologies. (more information: www.poseidonenergy.com)

NEW ZEALAND

John Huckerby, AWATEA

The principal change in 2007 was the introduction of the Energy Strategy and Energy Efficiency and Conservation Strategy, particularly the announcement of the Marine Energy Deployment Fund. Government policies and modelling explicitly include marine energy for the first time. The activity amongst marine energy projects has also increased.

Other initiatives include EnergyScape study, which includes basic mapping of marine energy resources; Electricity Commission's project on "Transmission to Enable Renewables" and proposals for a marine mammal sanctuary, particularly to protect the very endangered Maui's dolphin.

Policy & Prospects

There are no national targets for deployments of marine energy projects. However, the recently published New Zealand Energy Strategy (11 October 2007) sets a target of 90% of generation to come from renewable sources by 2025 (currently — 65%).

There are no feed-in tariff, ROC or production tax credits: it has been considered but appears to have been rejected in favour of 'level playing field'. A marine energy centre has been proposed but is not currently being developed. There is no streamlining of permitting for project development – all projects are subject to Resource Management Act 1991.

Current R&D funding is below NZ$ 1 million per annum. Current energy research funding round offers NZ$ 5 million total from 1 October 2008 – it may exceed $1 million for marine energy.

Relevant Legislation:

- New Zealand Energy Strategy – has five headline goals: 90% renewable generation by 2025; halving per capita emissions by 2040; 250,000 ha increase in forests by 2020; early deployment of electric vehicles and leading research on agricultural emissions reductions.
- New Zealand Energy Efficiency and Conservation Strategy – contains four initiatives for marine energy: Marine Energy Deployment Fund (see below), marine energy atlas by end-2009, technical and industry standards for supporting the roll-out of marine energy systems from 2010; ongoing support for the Aotearoa Wave and Tidal Energy Association (AWATEA).
- Marine Energy Deployment Fund – to promote prototype deployments; NZ$ 8 million available over 4 years (NZ$ 2 million per year); funding for deployments connected to meaningful load; first round opened on 17 October 2007; applications close on 29 February 2008; awards by end-May 2008.
- Emissions Trading Regime – from 1 January 2008; will include all sectors of the economy and all gases; forestry has already joined sector; stationary energy sector will follow on 1 January 2010.

Research and Development

Government has provided R&D funding to three marine energy projects over last four years. Principal beneficiary is Wave Energy Technology – New Zealand (WET-NZ) consortium, which comprises two Crown Research Institutes (Industrial Research Limited and National Institute for Water and Atmospheric Research) and a private company, Power Projects Limited.

Key organizations:

- Foundation for Research, Science and Technology – Government's Science R&D funding agency.
- Energy Efficiency and Conservation Authority – Crown Agency responsible for promoting energy efficiency and conservation and delivering Government's program in these areas. Nominal responsibility for Government's involvement in marine energy.
- Industrial Research Limited – Crown Research Institute (i.e., Government-owned research organization), specializing in electrical and mechanical research. Speciality in high-temperature superconductors.
- NIWA – also Crown Research Institute with expertise in marine sciences, including resource assessments, hydrodynamics and mooring.
- Power Projects Limited – private consulting company with focus on marine energy. Founder of AWATEA.

Technology Demonstration and Projects

There are 24 projects currently active in NZ at various scales and stages of development. Most are not public but the 4 most advanced are:

- **Crest Energy** – submitted resource consent application for incremental development of 200 MW tidal stream turbine project in outer part of Kaipara Harbour; consent applications due to be heard in first half of 2008; will utilize OpenHydro technology; currently privately funded.
- **Neptune Power** – submitted resource consent application for single tidal stream turbine deployment in Cook Strait, trial device is 1 MW (to be deployed between 2009 – 2011); 150 x 3 MW turbines by 2021.
- **Wave Energy Technology** – New Zealand (WET-NZ) – R & D consortium (see above) has developed 2 kW experimental wave energy converter, which has been deployed in Lyttelton Harbour during 2007; currently building second experimental device; plans to build 100 kW pre-commercial device; Government funded but seeking commercial partners.
- **Power Generation Projects** – proposal to import Pelamis technology (although largely fabricated in New Zealand); visited Ocean Power Delivery (OPD) and others in UK in June 2007; current status unknown.

Relevant National Association's Activities

Aotearoa Wave and Tidal Energy Association (AWATEA) has 56 Corporate, Professional, Non-profit and Individual members; held annual conference "Blue Energy: Taking the Plunge" in Wellington on 15 March 2007 (118 attendees) and mini-conference, following its Annual General Meeting on 8 August 2007. Presentations available on AWATEA website: www.awatea.org.nz.

NORWAY

Petter Hersleth, Statkraft SF

Policy & Prospects

In general there are no specific goals or funding/support for ocean energy, but a new recommendation on R,D&D will be published early 2008.

Approximately 15 initiatives on Ocean Energy have received support from the Norwegian Government:

- 60-70 % of the initiatives are on wave power, one project is on osmotic power and the rest is on tidal power.
- 8-10 of the initiatives are technology development and small-scale prototype testing by small technology developers.
- There are 3-4 larger R&D projects with several project partners.
- There are 2-3 ongoing large scale or full-scale prototype projects.
- In addition, Norwegian partners are involved in several projects that received support form EC FP6 program in 2007.
- The world's first prototype on osmotic power is under construction.

Research and Development

In Norway there is research and development on wave energy, tidal energy and osmotic power.

Two wave energy Research programs, co-sponsored by EU, under FP6 (app 3,4 MEUR) in three years, have key participants from Norway.

An ocean energy research program (app 10 MEUR in 4 years), including universities from Norway, Sweden and Denmark, has been initiated by Statkraft, a Norwegian power utility

Relevant National Association's Activities

Norwegian Offshore Renewable Energy Organisation (FFMFE) – a newly established group of energy companies in Norway has the overall goal of "realize the potential of offshore renewable energy".

INORE's 1st International PhD Symposium on Offshore Renewable Energy was held at Agdenes, Norway, in June 2007, arranged by the International PhD Network on Offshore Renewable Energy in cooperation with the Norwegian Centre for Renewable Energy (http://www.sffe.no).

PORTUGAL

Teresa Pontes, INETI

Policy & Prospects

Pilot Zone for Wave Energy Exploitation

The legislation to create a Pilot Zone for tests of prototypes and exploitation by pre-commercial and commercial offshore farms was partly published, being expected that the final publication will occur in early 2008. This Zone is located off the west coast 150 km north of Lisbon, and covers an area of approximately 400 km^2, between approximately 30m and 80 m water-depth. It will be connected to the local distribution grid for power up to 80 MW, and the national transportation grid for power up to 250 MW. The zone will be managed by an entity, with capacity for licensing, that will promote and manage the common infra-structures, namely the connection to the electrical grid, and the nautical and surveillance infra-structures.

Research and Development

MARTIFER ENERGIA SA has continued the development of an offshore floating wave energy converter. After the selection of the final geometry, the numerical modelling (including the power take off and mooring) in the frequency and time domains was carried out. This was followed by model testing in irregular wave tank. Patents were filled.

European Contracts

CA-OE – Co-Ordinated Action on Ocean Energy – with circa 50 participants (4 from Portugal), about half from industry. The main project activities were the organisation of dedicated interactive workshops and short-term young researchers placements, as a vehicle to exchange and analyse information for the Ocean Energy Development. The Wave Energy Centre participated in the core-group and coordinated the exchange of personnel component, INETI coordinated WP4 – Performance Monitoring of Ocean Energy Systems, and Instituto Superior Técnico (IST) acted as one of the developers. The other Portuguese participant was Kymaner Tecnologias Energéticas SA.

WAVETRAIN – Research Training Network towards Competitive Ocean Wave Energy, (2004–2008). The contract, involving 11 participants, was coordinated by Instituto Superior Técnico, with a relevant contribution in the management by the Wave Energy Centre. INETI was responsible for WP1 –Pre-normative Research. The main objectives of the project are the training of 15 young scientists in the field of wave energy. The proposal for the follow up WAVETRAIN II coordinated by the Wave Energy Centre obtained a good classification from the European Commission.

SEEWEC – Sustainable Economically Efficient Wave Energy Converter (2005 – 2008), aiming at developing and deploying a prototype of FO^3 device. Instituto Superior Técnico coordinated WP3 – Wave climate and environmental study.

POW´WOW – Co-ordinated Action on Prediction of Waves, Wakes and Offshore Wind (2005-2008). This contract involves 14 participants; INETI coordinates WP1 – Offshore Meteorology.

Aqua-RET – Aquatic Renewable Energy Technologies (2006-2008). The objective of this project is the development of online e-learning sessions on marine renewable energy technologies in order to inform the general public and stimulate industrial and other companies to act in this area. Wave Energy Centre is a member of this project.

WAVEPLAM – WAVe energy PLAnning and Marketing (2007-2010). The purpose of this project is to develop tools and establish the necessary conditions to find solutions for the probable non-technical barriers and conditioning factors that may arise with the deployment of large scale wave energy technologies. The Wave Energy Centre coordinates WP3 – Development of a basic guide for the promoters of wave energy projects.

National Contracts funded by the Ministry of Science and Technology

- Self-rectifying Impulse Turbines for WECs (The project terminated in 2007). It was coordinated by IST, and had the participation of INETI, New University of Lisbon (UNL). Preliminary numerical modelling of impulse turbine was carried out.
- Advanced Ocean Surface Data for Wave Energy Conversion and Primary Production (2006-2008). This project, incorporating two areas of knowledge, is co-ordinated by INETI; University of Lisbon and University of Minho are the other partners. In regard to wave energy, satellite wave data (altimeter and ASAR) were collected and its usefulness for resource assessment was evaluated.
- Modelling, Optimization and Control of offshore WECs (2005-2007) – The project was coordinated by IST and had the participation of INETI.
- Experimental Development of Offshore WECs (2007-2010). The project is coordinated by IST and has the participation of INETI and University of Porto.
- WEAM – Wave Energy Acoustic Monitoring (2007-2010). This project aims to develop instrumentation for the assessment of underwater noise produced by wave energy devices and to propose a monitoring plan. The project is coordinated by the Wave Energy Centre and has the participation of the University of Algarve.

Demonstration and Pre-Commercial Activities

Pico Plant

This pilot plant has undergone mechanical, structural and monitoring improvements, namely the replacement of the two sets of the turbine guide-vanes, the reinforcement of the turbine structure to avoid vibrations, the repair of the turbine ducts, and the replacement of data transmission cables for optical fibber. These improvements have been carried out and funded by the companies EFACEC and MARTIFER ENERGIA SA, and by the Wave Energy Centre. Numerical modelling of the plant dynamic operation has been started by Instituto Superior Técnico and the Wave Energy Centre. Plant testing has been performed over several periods along the year.

OWC Power Plant at the mouth of Douro River, Porto.

The construction of the 750 kW OWC wave power plant, planned to be incorporated in the new breakwater at the mouth of Douro River in Porto, did not start due to difficulties with the authorization for the modification of the two breakwater head-caissons to accommodate the two OWC chambers.

Pelamis Wave Farm

In October, during final preparations for positioning the three 750 kW Pelamis machines on site at Aguçadoura (northern Portugal), it was noted that the mooring units had sunk down from their earlier position, and for no obvious reason. Although care and attention had been exercised in the design, fabrication and installation of the buoyancy units employed, the integrity of the foam buoyancy and its encasement has clearly been compromised. Replacement buoyancy units were supplied and are waiting for a suitable weather window for installation.

Pelamis machines in Leixões Harbour waiting for installation

WaveRoller module in Peniche Shipyard

WaveRoller

A prototype of this bottom-mounted flat plate oscillating device developed by the Finish Company AW-Energy was deployed in April in Peniche, 100 km north of Lisbon. It is reported that a new company jointly owned by AW-Energy and the Portuguese Grupo Lena has been established to pursue the development. Plans for the construction of a 1 MW plant in 2008 were announced.

THE 7TH EUROPEAN WAVE AND TIDAL ENERGY CONFERENCE

The 7th European Wave and Tidal Energy Conference was held in Porto on 11-13 September, the Chairman being Prof. António Falcão from Instituto Superior Técnico. The conference was attended by about 350 participants, 86% from Europe. Taking into account that wave and tidal energy are not mature technologies, the participation from companies was remarkably high (65%) as compared with those from universities (29%) and other institutions (6%). The number of participants as well as the number of papers was significantly larger than in previous conferences, which shows an important increase of interest on ocean energy especially from companies. 103 papers were selected for presentation and publication in the CD proceedings after peer review of the full-length paper. The proceedings can be obtained from www.ewtec2007.com.pt.

RUSSIA

Alexander A. Temeev, Director of Applied Technologies Company Ltd (ATC)

Policy & Prospects

Various studies, evaluations and other research evidence on renewables available in Russia demonstrate that there is enormous potential as well as there are huge technical-economic opportunities for cost-effective energy-efficiency investments in the industrial, residential, and heating sectors. Renewable energy sources in Russia can play a significant and cost-effective role in energy supply in many geographic regions. However, despite the evidence shows that Russian technological capabilities to exploit these technical-economic potentials are strong, the market-related capabilities are still weak. Current status of the actual power production – consumption in Russia is characterized by domination of fuel burning technologies*. Approximately 54% of primary energy production consisted of natural gas burning, 19% oil product burning, 16% coal and other solid fuels burning, 5% of the power production are those of the nuclear power and about 6% are those of the hydro-power and other renewables. The actual annual energy production is at a level of 26-31 Quadrillion Btu. The structure of the electricity production in Russia is characterised by the similar indexes. Approximately 72% of the electricity production is those of the coal, oil product and gas burning; about 13% are those of the nuclear power and about 15% are those of the hydro-power and other renewables. At the same time, when hydroelectricity and renewable combustible (like wood and waste) are excluded, the share of all other renewable resources makes up less then 0,1% of the overall energy production. Russia receives practically no share of its energy supply from renewable energy sources.

Public funding/governmental support: State contract 02.516.11.6108 on the development of dynamic model of Float Wave Electric Power Station (FWEPS) module (amount of financing – 30000 US$).

* Energy Information Administration/International Energy Outlook 2007.

Research and Development

Key institutions with R&D activities in wave and tidal energy:

- Applied Technologies Company Ltd (ATC) develops an offshore Float Wave Electric Power Station (FWEPS) as efficient means for sea wave energy conversion and technology for hydrogen production by means of sea water electrolysis (established in Moscow, Russia). www.atecom.ru
- "Private productive science and technical company" develops wave energy converter for Renewable Energy Systems either floating or ground based (established in Moscow, Russia). http://ocean-power.narod.ru/index.html
- Joint Stock Company «Scientific Research Institute of Energy Structures» develops an installation for tidal power conversion (established in Moscow, Russia). http://www.niies.ru

Technology Demonstration and Projects

Wave Energy

The demonstrational model of the Float Wave Electric Power Station (FWEPS) module and assembly units are at the completion stage of manufacturing, adjustment and test preparation. Next plans include the development of full scaled 10 kW FWEPS and the development of multimodule grid installation.

The module of FWEPS consists of a mechanical wave energy converter 1, electric generator 2 and energy storage 3. They are maintained inside the sealed capsule-float of an axially symmetric streamline shape. The float is disposed on the sea surface in the direction of local vertical. The mechanical wave energy converter consists of an oscillatory system and a drive for electric generator. Under the action of sea waves the float – FWEPS and inner oscillatory system are in continuous oscillatory motion. The drive, engaged with the latter, provides a continuous electric generator rotation. Depending on the mission it is possible to develop both a single modular FWEPS for output power from units of watts up to 50 kW and multi-modular installation in a grid form of total capacity up to dozens of megawatts.

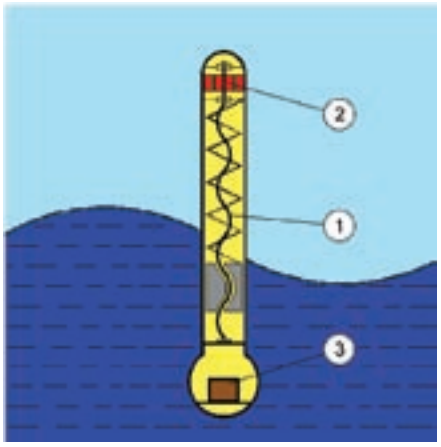


Diagram of single-module FWEPS



Experimental model in sea keeping basin with irregular waves and hull of FWEPS pilot module under manufacturing (yellow-black cylinder in the centre of picture)

Tidal power plant in Kislaya Bay on the Barents Sea

Tidal Energy

Design studies for tidal power development have been conducted in Russia since the 1930s. As part of this work, a small pilot plant with a capacity of 400 kW was constructed in Kislaya Bay on the Barents Sea and commissioned in 1968. The location has now become an experimental site for testing new tidal power technologies.

Early in 2007, GidroOGK, a subsidiary of the Russian electric utility, Unified Energy Systems (UES), began the installation of a 1.5 MW orthogonal turbine alongside the original Kislaya Bay tidal facility. The experimental turbines will be thoroughly tested as part of a pilot project to assist in the design of large-scale tidal power plants.

There are currently two ambitious projects for TPPs in the Federation:

- Mezenski Bay (on the White Sea, in northern Russia): proposed capacity 15 GW, annual output 40 TWh;
- Tugurski Bay (on the Sea of Okhotsk in the Russian Far East): of 7.98 GW capacity, 20 TWh annual output.

If the 1.5 MW experimental installation at the Barents Sea location proves successful, UES intends to embark on a program for constructing giant-size TPPs such as those projected.

SOUTH AFRICA

Terence Govender (Eskom) and Prof. Wikus van Niekerk (Centre for Renewable and Sustainable Energy Studies, Stellenbosch University).

Ocean Energy is an area where South Africa is well positioned with a significant resource in wave energy, 40-50 kW/m wave crest, and ocean current, the Agulhas current is estimated to flow between 1-2 m/s in some places. At this time a number of groups are investigating the harvesting of wave energy. Finavera Renewables have identified two sites and are busy with the required environmental impact assessments and permit applications. Other, such as the Stellenbosch Wave Energy Converter (SWEC), are still at the concept phase and will require significant R&D funding to commercialise. The major barriers to exploiting ocean energy is lack of regulations in South Africa to facilitate the development of renewable energy projects.

Policy & Prospects

The Department of Minerals and Energy, the DME, has in its White Paper on Renewable Energy Policy set the following non-mandatory target for SA, which was approved by Cabinet in November 2003. The White Paper on Renewable Energy Policy target states:

10 000 GWh (0.8 Mtoe) renewable energy contribution to final energy consumption by 2013, to be produced mainly from biomass, wind, solar & small-scale hydro. The renewable energy is to be utilised for power generation and non-electric technologies such as solar water heating and bio-fuels.

At the time of drafting this policy, Ocean Energy was not part of the generation mix and mainly seen as research. This target is up for review in 2008.

Both the DME and NERSA, the National Energy Regulator of South Africa, are busy with studies investigating the possibility of a tradable renewable energy certificate and/or a

feed-in tariff. To this end, the DME has set up a Renewable Energy Finance and Subsidy Office that is mainly aimed at financing commercial renewable energy projects. To date, no ocean energy projects have been funded.

In addition, the SA Government has embarked on national research program in renewable energy, including ocean energy. This is facilitated by the newly formed South African National Energy Research Institute (SANERI) that placed a contract at Stellenbosch University to act as the National Hub for the Postgraduate Program in Renewable and Sustainable Energy Studies. In 2007, SANERI made approximately R 4,5 million available for research into renewable energy, but only a small amount, less than R 100 000 was spend on ocean energy research.

In addition to the targets set by the SA Government in the White Paper, the Western Cape Provincial Government announced in June 2007 that the Province will source 15% of its energy from renewable sources by 2015. This is significant for ocean energy as the most of the sites where wave energy can be harvested are along this province's coastline. The MEC in charge of Environmental Affairs and Economic Development stated that the Province will draft its own Renewable Energy Act and also streamline process to apply for permits and licences to fast-track renewable energy projects. The Province is also currently negotiating a feed-in tariff with ESKOM and NERSA.

Research and Development

Eskom, the SA national power utility, has been investigating the possibility of using ocean energy conversion technologies as part of the Eskom generation mix since 2003. To date, a resource assessment has been completed for wave energy and Eskom is busy with tracking and assessing the progress of international technologies. In 2008, Eskom will continue with the resource assessments and chose a site for a possible demonstration plant installation. Thereafter, the necessary EIA's will be conducted. Eskom will then choose one technology to implement based on Techno-economic selection criteria. Research into ocean currents began in the late 2004 and to date detailed resources assessments are being conducted. 2008 will see research into turbine design, CFD studies, site selections and costing.

The time frame for possible implementation is for wave energy 2011 and for currents 2011-12.

More information can be found at: www.sabregen.co.za

At Stellenbosch University a research group was formed in the eighties as part of the Ocean Engineering Research Group to investigate ocean energy. After many years of research that quantified the ocean energy resources it was decided that wave energy holds the most promise and a device, the Stellenbosch Wave Energy Converter, was developed. After extensive model-testing the project was abandoned when the price of oil fell to below $ 10 in the nineties. This project is currently being resurrected by a group from Civil and Mechanical Engineering with involvement by outside consultant and an IPP, the Oelsner Group.

In Stellenbosch both the University as well as the CSIR (the national research laboratory) have extensive testing facilities in the form of model basins, wave plumes and a 90m towing tank. Both organisations also have capacity to conduct research in ocean engineering, mechanical and electrical engineering.

Model testing of SWEC (Stellenbosch Wave Energy Converter)

Key institutions:

The Centre for Renewable and Sustainable Energy Studies at Stellenbosch University
(www.sun.ac.crses)
The Centre is the National Hub of the Postgraduate Program in Renewable and Sustainable Energy Studies and coordinates research and postgraduate training in the field of renewable energy, including ocean energy. The Centre manages a hub and spoke model with researchers based at various other institutions involved as spokes.

The Department of Oceanography at the University of Cape Town
(http://www.sea.uct.ac.za/index.php)
The University of Cape Town has a well established Department of Oceanography that conducts research into ocean currents and temperature and its effect on Climate Change.

The Coastal Engineering and Port Infrastructure Research Group of the CSIR
(http://www.csir.co.za/Built_environment/Infrastructure_engineering/cepi.html)
CSIR Built Environment's Coastal Engineering and Port Infrastructure research group, originally established in 1971, provides predictive engineering solutions and decision support for the safe and cost-effective development and operation of ports and coastal sites. The group aims to use its expert knowledge, highly qualified and locally-based personnel to deliver solutions to engineering problems relating to ports and coasts.

South African National Energy Research Institute (SANERI)
(www.saneri.org.za)
SANERI's strapline is "Energy Innovation for Life" and it captures the essence of the company quite succinctly. The company strives to create and maintain a culture of innovation in the energy sector, to help develop South Africa's competitiveness internationally. Energy Innovation for Life implies sustainable benefit to communities and the ongoing pursuit of excellence. These are all values that are the hallmark of the company. SANERI is tasked with developing human capital in the energy research sector and also with funding fundamental and applied research in specified thematic areas, including renewable energy.

ESKOM
(www.eskom.co.za)
ESKOM is the national power utility that generates in excess of 95% of the electricity in the country and therefore a key partner in any renewable energy project.

Technology Demonstration and Projects

One device, the SWEC (Stellenbosch Wave Energy Converter), advanced to model testing.

SPAIN

Jose Luis Villate, Robotiker Energía, Tecnalia

Ocean energy in Spain is having a late deployment in comparison with other countries with a similar ocean power potential such as UK or Portugal. Nevertheless, activities involving ocean energy (basically wave power) have been growing steadily since 2005. In 2007, several research projects (aiming at new concepts of wave energy converters) and four demonstration projects (two under construction and another two in the pipeline) are being developed. Besides that, the conditions to set up a test and demonstration infrastructure of 20MW on the Basque coast have also been created. Regarding association activities, 2007 has seen the creation of a new section for marine energies (wave and tidal) inside the Spanish Renewable Energy Association and approval of a national standardisation group for wave and tidal energy converters.

National Policy

There are not national targets in Spain for ocean power, neither for electricity generation nor for other uses.

Only one region in Spain, the Basque Country, has considered targets in its energy strategy: 5MW of installed wave power by 2010. For that purpose, the Basque Government has allocated an investment of 15 millions Euro. This investment includes a test and demonstration infrastructure on the Basque Coast of about 20MW.

Other regions of Spain (Galicia, Asturias, Cantabria) have started analysing the marine energy potential but without specific targets.

The Spanish Ministry of Education and Science supports the PSE-MAR project, the main Spanish initiative in the field of ocean energy research. PSE-MAR is a Singular and Strategic Project on ocean energy, which aims to improve the competitive position of Spain in the ocean energy world market. The budget of this project is 25M€ for the period 2005-2009 with the objective of developing the three most promising Spanish technologies for wave energy converters. In parallel to this, the project includes the setting-up of an experimental and demonstration infrastructure in the Basque coast for validation of technologies (both those developed in project PSE-MAR and other ocean energy technologies).

In November 2007, a consortium led by EVE (with the participation of several European partners) started WAVEPLAM project, partially funded by the program Intelligent Energy – Europe, to speed up the introduction of wave energy onto the European renewable energy market, tackling in advance non-technological barriers and conditioning factors that may arise when these technologies are available for large-scale development.

Relevant legislation:

- Royal Decree 661/2007 (May 25th), which regulates the electricity production in special regime (it includes feed-in tariffs for renewable energy). Regarding ocean power the general tariff is 6.86c€/kWh for the first 20 years and 6.51 c€/kWh after (about 6 times lower than photovoltaics and similar to wind energy). Nevertheless, this Royal Decree includes the possibility of negotiating a particular tariff for each ocean power installation but a comprehensive description of the installation is needed.
- Royal Decree 1028/2007 (July 20th), which establishes the administrative procedure to apply for an authorization for electricity generation installations at sea. It is mainly focused on offshore wind, but it also includes a simplified procedure for other marine technologies.

Research and Development

Relevant research activities:

- PSE-MAR Project already mentioned. This project is coordinated by TECNALIA and includes the development of three technologies of Wave Energy Converters from the companies PIPO Systems, HIDROFLOT and TECNALIA.
- There are other private initiatives to develop wave energy converters, for example the company Arlas Invest, with the collaboration of UPC, is developing a wave energy converter based on a buoy concept.
- WAVENERGY Project (in the framework of INTERREG program) This project is aimed at developing a plan to define the actions and priorities for the development of wave energy. The project will pay special attention to ports as infrastructures with a large environmental impact but useful for including wave power generation.

Localisation of Powerbuoy wave farm project under construction

New sea-port of Mutriku under construction with OWC wave energy technology

Key institutions

IDAE: The Institute for Energy Diversification and Saving, IDAE, is a public body attached to the Spanish Ministry of Industry. Its main goal is the achievement of national targets on Energy Saving and Efficiency and Renewable Energies.
www.idae.es

EVE: The Basque Energy Agency, EVE, is a public body created by the Basque Government in 1982 with the mission to implement a coherent energy policy, geared towards security of supply, energy efficiency and reduction of environmental impact.
www.eve.es

TECNALIA: A private non-profit making technology corporation whose aim is to contribute to economic and social development through the development and dissemination of Research.
www.tecnalia.info

CETMAR: A Technology Centre (Public Foundation) promoted by the Regional Department of Fisheries and Maritime Affairs and the General Directorate of R&D of the Government of Galicia together with the Spanish Ministry of Education and Science.
www.cetmar.org

There are also several universities working on the marine energy sector such as UPC (Universidad Politécnica de Cataluña), Universidad de Cantabria, Universidad de La Laguna and USC (Universidad de Santiago de Compostela)

Technology Demonstration and Projects

Santoña, Cantabria:	
Description	Electricity generation from wave energy (offshore) with Power Buoy technology from the company Ocean Power Technologies. Under construction.
Promoters	IBERDROLA Energías Marinas de Cantabria S.A (partners Iberdrola, IDAE, SODERCAN, TOTAL and O.P.T.)
Main Characteristics	10 Power buoy´s plant
Total capacity	1.39 MW (1 Power buoy with a capacity of 40 kW and 9 Power buoys with a capacity of 150 kW each one)
Distance to the shore:	3-4 km
Investment	5.8M€
Mutriku, Basque Country	
Description	Electricity generation from wave energy (onshore) with Oscillating Water Column technology from Wavegen in the new sea-port of Mutriku. Under construction.
Promoters	Basque Government, EVE
Total capacity	16 turbines with a capacity of 20 kW each one (320 kW of total capacity)
Type of project	Demonstration project partially funded by the European Commission under FP6.
Investment	3.5M€
A Guarda, Galicia	
Description	Electricity generation from wave energy (onshore). Oscillating Water Column technology from Wavegen in the sea-port "A Guarda". Construction not started.
Promoters	Sea Energy
Main characteristics	First installation at seaport "A Guarda". If it is successful, afterwards in other thirteen seaports
Power capacity	Power capacity 600 kW
Investment	1.5M€
Granadilla, Tenerife	
Description	Electricity generation from wave energy (onshore). Oscillating Water Column technology. Construction not started.
Promoters	Cabildo de Tenerife, La Laguna University, Aut. Portuaria, Santa Cruz, Iter

Relevant National Association's Activities

- APPA (Spanish Renewable Energy Association) has recently created a specific section for Marine Energy (waves and tidal). This section is coordinated by the company "SEA ENERGY S.A." and has 10 members (ELECTRA NORTE, EVE, FOMENSA HISPANIA, GARRAD HASSAN & PARTNERS, IBERDROLA ENERGIAS RENOVABLES, NORVENTO, NEO ENERGÍA, SEA ENERGY, TECNALIA and TOTAL EOLICA)
- AENOR (Spanish standardisation body) has approved the creation of a mirror standardisation group for "Marine Energy – Wave and Tidal Energy Converters" and the participation as observers in the international committee IEC TC114. The first meeting will be held in February 2008.
- EVE and TECNALIA organised in January 2007 in Bilbao the "Second International Seminar of Ocean Energy" with the participation of about 300 delegates.

SWEDEN

Susanna Widstrand, The Swedish Energy Agency (STEM)

Policy & Prospects

The target of Swedish energy policy is the creation of a safe and reliable energy system, with minimum environmental and climate effects, all at a reasonable cost and against the background of a healthy economy.

The government's target is that electricity production from biomass, wind power, solar energy and wave energy shall increase by 17 TWh by 2016 in comparison with the production quantity in 2002.

The Swedish energy agency is responsible for Sweden´s national energy research program. Working closely with universities and business, it finances technical research and knowledge development. The results of this research are intended to support development of the country's energy system, while also finding applications in commercial activities and supporting robust energy and climate policy decisions.

Research and Development

The wave power and marine current research at Uppsala University, Division for electricity and lightning, are lead by Professor Mats Leijon. There are nine Ph. D. students working with wave power projects and three working in marine current projects and about eight senior staff members working in the group.
http://www.el.angstrom.uu.se/meny/eng/index_E.html

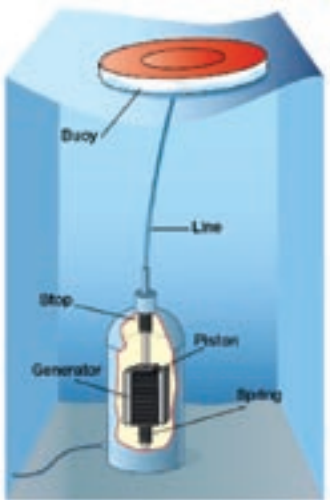
The company Seabased AB works in close cooperation with researchers at the Division for Electricity and Lightning Research at Uppsala University, Sweden. Seabased AB develops the industrial solution for conversion of ocean wave energy to electricity. Billy Johansson is the director of Seabased AB, which has eight full time employees and thirteen part time.

Technology Demonstration and Projects

At the moment there are two ongoing wave energy projects at Uppsala University. Seabased AB has just finished one project and has one starting by mid December 2007.

Uppsala University:
Project: **CFE-Centre for renewable electrical conversion**, timeline 2004-07-01 — 2008-06-30, with a total budget of 4.67 milj. €, funding STEM (The Swedish Energy Agency) 48 % . The Centre develops basic research in the areas of wave power, marine current and vertical wind.

Project: **Research facility for Wave power – Lysekil project part II**, 2006-06-01— 2009-12-31, with a total budget of 4.711 milj. €, fundig STEM 48 %.
The project aim is to study wave power technology under real conditions and impact from and on the environment. This pilot project consists totally of ten 10 kW generators which will be installed between 2006 and 2009, with the project continuing until 2014. The generators can be connected together in groups, 20-100 m below the surface. Power electronics convert the varying frequency AC from the generators to DC which is connected to a shore station by standard cables. An inverter then creates 50 Hz AC for connection to the electricity transmission or distribution system. In order to investigate the effects on the local environment, the project is being expanded with up to 30 mock buoys in order to be able to identify and investigate environmental effects more clearly. The technique should be able to extract energy from relatively small wave heights, as those found in for example, Kattegat.



Current status:
One generator has been launched off Lysekil at the Swedish west coast, and connected by sea cable to a load, showing good results. Two more generators are going to be launched in the beginning of 2008. A large step during the spring of 2007 was the launch of 21 mock buoys in the marine biological studies included in the project. Biological/ecological studies involve:

- Effects on the seabed fauna, mainly marine invertebrates
- Effects on fish living on the seabed (benthic) as well as on pelagic fish (living in the open water)
- Effects on seabirds
- Effects on marine mammals
- Effects such as fouling and artificial reefs

Seabased AB:
Project: **Pre-study for commercial wave power**, 2004-12-20 — 2007-09-30, total budget 1.2 M€, funding STEM 35 %, In this project a map of a industrial process line, a risk analysis, and an environmental-impact assessment have been made.

Project: **Performance test of wave system**, 2007-12-15—2009-12-31, total budget 2.89 M€, funding STEM 50 %. The performance test includes manufacturing of prototypes (20 and 50 kW), launch (at Lysekil and Orkney-Scotland), connection, start-up and operation. Every step comprises measurements to control the performance of components and systems.

Seabased generator: schematic picture and preparation of the generator for launch off at Lysekil (Courtesy from Uppsala University).
Seabased is a three-phase, permanent magnet, linear generator especially developed to be utilised in ocean bed arrays and directly driven by point absorbers (buoys) on the surface.

UNITED KINGDOM

Gary Shanahan, Department for Business, Enterprise and Regulatory Reform (BERR). BERR was established in July 2007 and took over many of the functions of the former Department for Trade and Industry.

Policy & Planning

A major review of UK energy policy was carried out in 2006 in which focused on ensuring that the UK remains on course for achieving its key energy goals of climate and energy security. Amongst other things, the review set out proposals to improve the Renewables Obligation (RO), the key support mechanism for renewable energy in the UK. Specifically, to increase the requirement placed on electricity suppliers to meet a growing proportion of their generation from renewable sources from the current 15% in 2015 up to 20% when justified and to adapt the RO to provide greater support to emerging technologies. Formal detailed proposals on how the RO may be used to assist emerging technologies formed part of an Energy White Paper published in May 2007.

Separately, the Scottish Government published proposals in September 2006 that will amend the Scottish Renewables Obligation so as to provide greater support for wave and tidal-stream technologies. The proposed initial phase of support is for up to 75MW giving support levels of £175/MWh for wave and £105/MWh for tidal-stream. The new legislation came into force in Scotland in April 2007.

In November 2005 the then Department of Trade and Industry (DTI) published guidance on consenting arrangements in England & Wales for a pre-commercial demonstration phase that leading wave and tidal-stream (marine) energy technologies are shortly expected to enter. The purpose of the guidance is to provide clarity on how existing regulations will be interpreted and applied across government when considering consent applications for marine energy device demonstrations. The guidance will provide certainty for the duration of the demonstration phase, but introduces no new regulation.

In September 2006 the Welsh Assembly Government announced a £1 million 3-year project to develop a Welsh Marine Renewable Energy Strategic Framework (MRESF) that will ensure the sustainable development of the marine renewable energy resource contained within the Welsh Seas.

Research, Development and Demonstration

In 2007 government continued to support research and development of marine energy technologies primarily through the Technology Program. The objectives of the program and related demonstration initiatives are to stimulate innovation, develop industrial capability and to gain an understanding of the long-term commercial prospects for low-carbon energy technologies. These new projects brought the total support for marine energy technology research & development projects through the Technology Program and its predecessors to some £30 million since 1999. R&D support for wave and tidal energy is also proposed through the newly established Energy Technologies Institute – http://www.energytechnologies.co.uk/– which announced in December 2007 a call for expressions of interest to develop a small number of major new development and demonstration projects in marine energy – each to be funded at a level of £5million to £10million

Within the R&D activities in the UK a number of full-scale prototypes are expected to be deployed and demonstrated during 2008. Amongst these is the SeaGen project led by Marine Current Turbines Ltd. The company expects to install their 1MW twin rotor tidal-stream device in Stangford Lough, Northern Ireland in the first half of 2008. The Carbon Trust is supporting a £3.5 million initiative in marine renewable energy called the Marine Energy Accelerator (MEA). The program aims to accelerate progress in cost reduction of marine energy technologies, to bring forward the time when marine energy becomes cost-competitive. The individual projects will involve device developers and component technology manufacturers working with engineering consultants, contractors and academic research groups. This follows-on from the Trusts' Marine Energy Challenge.

In 2007 the Scottish Government announced grants totaling £13 million under a 'Wave and Tidal Energy Support Scheme' that has total funding of £8 million. The aim of the Scheme is to provide grants to businesses to support the installation and commissioning/deployment of pre-commercial wave and tidal devices at EMEC. The scheme will also support components of projects requiring testing at EMEC e.g. mooring systems, foundation installation systems etc. that will lead to reduced project cost and/or improved operation and maintenance for the industry.

A BERR Scheme to support the first larger-scale multi-device grid connected pre-commercial demonstrations – "Wave and Tidal-stream Energy Demonstration Scheme" makes available a total of £42 million, with up to £9 million for individual projects. The funding is delivered through a combination of capital grant and revenue support. In addition to the capital and revenue support received under the Scheme projects may also receive revenue from the sale of electricity and green certificates under the existing market. The Scheme is part of a package of measures under the £50 million BERR Marine Renewables Deployment Fund. Other measures include support for infrastructure projects and a marine environmental research program.

The proposed 'Wave Hub' infrastructure project is an electrical grid connection point 15 km offshore into which wave energy devices can be connected. The chosen site is off the North Cornwall coast. The 'Wave Hub' approach is expected to bring a number of benefits to developers, including a well defined and monitored site with electrical connection to the onshore electricity grid and a simplified and shortened consents process, reducing the risk for developers of the first pre-commercial wave arrays.

The total project cost is estimated at some £28 million for 20MW capacity and BERR has announced support of up to £4.5m towards the cost of the project and planning consent was announced by Ministers in 2007. If the project receives the necessary support from the industry, then it could be commissioned as early as summer 2009.

In 2007 the European Marine Energy Centre (EMEC) in Orkney opened the tidal-stream testing facility in Eday. The new berths are grid connected having a total capacity of 20MW. As well as providing world leading test facilities, the measurement and independent verification of the performance of marine devices will form part of the services provided by EMEC.

Gaining an understanding of the environmental impacts of new marine technologies has been identified as a priority area. The UK Research Advisory Group (RAG) was created by BERR as a pan-government body to facilitate a co-ordinated approach among the regulatory and funding bodies to address the key impact issues of offshore renewables. The remit of RAG has now been extended to gain further understanding on the potential impacts of wave & tidal-stream energy generation and a total of £2 million has been allocated under the MRDF to a marine energy technologies research and monitoring program. The results from the program are to be published and will inform decisions makers both at a project and strategic level.

Along with the industry-led activities and initiatives in the UK, a new £6 million 4 year program of fundamental marine energy research involving a number of UK universities and known as Supergen Marine Consortium was approved by the Research Councils. This new program builds upon research carried out under the previous Supergen Marine I research program. Notably it seeks to better understand *device-sea interactions* and so should complement work that is ongoing under many of the other initiatives discussed above.

Sustainable Development Commission studying tidal power in the UK

In July 2006 a major £400k study on tidal power in the UK was commissioned by government. The study carried out by the Sustainable Development Commission considered the UK tidal resource and the technologies to harness tidal energy – including tidal barrages, lagoons and tidal stream technology. In particular, the study looked at the potential for tidal power developments in the Severn Estuary and related issues in depth.

The Sustainable Development Commission (SDC), the UK Government's independent advisory body on sustainable development published in October 2007 a report on the year – long major UK-wide study on tidal power. The study considered all tidal power technologies – tidal barrages and lagoons (offshore impoundments) as well as emerging tidal stream technologies – from a sustainable development perspective.

The UK has significant tidal resources around its coastlines, and the SDC is interested in how tidal power can be developed in a sustainable way to help mitigate climate change and achieve targets for renewable energy. A significant part of the SDC's brief for this study is to review options for tidal power in the Severn Estuary, which has been the subject of major studies in the past. The Severn Estuary, on the south-west coast of Britain, has the second highest tidal range in the world, and is protected under European and UK conservation laws.

The review considers the sustainability of several proposals for a tidal barrage, the largest of which could generate up to 5% of the UK's electricity demand.

Engagement with public and stakeholders A central element of the SDC's tidal power study is engagement with stakeholders and the public. The SDC believes that engagement is essential to effective, integrated policy-making that delivers sustainable development on the ground. The tidal power study has provided a valuable opportunity to develop an integrated program of public and stakeholder engagement – in parallel to a program of commissioned research and information gathering on the environmental, social and economic issues surrounding tidal power.
In March and April, the SDC held eight public and stakeholder engagement events around the UK with locations in Wales, England and Scotland. The SDC worked with Opinion Leader Research and the Environment Council to develop and deliver a program of engagement events around the UK. The objective of the engagement was to gain an understanding of the views of members of the public and stakeholders on a range of issues related to tidal power and renewable energy. The engagement program is being evaluated by an independent evaluator.

Deliberative public engagement
The public engagement aimed to work at a national, regional and local level and used a number of different techniques to facilitate public involvement. At a local and regional level, the approach was to use deliberative techniques and a series of six regional workshops and local discussion groups were organised and facilitated by Opinion Leader in locations around the UK. Recruited members of the public were asked to consider a range of renewable energy and sustainability issues related to different tidal power technologies and potential tidal power developments. At a national level, 1,000 people were asked questions through an omnibus poll on tidal power in the UK generally, as well as some specific questions on a possible barrage across the Severn Estuary. This helped to provide a snapshot of wider public opinion to complement the face-to-face, deliberative approach.

Stakeholder workshops
The other strand of the engagement involved convening two large, one-day workshops for stakeholders. The workshops, held in Aberdeen, Scotland, and Cardiff, Wales, were attended by around 70 stakeholders in total. The SDC's tidal power study has attracted significant interest from stakeholders since it was first announced on the SDC's website in mid-2006, and a number of stakeholders had already sent through relevant research and evidence, thus helping the SDC to develop a good evidence base on tidal power prior

to the project scoping phase. The workshops, facilitated by The Environment Council, were an opportunity for stakeholders to meet each other, actively consider the issues, and directly inform the SDC's work. The stakeholders were identified through a detailed stakeholder analysis and scoping process, and represented a wide range of interests, including representatives from Government, statutory agencies, ports, fishing, shipping, and yachting interests, industry, NGOs, academic institutions, and tidal technology developers.

The SDC published a report on October 1 2007. The report drew on the research and engagement, and included recommendations for policymakers. The commissioned research reports and the report from the engagement program were also published on the SDC's website. Further information about the SDC and the tidal power study are available at http://www.sdcommission.org.uk/pages/tidal.html.

Severn Tidal Power Feasibility Study
The UK Government announced in September 2007 its commitment to study the feasibility of generating electricity from the tidal range of the Severn Estuary, which – as the Sustainable Development Commission confirmed – has the potential to generate some 5% of UK electricity from a renewable indigenous resource.

The Government published the terms of reference for the Feasibility Study in January 2008.

Building on the work of the Sustainable Development Commission and earlier studies, the feasibility study will:

- assess in broad terms the costs, benefits and impact of a project to generate power from the tidal range of the Severn Estuary, including environmental, social, regional, economic, and energy market impacts;
- identify a single preferred tidal range project (which may be a single technology/location or a combination of these) from the number of options that have been proposed;
- consider what measures the Government could put in place to bring forward a project that fulfils regulatory requirements, and the steps that are necessary to achieve this;
- decide, in the context of the Government's energy and climate change goals and the alternative options for achieving these, and after public consultation, whether the Government could support a tidal power project in the Severn Estuary and on what terms.

The work will be carried out by a cross-Whitehall team led from the Department for Business, Enterprise and Regulatory Reform, including representatives of the Welsh Assembly Government and the South West Regional Development Agency, taking external advice as necessary and engaging stakeholders and the wider public. The study is expected to last roughly two years.

The study will look at the range of options for power generation from the Severn Estuary tidal range, including barrages, lagoons and other technologies. It will include a Strategic Environmental Assessment of plans for generating electricity from the Severn Estuary tidal range to ensure a detailed understanding of its environmental resource, recognising the nature conservation significance of the Estuary.

The feasibility study team will report to the Secretary of State for Business, Enterprise and Regulatory Reform supported by Ministers from DCLG, Defra, DfT, Treasury, Wales Office, the Welsh Assembly Government and the Minister for the South West.

If the outcome of the feasibility study is a decision to proceed, extensive and detailed further work would be needed to plan and implement a tidal power project, and secure the regulatory consents that would be required.

It is clear that a unique opportunity now presents itself for greater collaboration between government, industry and the research community so as to better understand the long-term prospects for marine energy as a contributor to the achievement of the government's energy goals.

USA

Walt Musial, National Renewable Energy Laboratory, Colorado

Overall the United States has advanced itself in the field of ocean renewables this year on several levels. For the first time, the U.S. Congress has appropriated funding to begin a significant research and development program at DOE. State interest has also grown, and key states such as Oregon and Florida have provided funding to local organizations. Regulatory agencies have acknowledged some of the difficulties in obtaining approval for new technologies to be tested in open water, and have made efforts this year to address long regulatory delays. A test of these new policies will be to see if project approvals are indeed faster. New deployments have not increased significantly, but a new test facility was commissioned in Newport Oregon this year and has begun open ocean testing on a limited (off-grid) basis.

Policy & Prospects

The interest in ocean renewable energy has been growing in the United States throughout 2007. Most notably, the U.S. Congress has passed for the first time appropriations to fund a $10 million research program for water power, which will be directed by the Department of Energy (DOE) and executed largely by the national laboratories for the coming fiscal year in 2008. Part of this new money will be devoted to assessing potential opportunities to expand the current conventional hydroelectric capacity without building new dams, but the emphasis will be to begin research, development and deployment activities for ocean renewables including wave, tidal, hydrokinetic river turbines, and ocean current devices. In addition, federal legislation has been passed authorizing up to $50 million dollars of annual funding for future years with provisions for the formation of test facilities in key ocean states. Although this level of appropriation is very optimistic, the legislation indicates a growing federal interest and sets the stage for sustained federal funding.

In October 2007, the Federal Energy Regulatory Commission (FERC), which is primarily responsible for permitting all ocean energy devices that are connected to the grid within U.S. state waters (inside 3-nautical miles from the coast), announced a new streamlined permitting approach for ocean energy devices that could potentially reduce the approval process for pilot projects under 5 MW for a 5-year license from 5 years to 6 months. However, these regulatory process advances do not apply to commercial projects.

In November 2007, the Mineral Management Service (MMS) announced the release of a Programmatic Environmental Impact Statement (PEIS) that is intended to reduce the individual developers' efforts for siting projects in federal waters (ocean waters 3 or more nautical miles from shore). At the same time, MMS announced that they would open the outer continental shelf to proposals for research and experimental projects involving the measurement of MET ocean conditions, as well as ocean energy demonstration projects (excluding offshore wind).

Ocean wave and tidal energy sources do not currently benefit from the incentives that are available to other renewable energy sources, but efforts to have ocean renewables recognized in future legislation for renewable energy incentives are continuing.

Research and Development

In 2007, $4.5 million of public funding was appropriated by the State of Oregon for the Oregon Wave Energy Trust (OWET), and an additional $3.0 million was appropriated to establish a wave energy test site in Newport, Oregon. The test facility began off-grid testing this year. (See below.)

This year, the State of Florida provided $5 million in funding to Florida Atlantic University (FAU), where a research program to develop technology for ocean current turbines is being established.

Several other organizations have demonstrated or expressed interest in advancing ocean renewable energy development this year, including University of Massachusetts at Dartmouth, Tacoma Power, Snohomish County Public Utility District (SnoPUD), Maine Maritime Academy, Pacific Gas and Electric, Massachusetts Technology Collaborative, Counties of Lincoln and Douglas, Oregon.

In addition, Bonneville Power Administration (BPA) in Washington State initiated several small technology development contracts this year. One contract went to SnoPUD to perform a feasibility study to extract tidal energy from the currents through the Admiralty Strait leading into Puget Sound, and another to Tacoma Power to perform a feasibility study to extract tidal energy from the currents through the Tacoma Narrows. Another contract funded a wave energy simulator built and commissioned this year at the Oregon State University (OSU) WSERF (Wallace Energy Systems & Renewables Facility). Another project funded Peregrine Power Company of Portland, Oregon to advance their concept for developing a wave energy point-absorber. Finally, another contract went to the Electric Power Research Institute to research the accuracy of wave forecasting technology.

Earlier this year, DOE launched a competitive small business grant solicitation for ocean-energy device manufacturers under Phase I of the Small Business Innovative Research (SBIR) program. The total amount that will be allocated is not yet known but will significantly help ocean-energy device manufacturers advance the development their products toward commercialization.

Finally, in addition to the $10 million of water power funding for 2008 fiscal year, Ocean Power Technologies will receive $2 million dollars of congressionally directed funds to further the development of their point absorber wave energy devices.

Technology Demonstration and Projects

Oregon Wave-Energy Test Site
Through collaboration with the central coastal Oregon fishing and crabbing community, a low-impact test berth site for wave-energy device testing was sited north of Newport, OR, 2 miles west of Agate Beach, and 1 mile southwest of the Yaquina Head Lighthouse. The necessary permitting was completed to allow both OSU and Finavera Renewables to test devices in the summer and fall of 2007. OSU is also moving forward with the plans for a single, full-scale test berth off Newport.

Wave-Energy Linear Test Bed
To comprehensively research, test, evaluate and advance wave-energy conversion devices, OSU has just installed a Linear Test Bed (LTB) in their Energy Systems Lab at WESRF. The LTB is designed to generate the relative linear motion created by ocean waves to optimize wave-energy device technologies (see Figure 2; OSU's ocean tested buoy being tested on the LTB).

- Makah Bay, Washington State – Finavera received a full license from FERC (first in the U.S.) – the agency that regulates interstate transmission of electricity and licenses hydroelectric projects in nonfederal waters – for a 1-MW wave point-absorber project consisting of four 250-kW units.
- Reedsport, Oregon – Ocean Power Technologies (OPT) completed 36-months of cumulative open ocean testing this year and received $2M of federal funding to continue testing of their buoy concepts. They plan to deploy a 150-kw prototype next year off Reedsport Oregon as the beginning phase of a 50-MW commercial facility.
- ORPC Maine, the regional development company of Ocean Renewable Power Company, LLC successfully launched its Turbine-Generator Unit (TGU), the ORPC Maine Energy Tide I, December 8, 2007. ORPC Maine plans to test the unit over a three-week period off Eastport, Maine.

Figure 1 – OSU Open Ocean Testing of SeaBeav1

OSU Wave Energy Linear Test Bed with SeaBeavI

ORPC Testing December 2007 – shows the unit being prepared off the back of a barge

- San Francisco Bay – Oceana/Golden Gate Energy was granted a preliminary permit to investigate a current turbine project in San Francisco Bay.
- Washington State – Tacoma Power was granted a preliminary permit to investigate a current turbine project in the Tacoma Narrows.
- As of December 31, 2007, thirty nine (39) preliminary permits for TISEC power plants have been granted by FERC and sixteen (16) are in the pending stage. Further information can be obtained at the FERC website (http://www.ferc.gov/industries/hydropower/indus-act/hydrokinetics/permits.asp).
- As of December 31, 2007, there have been 11 preliminary wave permit applications filed with FERC (a preliminary permit gives the permit holder the first right of refusal to a site for a 3-year period to study the site and file a construction license application); four of which have been granted and seven of which are pending. The location of these sites is in the Pacific Northwest. The pace of industry's development can be seen in the increasing role of the investment community in the technology. For example, in August 2006, Verdant Power closed a $15 million institutional investment.
- New York, NY – Verdant Power was allowed by FERC to deploy 6 turbines to support their license application for the Roosevelt Island Tidal Energy (RITE) Project in the East River. The demonstration is supported by permits from the New York State Department of Environmental Conservation and U.S. Army Corps of Engineers. The New York State Energy Research and Development Authority has partnered with Verdant on the project. Investing over $2 million to date.

Relevant National Association's Activities

- The Energy Ocean 2007 Conference, sponsored by *Ocean News Magazine*, was held in August 2007 in Oahu, Hawaii, and was attended by over 250 people. The next conference will be held in June 2008, in Galveston Texas.
- The Ocean Renewable Energy Coalition (OREC), a major U.S. trade association for ocean renewables, reached a membership of 35 this year.
- The National Renewable Energy Laboratory, OREC, and the Minerals Management Service will sponsor the Global Marine Renewable Energy Conference in New York City, April 17-18, 2008, to help introduce ocean renewable energy to the United States as part of the activities surrounding the 14th IEA-OES Executive Committee meeting that will be held on April 15-16 in New York City at the headquarters on the American National Standards Organization (ANSI).
- The National Hydro Association (NHA) will sponsor its bi-annual Hydrovision Meeting in Sacramento, CA from July 14-18, 2008. Ocean energy will be featured in many of the sessions.

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About IEA-OES

The IEA's program of International Energy Technology Co-operation includes a mechanism called an "Implementing Agreement" (IA). There are currently 42 Implementing Agreements under the IEA International Energy Technology Co-operation Framework. The newest Implementing Agreement in the renewable energy strand is the Ocean Energy Systems Implementing Agreement (IEA-OES). This IA was established in 2001 with the mission of enhancing international collaboration to make ocean energy technologies a significant energy option in the mid-term future. By end 2007, 11 countries and the European Commission are members of the IEA-OES.

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